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RESEARCH ARTICLE

Relation between Star Numbers and Triangular, Square and Centred Square numbers

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ABSTRACT

In this paper we have introduced Star numbers and established the connection between Star numbers and well known family of numbers like Triangular numbers, Square numbers, and Centred Square numbers.

Keywords: Star numbers, Triangular numbers, Square numbers, Centred Square numbers.

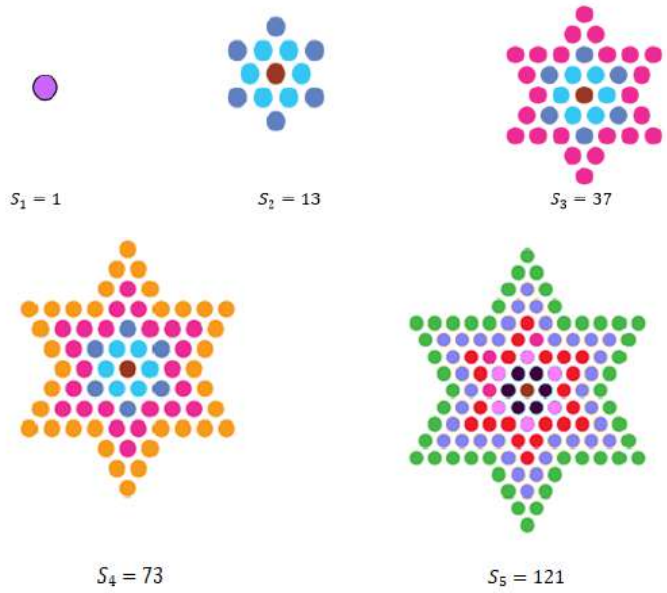
INTRODUCTION

A figurate number is a number formed by taking points, or dots and arranging them into regular shape, such as a triangular, square, pentagon. Such numbers are called Polygonal numbers or in general, Figurate numbers. Star numbers also falls under the category of Centred Figurate number, where these numbers are represented in Hexagrams shape. In this paper we introduce star numbers and provide results in which star numbers are equal to triangular, square, and centred square numbers.

DEFINITION

STAR NUMBERS

Star numbers are numbers which can be represented in the shape of Centred Hexagrams (six point star). These appear as concentric layers of dots, each layers being arranged in the shape of a hexagram, around a centred dot. The m th star number is defined by $S_m = 6m(m-1) + 1(1)$. The list of first few star numbers are given by $1, 13, 37, 73, 121, 181, 253, 337, 433, \ldots$ Below are representations of the first few Star numbers:



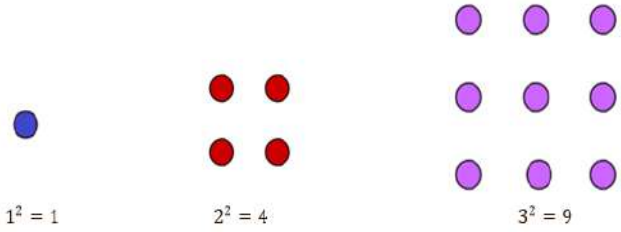
TRIANGULAR NUMBERS

Triangular numbers are numbers that can represented as a triangle. The first triangular numbers $T_1 = 1$. The second triangular number is found by adding 2 to the previous triangular number and so $T_2 = 1 + 2 = 3$.The third triangular number is found by adding 3 to the previous triangular number and so $T_3 = 1 + 2 + 3 = 6$. The $n\,th$ triangular number is$T_n = 1 + 2 + 3 + \cdots + n = \frac{n(n+1)}{2}$. (2) Below are representations of the first few Triangular numbers:



SQUARE NUMBERS

A square number is a number that has been multiplied by itself. It is the product of two equal numbers.$n^2 = n \times n$ (3) Below are representations of the first few Square numbers:

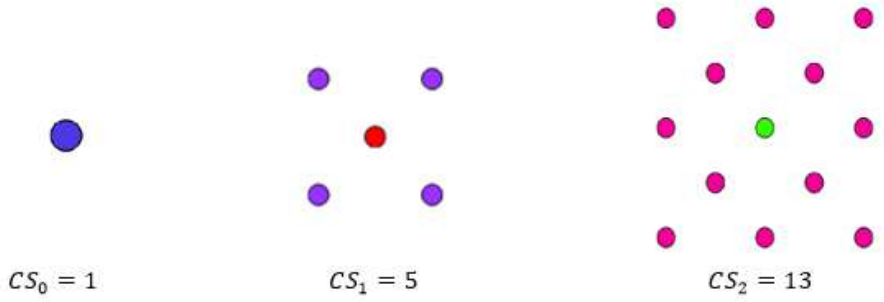


CENTRED SQUARE NUMBERS

A Centred square number is a centred figurate number that represents the number of dots in a square that is centred with in larger square, with a constant number of dots separating the two squares along each side.

The nth centred square number is $CS_n = \frac{4n(n+1)}{2} + 1 = 2n^2 + 2n + 1$ (4)

Below are representations of the first few Centred square numbers:



Lemma

Consider the quadratic Diophantine equation $ax^2 - by^2 = c$ (5). Consider $D = ab$. Let (x_0, y_0) be a solution of equation (5) and $u^2 - Dv^2 = 1$ (6).

Then $x = x_0u + b\beta v, y = \beta u + \alpha v$ (7) and $x = |-x_0u + b\beta v|$, $y = |\beta u - \alpha v|$(8) where $\alpha = ax_0, \beta = y_0$ (9) are also solutions of equation (5).

Proof

From the hypothesis, we have $ax_0^2 - by_0^2 = c$. Using (6), (7) and (9), we have

$$ax^2 - by^2 = a(x_0u + by_0v)^2 - b(y_0u + ax_0v)^2 = u^2(ax_0^2 - by_0^2) - abv^2(ax_0^2 - by_0^2)$$
$$= (u^2 - abv^2)(ax_0^2 - by_0^2) = 1(c) = c$$

Hence the values of x and y from (7) forms solution to (5). Now using (8), we have

$$ax^2 - by^2 = a(-x_0u + by_0v)^2 - b(y_0u - ax_0v)^2 = u^2(ax_0^2 - by_0^2) - abv^2(ax_0^2 - by_0^2)$$
$$= (u^2 - abv^2)(ax_0^2 - by_0^2) = 1(c) = c$$

Thus the values of x and y from (8) forms solution to (5).

Also we notice that if (x_0, y_0) is one of the solutions to (5), then we can generate infinitely many solutions of (5), using (7) and (8).

In the following section we prove some interesting results.

Theorem 1

There exists infinitely many Star numbers which are also triangular numbers.

Proof: let S_m be the mth star number and let T_n be nth triangular number.

If $S_m = T_n$ for some m, n then we have

$6m(m-1)+1=\frac{n(n+1)}{2}$ (10)

$n^2+n-12m^2+12m-2=0$

$n=\frac{-1\pm\sqrt{1^2-4(1)(-12m^2+12m-2)}}{2(1)}$

$(2n+1)^2=48m^2-48m+9$

$(2n+1)^2=3(16m^2-16m+3+1-1)$

$(2n+1)^2=3(4m-2)^2-3$

$(2n+1)^2-3(4m-2)^2=-3$ (11)

If we now consider $X=(2n+1)$ and $Y=4m-2$ then (11) can be written as

$X^2-3Y^2=-3$ (12)

Comparing with (5), we get $a=1,\quad b=3,\quad D=ab=3,$

One of the solutions for (12) is $(X_0,Y_0)=(3,2)$

Now, consider $u^2-3v^2=1$ (13)

The continued fraction for $\sqrt{3}$ is given by $\sqrt{3}=[1;\overline{1,2}]$ (14)

The successive convergents obtained from continued fraction of $\sqrt{3}$ are given below

$\frac{1}{1},\frac{2}{1},\frac{5}{3},\frac{7}{4},\frac{19}{11},\frac{26}{15},\frac{71}{41},\frac{97}{56},\frac{265}{153},\frac{362}{209},\frac{985}{571},\frac{1351}{780},\frac{3691}{2131},\frac{5042}{2911},\frac{13775}{7953},\frac{18817}{10864},$

$\frac{51409}{29681},\frac{70226}{40545},\frac{191861}{110771},\frac{262087}{151316}$ ...(15)

We observe that the numerators and denominators of second, fourth, sixth, eighth, tenth, and so on convergents from (15) forms solution to (13).

In particular we observe that the pair of $(u,v)=(2,1);(7,4);(26,15);(97,56);(362,209);(1351,780);(5042,2911);$ (18817,10864), (70226,40545); (262087,151316) ... (16)

forms solution to (13).

Now, $(X_0,Y_0)=(3,2)$ is initial solution to $X^2-3Y^2=-3$

$\alpha=ax_0=3,\quad \beta=y_0=2,$

By lemma (3) we obtain

$X=x_0u+b\beta v=3u+6v$ (17)

$Y=\beta u+\alpha v=2u+3v$ (18)

From equations (17) and (18) for every pair of (u,v) given by (16), we obtain the solution of equation (12). Such solutions are given by

$(X,Y)=(12,7);(45,26);(168,97);(627,362),(2340,1351);(8733,5042);$
(32592,18817); (121635,70226); (453948,262087); (1694157,978122) ... (19)

Since $m=\frac{Y+2}{4}$ and $n=\frac{X-1}{2}$, we have $(m,n)=\left(\frac{9}{4},\frac{11}{2}\right);(7,22);\left(\frac{99}{4},\frac{167}{2}\right);(91,313);$
$\left(\frac{1353}{4},\frac{2339}{2}\right);$ (1261,4366); $\left(\frac{18819}{4},\frac{32591}{2}\right);$ (17557,60817); $\left(\frac{262089}{4},\frac{453947}{2}\right);$
(244531,847078) ... (20)

By lemma (3) we obtain

$X=|-x_0u+b\beta v|=|-3u+6v|$ (21)

$Y=|\beta u-\alpha v|=|2u-3v|$ (22)

From equations (21) and (22) for every pair of (u,v) given by (16) we obtain the solution of equation (12). Such solutions are given by

$(X,Y)=(0,1);(3,2);(12,7);(45,26);(168,97);(627,362);(2340,1351);(8733,5042);$
(32592,18817); (121635,70226); ... (23)

Since $m=\frac{Y+2}{4}$ and $n=\frac{X-1}{2}$,

We have

$(m,n)\left(\frac{3}{4},\frac{-1}{2}\right)$; (1,1); $\left(\frac{9}{4},\frac{11}{2}\right)$; (7,22); $\left(\frac{99}{4},\frac{167}{2}\right)$; (91,313); $\left(\frac{1353}{4},\frac{2339}{2}\right)$; (1261,4366); $\left(\frac{18819}{4},\frac{32591}{2}\right)$; (17577,60817); ... (24)

Now considering positive and integers values of (m,n) through (20) and (24), we can neglect the repeated values and substituting in (10), we notice that the numbers $1, 253, 49141, 9533161, 1849384153, 358770992581, \ldots$(25) are both Star numbers as well as Triangular numbers.

Theorem 2

There exists infinitely many Star numbers which are also Square numbers.

Proof: let S_m be the mth Star number and let n^2 be nth Square number.

If $S_m = n^2$ for some m, n then we have

$6m(m-1) + 1 = n^2$ (26)

$6m^2 - 6m + 1 - n^2 = 0$

$$m = \frac{6 \pm \sqrt{6^2 - 4(6)(1-n^2)}}{2(6)}$$

$(12m-6)^2 = 24n^2 + 12$

$\left(6(2m-1)\right)^2 = 4n^2 + 2$

$6(2m-1)^2 - 4n^2 = 2$

$(2n)^2 - 6(2m-1)^2 = -2$ (27)

If we now consider $X = 2n$ and $Y = 2m-1$ then (27) can be written as

$X^2 - 6Y^2 = -2$ (28)

Comparing with (5), we get $a = 1, b = 6,\ D = ab = 6$

One of the solutions for equations (27) is $(X_0, Y_0) = (2,1)$

Now consider $u^2 - 6v^2 = 1$ (29)

Consider $\left(5 - 2\sqrt{6}\right)\left(5 + 2\sqrt{6}\right) = 1$

$$5 - 2\sqrt{6} = \frac{1}{5 + 2\sqrt{6}} = \frac{1}{10 - (5 - 2\sqrt{6})}$$

$$5 - 2\sqrt{6} = \frac{1}{10 - \frac{1}{10 - \frac{1}{10 - \frac{1}{10\ldots}}}}$$

$$2\sqrt{6} = 5 - \frac{1}{10 - \frac{1}{10 - \frac{1}{10 - \frac{1}{10\ldots}}}}$$

The successive convergents of the continued fraction expansion of $2\sqrt{6}$ are given by

$\frac{5}{1}, \frac{49}{10}, \frac{485}{99}, \frac{4801}{980}, \frac{47525}{9701}, \frac{470449}{96030}, \frac{4656961}{950599}, \frac{46099201}{9409960}, \ldots$

Multiplying each of the denominators of the convergents obtained above by 2, the solutions to (29) are given by $(u,v) = (5,2), (49,20), (485,198), (4801,1960), (47525, 19402),$
$(470449,192060), (4656965,1901198), (46099201,18819920), \ldots$ (30)

By lemma (3), we obtain

Now, $(X_0, Y_0) = (2,1)$ is initial solution to $X^2 - 6Y^2 = -2$

$\alpha = ax_0 = 2, \quad \beta = y_0 = 1$

$X = x_0u + b\beta v = 2u + 6v$ (31)

$Y = \beta u + \alpha v = u + 2v$ (32)

From equations (31) and (32) for every pair of (u,v) given by (30), we obtain the solutions of equation (28). Such solutions are given by $(X,Y) = (22,9), (218,89), (2158,881),$
$(21362, 8721), \quad (211462,86329), (2093258,854569), (20721118,8459361),$
$(205117922,83739041), \ldots$ (33)

Since $m = \frac{Y+1}{2}$ and $n = \frac{X}{2}$ from (33) we have $(m,n) = (10,11), (45,109), (441,1079),$
$(4361, 10681,), (43165, 105731), (427285, 1046629), (4229681, 10360559),$

(41869521, 102558961), … (34)

By lemma (3), we obtain

$X = |-x_0 u + b\beta v| = |-2u + 6v|$ (35)

$Y = |\beta u - \alpha v| = |u - 2v|$ (36)

From equations (35) and (36) for every pair of (u, v) given by (30), we obtain the solution of equation (28), such solutions are given by

(X, Y) = (2, 1), (22, 9), (218, 89), (2158, 881), (21362 , 8721), (211462, 86329), (2093258, 854569), (20721118, 8459361), (205117922, 83739041), … (37)

Since $m = \frac{Y+1}{2}$ and $n = \frac{X}{2}$ from (33) we have (m, n) = (1, 1), (5,11), (45,109), (441,1079), (4361, 10681,), (43165, 105731), (427285, 1046629), (4229681, 10360559), (41869521, 102558961), … (38)

Now considering positive values of (m, n) through (34) and (38), we can neglect the repeated values and substituting in (26), we notice that the numbers

1, 121, 11881, 1164241, 114083761, 11179044361, 1095432263641,107341182792481, 10518340481399521, … (39)

are both Star numbers as well as Square numbers.

Theorem

There exists infinitely many Star numbers which are also Centred Square numbers.

Proof: let S_m be the mth Star number and let CS_n be nthCentred Square number.

If $S_m = CS_n$ for some m, n then we have

$6m(m-1) + 1 = 2n(n+1) + 1$ (40)

$2n^2 + 2n - 6m^2 + 6m = 0$

$$n = \frac{-2 \pm \sqrt{2^2 - 4(2)(-6m^2 + 6m)}}{2(2)}$$

$(4n + 2)^2 = 4 + 48m^2 - 48m$

$\big(2(2n + 1)\big)^2 = 4 + 48m^2 - 48m$

$(2n + 1)^2 = 12m^2 - 12m + 1$

$$(2n + 1)^2 = 3\left[4m^2 - 4m + \frac{1}{3}\right]$$

$$(2n + 1)^2 = 3\left[4m^2 - 4m + 1 - 1 + \frac{1}{3}\right]$$

$$(2n + 1)^2 = 3\left[(2m - 1)^2 - \frac{2}{3}\right]$$

$(2n + 1) - 3(2m - 1)^2 = -2$ (41)

If we now consider $X = 2n + 1$ and $Y = 2m - 1$ then (41) can be written as

$X^2 - 3Y^2 = -2$ (42)

Comparing with (5), we get $a = 1, b = 3,\ D = ab = 3$

One of the solutions for equations (42) is (X_0, Y_0) = (5,3)

Now consider $u^2 - 3v^2 = 1$ (43)

The continued fraction for $\sqrt{3}$ is given by $\sqrt{3} = [1; \overline{1,2}]$ (44)

The successive convergents obtained from continued fraction of $\sqrt{3}$are given below $\frac{1}{1}, \frac{2}{1}, \frac{5}{3}, \frac{7}{4}, \frac{19}{11}, \frac{26}{15}, \frac{71}{41}, \frac{97}{56}, \frac{265}{153}, \frac{362}{209}, \frac{985}{571}, \frac{1351}{780}, \frac{3691}{2131}, \frac{5042}{2911}, \frac{13775}{7953}, \frac{18817}{10864}, \ldots$ (45)

The second, fourth, sixth, eighth, tenth, and so on convergents in (45) forms solution to (43).

In particular we observe that the pair of values (u, v) = (2,1); (7,4); (26,15); (97,56); (362,209); (1351,780); (5042,2911); (18817,10864), … (46)

forms solutions to (43)

Now (X_0, Y_0) = (5,3) is initial solution to $X^2 - 3Y^2 = -2$

By lemma (3), we obtain

$\alpha = ax_0 = 5, \quad \beta = y_0 = 3,$

$X = x_0 u + b\beta v = 5u + 9v$ (47)

$Y = \beta u + \alpha v = 3u + 5v$ (48)

From equations (47) and (48) for every pair of (u, v) given by (46), we obtain the solution of equation (42). Such solutions are given by (X, Y) = (19,11), (71,41), (265, 153),
(989,571), (3691,2131), (13775,7953), (51409,29681), (191861, 110771), ... (49)

Since $m = \frac{Y+1}{2}$ and $n = \frac{X-1}{2}$ from (49) we have (m, n) = (6,9), (21, 35), (77, 132),
(286, 494), (2132,1845), (3977,6887), (14841,25704), (55386,191860), ...(50)

By lemma (3) we obtain

$X = |-x_0 u + b\beta v| = |-5u + 9v|$ (51)

$Y = |\beta u - \alpha v| = |3u - 5v|$ (52)

From equations (51) and (52) for every pair of (u, v) given by (46) we obtain the solution of equation (42). Such solutions are given by

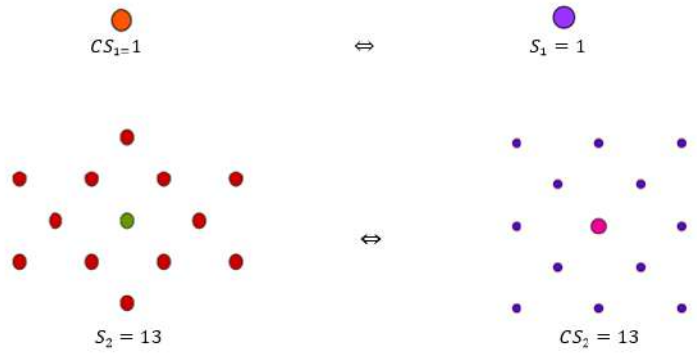
(X, Y) = (1,1), (1,1), (5,3), (19,11), (71,41), (265, 153), (989,571), (3691,2131), ...(53)

Since $m = \frac{Y+1}{2}$ and $n = \frac{X-1}{2}$ from (53) we have (m, n) = (1,0), (2,2), (6,9), (21, 35),
(77, 132), (286, 494), (2132,1845), (3977,6887) ... (54)

Now considering positive values of (m, n) through (50) and (54), we can neglect the repeated values and substituting in (40), we notice that the numbers

1, 13, 181, 25201, 35113, 489061, 6811741, 94875313, 1321442641, 18405321661, ... (55) are both Star numbers as well as Centred Square numbers.

The Star numbers and Centred square numbers diagram are given below



CONCLUSION

In this paper, after introducing star numbers we have established three theorems related to set of star numbers which are also triangular numbers, square numbers and centred square numbers respectively. The star numbers considered as part of figurate numbers, thus exhibit fascinating connection between other class of figurate numbers. One can try to establish equality of star numbers with other class of interesting sequence of numbers as presented here.

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RESEARCH ARTICLE

Pharmacokinetic Profiling and Hepatoprotective Efficacy of Methanol Extract and Bioactive Compounds from Grains of *Pennisetum glaucum* L.

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ABSTRACT

The aim of this study was to evaluate the hepatoprotective efficacy of methanol extract from grains of *Pennisetum glaucum* using rat models. The extract was subjected to GC-MS for phytochemical screening where, sterols, carbohydrates, phenols, flavonoids, proteins tannins, saponins, and terpenoids were identified. The total phenolic content and total flavonoid content of the extract are found to be 12.5 mg GAE/g and 62.1 ± 4.17 mg QE/g, respectively in the extract. Acute toxicity tests determined the optimal dosage of MEPG and no symptoms of toxicity or mortality up to a dosage of 2000 mg/kg body weight was noticed. The hepatoprotective effect of methanol extract was assessed using carbon tetrachloride and paracetamol-induced models at doses of 200 mg/kg and 400 mg/kg which demonstrated a significant reduction in CCl_4 and paracetamol-induced liver damage which was confirmed through histopathological studies. Furthermore, the decrease in the levels of serum biochemical markers such as

ALP, Bilirubin, AST and ALT were also observed indicating a hepatoprotective effect of the extract under study. The results indicate that *Pennisetum glaucum* is an excellent source of phytochemicals and therefore, further studies are needed on various biochemical aspects where the data procured might help in the developments of lead products and formulations suitable for the management of various liver diseases.

Keywords: *Pennisetum glaucum,* Acute Toxicity, Paracetamol, Carbon tetrachloride, Serum markers and Hepatoprotective efficacy

INTRODUCTION

The liver, one of the largest organs in the human system, is crucial due to its oversight of many functions, including metabolism, which is necessary for survival [1]. The organ's position in the human anatomy makes it susceptible to a wide variety of outside toxins. The intestinal absorption of these xenobiotics begins in the liver, making it an organ vulnerable to ailments [2]. An abundance of hepatotoxic agents, including alcohol, viruses, and chemicals such as carbon tetrachloride (CCl_4) and paracetamol, are currently responsible for the poor well-being of countless individuals [3-4]. More than 20,000 people die each year from liver diseases, making it a major health concern around the world [5]. Traditional medicine for liver problems may not be effective enough or may even cause harm [6]. This is the reason why switching from chemical medications to herbal remedies is crucial. As a result, herbal treatments have become widely popular and extensively utilized. A large range of medicinal plants and their preparations around the world have asserted hepatoprotectiveactivity. Research has shown that 101 different plants contain around 160 phytoconstituents that protect the liver [7]. In recent years, there has been more interest in naturally occurring substances from plants, such as phenolic acids, flavonoids, terpenoids, and sterols, because they have a wide range of pharmacological effects, including antioxidant and hepatoprotective activity [8]. India and Africa both rely on pearl millet, scientifically known as *Pennisetum glaucum*, as a mainstay crop in their dry and semi-arid climates. Although it has its roots in the Sahel area of Africa, it has consistently grown in India and Africa since ancient times [9-10]. Despite its humble origins, this cereal has the potential to be a rich source of dietary antioxidants like flavonoids and phenolic acids. These bioactive compounds have been shown to reduce oxidative stress caused by free radicals, which could help prevent ageing and a host of diseases linked to oxidative stress, including cancer, cardiovascular disease, diabetes, asthma, and neurodegenerative disorders [11-12].

Additionally, it controls blood pressure and plasma low-density lipoprotein cholesterol levels and has anti-allergenic properties [13-14].In light of the foregoing, the current investigation set out to assess the histopathological findings and *in vivo* hepatoprotective effects of a MEPG using paracetamol and carbon tetrachloride-induced models. Acute liver damage can occur from the over administration of paracetamol (acetaminophen), a commonly used antipyretic and analgesic [15-16]. Glucuronide and sulphate conjugates are the primary products of paracetamol's metabolism in the liver [17-18]. But when hepatic cytochrome P450 activates a portion of paracetamol, it forms the extremely reactive metabolite N–acetyl–P–benzoquinone imine (NAPQI), which is responsible for its hepatotoxicity [19-20]. NAPQI can covalently bind to protein cysteine groups, resulting in the formation of 3-(cystein-S-yl) acetaminophen adducts [21]. Glutathione protects hepatocytes by preventing the covalent attachment of paracetamol's reactive metabolite to liver proteins[22]. The CCl_4 is a commonly used poison to induce liver damage in lab animals for experimental purposes [23]. A liver-toxic substance is similar to a virus in that it damages liver cells. When CCl_4 reaches the liver, it is recognised as a xenobiotic. Microsomal mechanisms utilize monooxygenase P-450 to convert it into two free radicals, trichloromethyl and trichloromethyl-peroxyl. These two radicals cause lipid peroxidation, resulting in severe liver damage [24]. Research has shown that antioxidants protect the liver from oxidative damage and reduce the risk of liver disease [25]. Because of this, there is a growing movement to find natural compounds with antioxidant properties and employ them to protect the liver from oxidative stress-related diseases [26].

MATERIALS AND METHODS

Plant Collection

The *Pennisetum glaucum* grains have been purchased from an authorised millet store in Hyderabad. The material was identified by a botanist in December 2021, and its authenticity was confirmed by the professor and head of the Department of Botany at Government Degree College, Kukatpally, Hyderabad. After rinsing, the botanist crushed the grains into a coarse powder. The material that had been pulverised was kept for the extraction process.

Preparation of Methanolic Extract of *Pennisetumglaucum* (MEPG)

Millet powder (950g) was kept inside the Soxhlet apparatus directly or it is put within a thimble of filter paper. To fix the powder, the methanol is initially siphoned once before boiling. Fragments of activated porcelain were added to the flask in order to prevent the solvent from getting bumped. As soon as the liquid reaches the point of return, it moves the contents of the extractor chamber to the flask, creating a syphon in the syphon tube. When the resulting liquid rises to the top of the extractor's liquid level, the vapours travel via the side tube. To accomplish efficient extraction, one can syphon back and evaporate the solvent in cycles as frequently as feasible without altering it. This technique, which consists just of a few quick macerations, is an ongoing extraction procedure. After drying by evaporation at ambient temperature,the resultant organic extracts were placed in sealed containers for further use.

Phytochemical screening

Preliminary phytochemical analysis was carried out in order to determine the various phytoconstituents present in MEPG.

GC Condition and Identification of Compounds of MEPG

A Scion 436-GC Bruker model equipped with a triple quadruple mass spectrophotometer and a BR-5MS fused silica capillary column, composed of 5% diphenyl/95% dimethyl polysiloxane, performed the GC-MS analysis. Helium at a flow rate of 1 mL/min was employed as a carrier gas. The ion source is kept at 280°C and the injector at 250°C. The oven was programmed to increase from 200°C to 280°C at a rate of 10°C/min, followed by a further increase of 5°C/min until reaching 280°C. It then maintained an isothermal period of at 280°C with a final hold time of 9 min.

Estimation of total phenolic content

The total phenols present in all the extracts were determined by method described in the literature [27] and in quintuplicate. To an aliquot consisting of 5µL of MEPG, 1M Na_2CO_3 and Folin-Ciocalteau reagent were added. The colour developed after 15 minutes of the reaction in dark was measured at 760nm against reagent blank and gallic acid was served as the reference standard. The total phenols were determined as mg of gallic acid equivalent per gm of sample using a calibration curve.

Estimation of total flavonoids

The total flavonoids were determined with the colorimetric assay using $AlCl_3$ as published in literature [28] and performed in quintuplicate. To the appropriately diluted extract (200µl), $AlCl_3$ (10%, 0.2ml), Potassium acetate (1M, 0.2ml) and distilled water (5.6ml) were added. The reaction mixture and incubated for 30 mi. at room temperature. The absorbance was recorded at 420 nm and the total flavonoids were determined using a calibration curve as mg of quercetin equivalent per gm of sample.

Animals

The pharmacological activities were carried out using Wistar Albino rats of either sex weighing 200–250 g and Swiss Albino mice weighing 20–30 g. They were housed in polypropylene cages and subjected to a diurnal cycle with a temperature of 25 ± 2 °C and a relative humidity of 45–55%. Prior to any studies being conducted, the animals were allowed to adjust to the laboratory environment for around one week. Routine animal feed and unlimited water were

provided to them. Institutional Animal Ethics Committee (IAEC) approval was obtained for all pharmacological experimental protocols.

Acute Toxicity Studies

An investigation was done to find out if the extract was unsafe. The study was conducted in accordance with the OECD. The acute oral toxicity is evaluated using the up-and-down method. An inbred colony of adult Wistar albino rats (weighing 150–200 grammes) is used in this study. The IAEC approved all the experimental pharmacological methodologies.

***In vivo* Evaluation of Hepatoprotective Activity**

Paracetamol Induced Hepatotoxicity

This seven-day study will involve thirty healthy Wistar albino rats of either sex, weighing between 200 and 250 g. For a duration of seven days, the animals get their subsequent treatment orally. All animals are categorised into five groups of six animals each [29].

Carbon Tetrachloride Induced Hepatotoxicity

This 28 days study will involve thirty healthy Wistar albino rats of either sex, weighing between 200 and 250 g. For a duration of seven days, the animals get their subsequent treatment orally. All animals are categorised into five groups of six animals each [30-31].

Measurement of serum biochemical markers

After 24 hours following the last treatment, blood was collected from the retro-orbital plexus and allowed to coagulate for an hour at ambient temperature, and the serum is then separated by centrifugation at 2500 rpm for 15 mins at 30˚C. After separation, the serum was tested for several biochemical factors.

Histopathological examination

Liver tissues were subjected to a photomicroscopy examination after one week of dehydration in a series of ethanol solutions, embedding in paraffin, sectioning into 5 micrometre pieces, and staining with haematoxylin-eosin dye.

ADMET Analysis

ADMET (Absorption, Distribution, Metabolism, Excretion, and Toxicity) analysis was carried out utilising the Swiss-ADME tool. For a compound to be regarded as a therapeutic candidate, the ADMET analysis is deemed too important [32]. Utilising the web-based database pkCSM, the pharmacokinetic scores of substances were assessed.

Statistical analysis

Values were analysed using SPSS 18.0 software and presented as the Mean ± SD. A one-way analysis of variance (ANOVA) was used, along with the LSD and Dunnett's tests. statistical significance was set to $P < 0.05$.

RESULTS

The *P. glaucum* grains were identified, verified, gathered, desiccated, and ground into powder and the yield of MEPG was found to be 12% w/w.

Phytochemical Analysis

The phytochemicals in the methanolic grain extract of *P. glaucum* showed that it contained flavonoids, steroids, phenols, carbohydrates, tannins, terpenes, fatty acids, proteins, and volatile oils (Table-3).

GC-MS of MEPG

After the GCMS analysis, the subsequent bioactive components in the extract were determined and presented (Table-4).

Total Phenol and Flavonoid Content

The total phenolic content and total flavonoids content of MEPG were found to be 12.5 mg GAE/gm and.62.1 ± 4.17 mg QE/gm respectively (Fig-2 & 3)

Acute Toxicity Studies

Swiss albino mice showed no signs of toxicity or death up to a dosage of 2000 mg/kg body weight in the experiments. All the animals were found to be healthy, even after fourteen days of surveillance. Consequently, the extract was found to be acceptable up to a dosage of 2000 mg/kg bd.wt.

Dose selection

Results showed that 2000 mg/kg bd wt was safe in the toxicity tests mentioned earlier. The pharmacological studies were conducted using 200 and 400 mg/kg bd.wt. dosages.

***In vivo* Hepatoprotective Activity**

This study set out to test the hypothesis that theMEPG has hepatoprotective effects against CCl_4 and paracetamol-induced hepatotoxicity at varying dosages.

Paracetamol Induced Hepatotoxicity

Paracetamol alone does not cause hepatic damage or drug-induced liver disease. Rather, one of its metabolites, N-acetyl-p-benzoquinoneimine(NAPQI), does. NAPQI directly destroys liver cells and reduces glutathione, the liver's natural antioxidant, leading to hepatic failure. Hepatic toxicity is indicated by elevated levels of various biochemical markers that include total bilirubin, alkaline phosphatase (ALKP), alanine aminotransferase (ALT), and aspartate aminotransferase (AST) [33]. The levels of AST, ALP, ALT and bilirubin in the blood were slightly lower in the groups that were given MEPG at 200 mg/kg bd., wt., and 400 mg/kg bd., wt (Table-5). Statistically substantial evidence supported the outcomes. MEPG had an impact on the levels of bilirubin, ALP, ALT and AST (Fig- 4 & 5). The animals given this extract experienced a significant and satisfactory reduction in the research parameters. However, paracetamol-administered mice showed a very significant decrease in liver parameters. The results were given as Mean ± SEM (n = 6). ANOVA was used for statistical analysis, followed by Dunnett's test. The findings were presented as when compared to control (* = $p < 0.0001$, ** = $p < 0.05$), disease control (^{A} = $p < 0.0001$), standard (^{a} = $p < 0.0001$, ^{b} = 0.0005, ^{c} = $p< 0.05$).

Carbon Tetrachloride Induced Hepatotoxicity

CCl_4, a well-known liver-damaging substance, is frequently used to assess how well drugs generally shield the liver from harm by avoiding liver damage. Acute viral hepatitis and CCl_4-induced liver injury cause similar changes. Following liver metabolism, the conjugates of glucuronide and sulphur can be eliminated [32]. Disruption of the transportation function of hepatocytes results in hepatic injury, causing the leakage of cellular enzymes into the plasma [33]. Damage to the liver's cell plasma results in the release of enzymes from the cytosol into the blood, thereby increasing the enzyme count in the serum. The measurement of serum enzyme levels is a useful quantitative indicator of severity [34]. The treatment groups of MEPG at 200 and 400 mg/kg, bd.wt. (Table-6) exhibited a slight reduction in the serum levels of ALT, AST, bilirubin, and ALP (Fig- 6 & 7). The statistical significance of these reductions was discovered. The parameters were compared between the groups treated with silymarin and CCl_4. The results are given as Mean ± SEM (n = 6). ANOVA was used for statistical analysis, followed by Dunnett's test. The findings were presented as when compared to control (* = $p < 0.0001$, ** = $p < 0.05$), disease control (^{A} = $p < 0.0001$), standard (^{a} = $p < 0.0001$, ^{b} = 0.0005, ^{c} = $p< 0.005$, d = $p < 0.001$).

Histopathological Studies

The histopathological assessment of the livers in the control, disease control and treatment groups of rats as shown in Fig-8.

A) **Normal Control:** Hepatic cells with portal, periportal, and centrilobular regions exhibited normal morphology in the liver.

B) **Diseased control:** The liver's periportal and centrilobular regions showed multiple focal, tiny foci of hepatocyte necrosis, accompanied by an infiltration of inflammatory cells.
C) **MEPG (200 mg/kg):** The shape of the area around the port was normal, but the shape of the area in the middle of the lobe had many dead liver cells and lymphocytes moving in.
D) **MEPG (400 mg/kg):** There was little sinusoidal dilatation between the hepatocytes, but the portal and centrilobular regions showed a normal hepatocyte appearance.
E) **Silymarin (50 mg/kg):** There was modest sinusoidal dilatation and haemorrhage, but the hepatocytes in the periportal and centrilobular regions looked usual.

DISCUSSION

Chemically driven liver damage, or hepatotoxicity, can result from drug exposure or a spike in free radical levels. Two approaches were used to evaluate hepatoprotective activity: paracetamol-induced hepatotoxicity and CCl_4 inhibition. Overdosing on paracetamol or taking too much of the medicine poses health risks. Paracetamol and its metabolites, NAPQI, are not the primary agents responsible for hepatotoxicity, often known as drug-induced liver injury. NAPQI causes liver failure by destroying liver cells immediately and by lowering the liver's intrinsic antioxidant glutathione. Hepatic toxicity is indicated by a rise in biochemical markers such as overall bilirubin, AST, ALT, and ALKP [35]. The groups administered 200 mg/kg bd., wt. of MEPG or 400 mg/kg bd., wt. of MEPG exhibited slight reductions in all measured parameters, including bilirubin, AST, ALT, and ALP. The results showed statistical significance. Meloxicam changed bilirubin, AST, ALT, and ALP levels. After receiving this extract, the animals exhibited a significant and positive improvement in the studied parameters. However, paracetamol caused a dramatic reduction in liver parameter values in mice [36]. The general efficacy of drugs in avoiding liver damage has been measured using the widely known hepatotoxic toxin CCl_4. Similar to the changes caused by acute viral hepatitis, CCl_4-induced liver injury compromises liver function. Following liver metabolism, glucuronide and sulphur conjugates are excretable [37]. The primary indication of liver injury is the release of cellular enzymes into the plasma due to interference with the transport function of hepatocytes [38]. The breakdown of the liver's cellular plasma releases a plethora of enzymes normally found in the cytosol, elevating the serum enzyme concentration. As a quantitative measure of severity, the serum enzyme estimateswork well [38]. Serum AST, bilirubin, ALP, and ALT levels in the MEPG treatment groups at 200 and 400 mg/kg, bd.wt., were slightly lower than those in the control groups. A statistical analysis confirmed their significance. We compared the parameters with two groups: one treated with silymarin and another with CCl_4. Liver histology studies in rats administered 200 mg/kg bd.wt. of MEPG revealed some hepatocyte regeneration in the periportal area along with lymphocyte infiltration, but rats administered 400 mg/kg bd.wt. of MEPG exhibited substantial hepatocyte regeneration along with mild sinusoidal dilatation. The GCMS results identified sterols, fatty acids, phenols, flavonoids, vitamins, terpenoids, and linoleic acid, an n-6 polyunsaturated fatty acid. Among saturated fatty acids, palmitic acid is by far the most common, while linolenic acid is an essential omega-3. Linoleic, linolenic, and palmitic acids all help lower oxidative stress and raise serum parameters in liver toxicity caused by drugs. They are also biomarkers of liver damage [39].

The omega-9 fatty acid category includes oleic acid. This fatty acid reduces oxidative stress in rats' liver and spleen by lowering antioxidant levels observed under hepatotoxic conditions [40].Saturated fatty acids, like stearic acid, have an 18-carbon chain. It is a pentacyclic triterpene that protects the liver by lowering oxidative stress and inflammation-causing substances. It is a pentacyclic triterpene that protects the liver by lowering oxidative stress and inflammation-causing substances [41]. Other types of vitamin E, such as γ-tocopherol and γ-tocotrienol, are better antioxidants than α-tocopherol at protecting against long-term health problems like liver damage caused by drugs. Insufficient solubility in the intestinal fluid may limit the intestinal absorption through the portal vein system to obtain a therapeutic effect when systemic effects are warranted. For oral administration, solubility is a major property influencing absorption. Similarly, a drug meant for parenteral usage has to be highly soluble in water to deliver a sufficient quantity of the active ingredient. The water solubility is critical for the absorption and distribution of drugs within the body, and it ranged from -7.068 to -1.377, and all the readings were within the recommended range, which

showed the possible good absorption and distribution of MEPG phytocompounds. One important element that determines how effective medications are is their permeability across the blood-brain barrier. It was hypothesised that MEPG phytocompounds had outstanding permeability across the central nervous system. In addition, as these substances are involved in the excretion of drugs, the most frequent isoforms of cytochrome were tested against them. These isoforms inhibit drug interactions. Tocopherol was the only compound that inhibited CYP2C19, while linoleic acid, oleic acid, linolenic acid, arachidonic acid, stearic acid, palmitic acid, lupeol, vanillic acid, campesterol, sitosterol, ergosterol, and indomethacin inhibited the CYP3A4 substrate.In order to determine steady-state concentrations, it is essential to calculate the drug clearance of a chemical. Oleic acid, stearic acid, palmitic acid, arachidonic acid, linolenic acid, and linoleic acid all have sufficient clearance values. Organic Cation Transporter 2 (OCT2) did not recognise any of the substances as substrates. Before a medicine is considered for clinical trials or even in the pre-formulation phase, it must undergo drug toxicity profiling. As a result, the compounds' toxicity has been evaluated. Campesterol, sitosterol, oleic acid, stearic acid, palmitic acid, lupeol, vanillic acid, ferulic acid, tocopherol, indomethacin, and campesterol have all shown hepatoprotective effects.

CONCLUSION

Methanolic extract of *P. glaucum* demonstrated hepatoprotective properties against liver damage induced by PCM and CCl_4 in this investigation. The greater percentage of components like flavonoids and total phenols in the methanolic extract scavenge free radicals, which may explain its hepatoprotective properties. In order to find a new hepatoprotective drug that works well, more research needs to be done to find the pure active principle or principles that protect the liver.

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COMPETING INTERESTS

Authors have declared that there are no competing interests.

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Table 1: Experimental Design for Paracetamol Induced Hepatotoxicity

Groups	Treatment
Group I	Control
Group II	Disease control: Paracetamol (1g/kg bd. wt, *p.o.*, from 1-7days)
Group III	Paracetamol (1g/kg bd. wt, *p.o.*,) + MEPG (200mg/kg bd. wt.) from 1-7days
Group IV	Paracetamol (1g/kg bd. wt, *p.o.*,) + MEPG (400mg/kg bd. wt.) from 1-7days
Group V	Paracetamol (1g/kg bd. wt, *p.o.*,) + Silymarin (50mg/kg bd. wt.) from 1-7days

Table 2: Experimental Design for Carbon Tetrachloride Induced Hepatotoxicity

Groups	Treatment
Group I	Control
Group II	Disease control: CCl_4 (0.5g/kg bd. wt, *i.p.*, from 1-28days)
Group III	CCl_4 (0.5g/kg bd. wt, *i.p.*,) + MEPG (200mg/kg bd. wt.) from 1-28days
Group IV	CCl_4 (0.5g/kg bd. wt, *i.p.*,) + MEPG (400mg/kg bd. wt.) from 1-28days
Group V	CCl_4 (0.5g/kg bd. wt, *i.p.*,) + Silymarin (50mg/kg bd. wt.) from 1-28days

Table 3: Preliminary Phytochemical Analysis of MEPG

Phytoconstituents	Results
Flavonoids	+
Steroids	+
Phenols	+
Carbohydrates	+
Tannins	+
Terpenoids	+

Fatty acids	+
Proteins	+
Volatile oils	+

Table 4: Compounds from GC-MS

S. No	Name of the Compound	Molecular Weight	RetentionTime (Min.)	Area (%)
1.	Linoleic acid	288.44	22.64	2.14
2.	Glucose	180.56	23.56	7.12
3.	Oleic acid	282.47	22.88	0.19
4.	Linolenic acid	278.43	24.23	0.15
5.	Arachidonic acid	304.47	25.12	0.18
6.	Stearic acid	284.48	26.16	0.17
7.	Palmitic acid	256.40	21.26	0.05
8.	Lupeol	426.72	32.71	0.16
9.	Campesterol	400.68	31.37	0.82
10.	Sitosterol	414.71	32.05	14.04
11.	Ergosterol	396.65	31.95	0.05
12.	Tocopherol	416.68	30.25	0.71
13.	Vanillic acid	168.14	29.80	2.56
14.	Ferulic acid	194.18	27.50	1.98

Table-5: Effect of paracetamol on serum parameters

Groups	Alkaline Phosphatase	Bilirubin	Aspartate Transaminase	Alanine Transaminase
Control	53.0 ± 0.51	0.21 ± 0.02	163.3 ± 0.66	26.3 ± 0.49
Disease control	145.0 ± 0.96*	1.73 ± 0.06*	54.5 ± 0.42*	64.3 ± 0.71*
MEPG (200mg/kg)	73.8 ± 0.60^{*Aa}	0.65 ± 0.02^{*Ac}	32.1 ± 0.47^{*Aa}	55.3 ± 0.88^{*Aa}
MEPG (400mg/kg)	63.5 ± 0.42^{*Aa}	0.45 ± 0.02^{*Aa}	25.3 ± 0.49^{*Ab}	44.6 ± 0.88^{*Aa}
Silymarin (50mg/kg)	59 ± 0.49^{*A}	0.33 ± 0.02^{**A}	22.1 ± 0.30^{*A}	37.5 ± 0.76^{*A}

Table-6: Effects of CCL_4 on serum parameters

Groups	Alkaline Phosphatase	Bilirubin	Aspartate Transaminase	Alanine Transaminase
Control	52.5 ± 0.42	0.23 ± 0.02	15.6 ± 0.33	24.3 ± 0.33
Disease control	153.3 ± 0.50*	2.28 ± 0.04*	63.8 ± 0.47*	73.8 ± 0.47*
MEPG (200mg/kg)	83.5 ± 0.42^{*Aa}	0.66 ± 0.02^{*Aa}	32.6 ± 0.66^{*Aa}	54.1 ± 0.60^{*Aa}
MEPG (400mg/kg)	73.5 ± 0.42^{*Aa}	0.45 ± 0.02^{*Ac}	24.5 ± 0.49^{*Ad}	42.0 ± 0.51^{*Ab}
Silymarin (50mg/kg)	63.3 ± 0.49^{*A}	0.33 ± 0.02^{**A}	22.1 ± 0.30^{*A}	37.8 ± 0.60^{*A}

Table 7: ADME Parameters of the compounds

Compound	Absorption		Distribution		Metabolism		Excretion	
	Water solubility (log mol/L)	Intestinal absorption (%)	VDss (log L/Kg)	BBB permeability (log BB)	CYP3A4 substrate	CYP2C19 inhibitor	Total Clearance (log ml/min/kg)	Renal OCT2 substrate
Glucose	-1.377	21.51	0.148	-0.943	No	No	0.626	No
Linoleic acid	-5.862	92.329	-0.587	-0.142	Yes	No	1.936	No
Oleic acid	-5.924	91.823	-0.558	-0.168	Yes	No	1.884	No

Linolenic acid	-5.787	92.836	-0.617	-0.115	Yes	No	1.991	No
Arachidonic acid	-6.042	92.655	-0.644	-0.172	Yes	No	2.102	No
Stearic acid	-5.973	91.317	-0.528	-0.195	Yes	No	1.832	No
Palmitic acid	-5.562	92.004	-0.543	-0.111	Yes	No	1.763	No
Lupeol	-5.861	95.782	0	0.726	Yes	No	0.153	No
Vanillic acid	-1.838	78.152	-1.739	-0.38	No	No	0.628	No
Ferulic acid	-2.817	93.685	-1.367	-0.239	No	No	0.623	No
Campesterol	-7.068	94.543	0.427	0.774	Yes	No	0.572	No
Sitosterol	-6.773	94.464	0.193	0.781	Yes	No	0.628	No
Ergosterol	-6.947	95.197	0.406	0.767	Yes	No	0.564	No
Tocopherol	-6.901	89.782	0.709	0.876	Yes	Yes	0.794	No
Indomethacin	-3.824	98.649	-1.633	-0.563	No	No	No	No

Table-8: Hepatotoxicity profile of Compounds

Compound	Hepatotoxicity
Glucose	No
Linoleic acid	Yes
Oleic acid	No
Linolenic acid	Yes
Arachidonic acid	Yes
Stearic acid	No
Palmitic acid	No
Lupeol	No
Vanillic acid	No
Ferulic acid	No
Campesterol	No
Sitosterol	No
Ergosterol	No
Tocopherol	No
Indomethacin	No

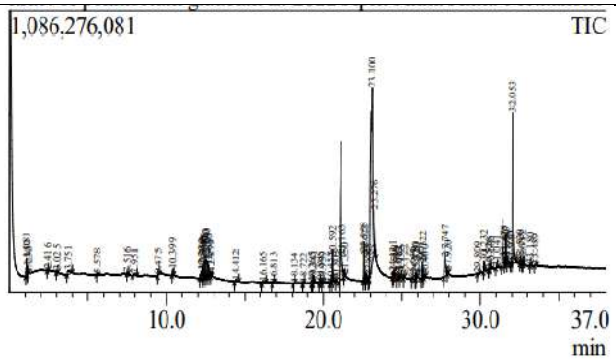


Fig-1: GCMS Study of MEPG

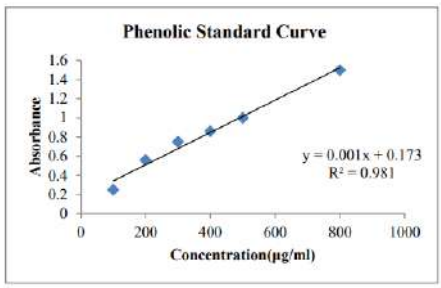


Fig-2: Calibration curve of gallic acid

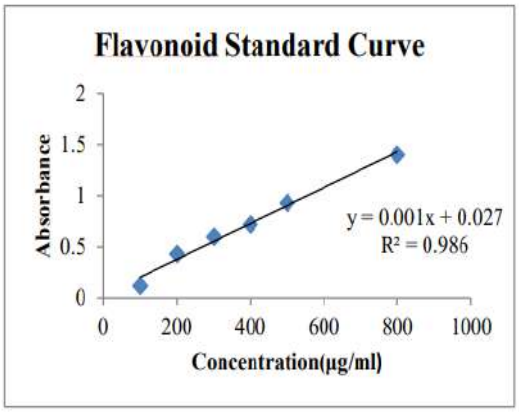


Fig-3: Calibration curve of quercetin

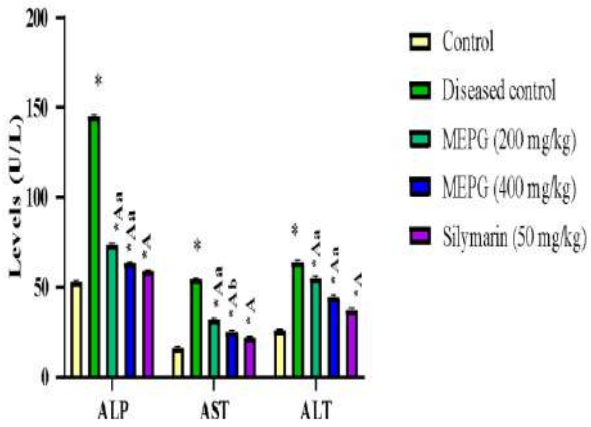


Fig-4: Effect of paracetamol on ALP, AST, and ALT levels

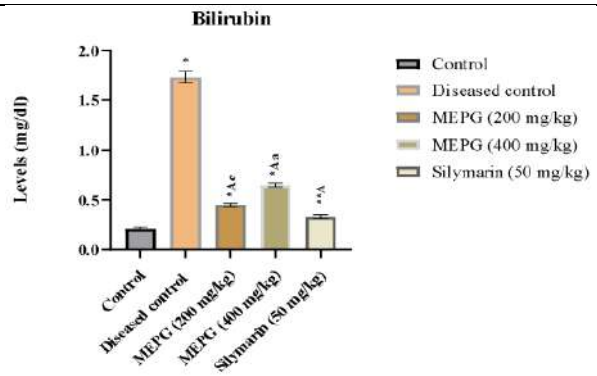


Fig-5: Effect of paracetamol on bilirubin levels

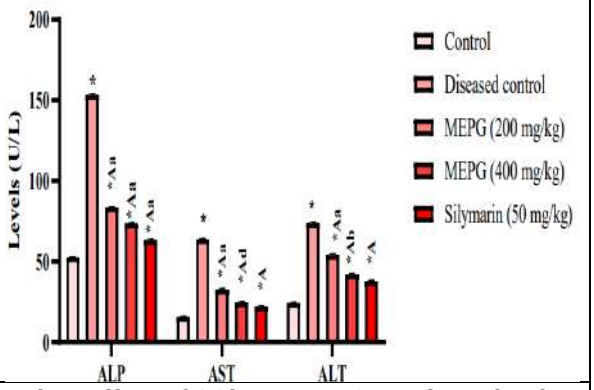


Fig-6: Effects of CCl_4 on ALP, AST, and ALT levels

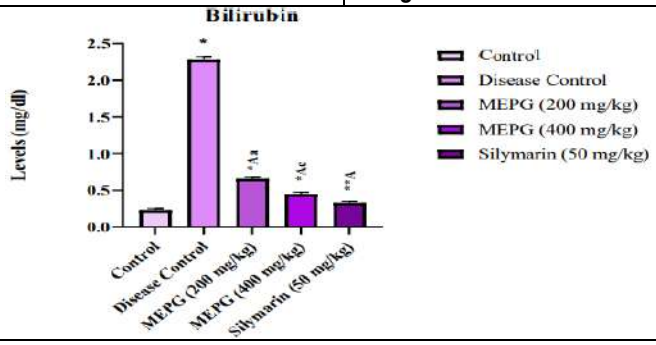


Fig-7: Effect of CCl_4 on bilirubin levels

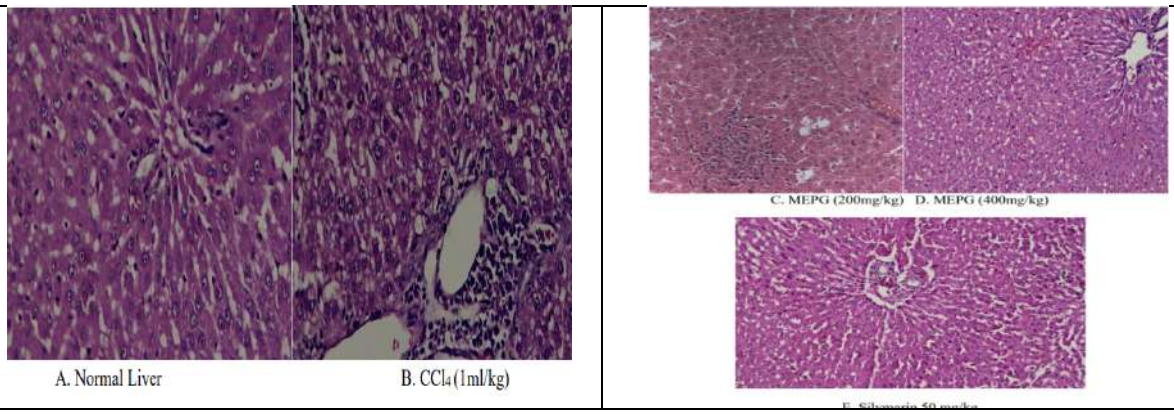


Fig-8: Histopathological studies of rat liver

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RESEARCH ARTICLE

Analysis on the LDPE Biodegradation by Microorganisms Isolated from Plastisphere Soil

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ABSTRACT

In this study, bacteria and fungi were isolated and identified from partially degraded LDPE samples, with notable findings including the presence of *Pseudomonas aeruginosa*, *Bacillus* sp., *Aspergillus niger*, *Trichoderma* sp., and *Beauveria bassiana*. These microorganisms were selectively cultured and inoculated in Minimal Salt medium containing LDPE films, leading to a substantial weight loss of 22.17% over a 60-day period under aerobic conditions. *Pseudomonas aeruginosa* exhibited superior degradation capabilities compared to other isolates. Biofilm formation was observed, with significant protein synthesis detected, particularly by *Aspergillus niger*. The observed protein concentrations correlated with the degree of LDPE weight loss. Structural changes in LDPE were confirmed through SEM and FT-IR analysis, highlighting the presence of aliphatic compounds and other chemical alterations indicative of biodegradation. SEM analysis revealed biofilm colonization, cracks, holes, and surface modifications on LDPE films. Overall, this research underscores the potential of microbial biodegradation as an effective and eco-friendly approach for managing plastic waste.

Keywords: Biodegradation, biofilm formation, LDPE, FTIR and SEM analysis.

INTRODUCTION

Plastic pollution has emerged as a critical environmental concern worldwide, with significant attention focused on the accumulation of plastic debris in every ecosystem [1,2]. Among the various types of plastic polymers, Low-Density Polyethylene (LDPE) represents a major contributor to plastic waste due to its widespread use in packaging and consumer goods[3]. The persistence of LDPE in the environment poses a significant challenge, highlighting the urgent need for effective biodegradation strategies. Traditional methods of plastic disposal include land filling, incineration, and thermal degradation[4,5,6].Microbial degradation of plastic wastes is an interesting and important strategy to reduce these synthetic polymers without accumulation of toxicity. In recent years, the concept of the "plastisphere" has garnered attention, referring to microbial communities that colonize the surface of plastic debris [7]. Understanding the dynamics of plastisphere microorganisms and their potential to degrade LDPE offers promising avenues for addressing plastic pollution. Bioremediation and biodegradation[8] represent eco-friendly approaches to managing plastic waste, providing safe disposal methods. Researchers have documented the degradation of LDPE by fungi,bacteria, microalgae[9], and other microorganisms. These microbes grow and produce extracellular enzymes that degrade plastics, releasing oligomers and monomers. Fungi, constituting nearly 3% of the plastisphere, play a crucial role in plastic degradation[10]. Various studies have identified plastic-degrading fungi such as *Aspergillus* spp., *Fusarium* spp., and *Penicillium* spp. from the plastisphere [11,12,13].In this study we aimed to isolate and characterize the microbial colonies that are involved in the biodegradation of LDPE plastic wasted from the plastisphere soil of Tirupattur region, Tamilnadu, India.

MATERIALS AND METHODS

Collection and Isolation of Microorganism

Plastic debris were collected from the waste dump yard sites around Tirupattur district, Tamilnadu, Indiausing sterile techniques to prevent contamination and rinsed using distilled water to remove loosely attached particles and debris. Mineral Salt Medium (MSM) was prepared and the collected samples were inoculated into the MSM.

Preparation of Minimal salt medium

By employing LDPE as the only source of carbon in the growth media, fungi and bacteria that decompose LDPE were cultivated in MSM containing 0.5 g K_2HPO_4, 0.04 g KH_2PO_4, 0.002 g $CaCl_2{\cdot}2H_2O$, 0.2 g $(NH_4)_2SO_4$, 0.1 g NaCl, 0.02 g $MgSO_4{\cdot}7H_2O$, 0.001 g $FeSO_4$, and 0.01 g $MnSO_4$. The recovered deteriorated plastics were cultured with the fungus that was taken from the dump yard in a minimum salt media. For the first five days, these culture flasks were incubated at 30 °C with rotation at 160 rpm. The resulting turbid growth and mycelia were purified using Whatman's No. 1 filter paper, then placed on Nutrient agar and SDA plates for analysis of the cultural traits respectively. Subsequently, LB agar plates were prepared and inoculated with the incubated cultures to identify the dominant microbial strain involved in the degradation process [14].

Plate Morphology and Microscopic Identification of fungi

Plate morphology was conducted to determine the fungi on the basis of their color and edges. For microscopic identification, one drop of Lactophenol Blue solution was added to the slide. Fungal culture was emulsified on it. Then, the slide was fixed with a cover slip. The slide was observed under a microscope and fungal isolates were identified on the basis of their hyphae and spores

Evaluation of the LDPE plastic degradation

A second batch of minimal salt medium, enriched with fresh 2 × 2 cm LDPE films, was added to the MSM. Incubation was then maintained for 45 days at regular intervals for biofilm formation analysis. The oxidised LDPE films were collected and treated with sodium dodecyl sulphate (SDS) 2% v/v for 4 hours after 45 days of incubation. SDS was then removed from the LDPE films by washing them in double-distilled water. The pellets were dried in an oven at

60°C for the entire night to eliminate the adsorbed moisture. A weighing balance with an accuracy of 0.02 mg was used to measure the resulting oxidised LDPE.

Analysis of the physical and chemical parameters of LDPE

The biodegradation of polyethylene (LDPE) was evaluated by surface cracking, weight loss, biofilm formation, decolourisation, chemical alteration and microscopy techniques.

Estimation of proteins on the LDPE samples

The total protein content after incubation was spectrophotometrically estimated by Bradford's method [15].At 20-day intervals, the PE films were purposely removed from the culture media and gently washed with water to remove any medium debris or loosely adhering cells. The bacterial biomass extracted from the PE film was treated to mild water bath sonication in 1 ml of 0.85% saline for 4 minutes [16]. The resulting saline solution was used to measure protein content at 595 nm using spectrophotometers.

Scanning electron microscopy

LDPE films treated with isolated culture for 60 days were withdrawn from the medium and examined using Field-emission Scanning Electron Microscopy (FE-SEM) to detect biofilm development and surface degradation. The microbial morphology of biofilm on the PE surface was studied after washing the films in 0.01 M phosphate buffer for 2 minutes to remove excess medium adherent to bacterial colonies. To evaluate surface changes, the PE films were washed with 2% SDS and warm distilled water for 10-20 minutes to eliminate bacterial biomass. The polyethylene films were then fixed in 4% glutaraldehyde for 2 hours at 4°C before being dehydrated with 50% ethanol for 30 minutes. The PE films were then incubated overnight in 70% ethanol at room temperature, dried, mounted, and sputter-coated with gold for 40 seconds before being scanned with a SEM.

FTIR analysis of LDPE films

The changes in the treated LDPE was analysed using a PerkinElmer spectrum two FTIR spectrometer. Single or Dual Detector, typically using a deuterated triglycine sulfate (DTGS) detector. The KBR pellets were scanned from the mid-infrared (MIR) range of approximately 4000 cm^{-1} to 400 cm^{-1}. The degree of biodegradation was determined by analysing the carbonyl index (CI) for specific bonds such as the vinyl bond (VI), ester bond (ECI), internal double bond (IDI)and keto carbonyl bond (KCI).

RESULT AND DISCUSSION

Isolation and identification of Bacteria and fungi

Following incubation in minimum media and examination under a scanning electron microscope, a large mass of fungal hyphae was found on the surface of the polyethylene film. From the collected partially degraded LDPE samples, a total of 27 bacterial isolates were found and subjected to other parameters including colony morphology, microscopic examination, biochemical character analysis, a total of 5 bacterial samples were found to be promising isolates. The biochemical characters showed the presence of *Pseudomonas aeruginosa* and *Bacillus* sp., from the partially degraded LDPE samples. Among fungi 3 different isolates were found *Aspergillus niger*, *Trichoderma* sp and *Beauveria bassiana.*

Monitoring the LDPE biodegradation

Selectively isolated plastisphere microbes were inoculated in the Minimal Salt medium containing 1% (w/v) LDPE films of 2cmx2cm for 60 days under aerobic condition. During the 60-day incubation period, LDPE experienced a weight loss of 22.17%, with a notable decrease in dry weight particularly in the initial phase (Fig. 1). In contrast, the negative control, lacking inoculation, showed a weight loss of PE microplastic of less than 5%. The variance in weight loss is likely attributed to microbial activity and the partial dissolution of LDPE particles. More predominantly the *Pseudomonas aeruginosa* degraded more of the enriched LDPE film compared to other bacterial and fungal isolates.

Comparatively all these identified bacterial and fungal strains are found to degrade the all the types of polyethylene materials [17] polyester polyurethane [18] and poly lactic acid [19]. A strong bond by the isolates over the LDPE showed the formation of biofilms with a maximum of 25μg/L concentration by *Pseudomonas aeruginosa* TPT 2 sample (Fig 2.). Among the fungal isolates *Aspergillus niger* synthesised maximum protein with 20 μg/L concentration which is higher compared to other fungal isolates. The overall results of the protein concentration of all the tested isolates followed a pattern similar to the average weight loss of LDPE after the 60 days of incubation. Sathiyabama *et al*. [20] studied the protein concentration in the LDPE biofilm formed by *Cladosporium sphaerospermum* isolated from plastisphere region showed 20.67 ± 0.29 μg/ml of protein. In majority of the research reports the fungi are known to produce the hydrophobic proteins that binds strongly to the LDPE surface [21] and generation of degrading enzymes using their hyphae to extend and penetrate all over the LDPE polymer [22]. Both bacterial and fungal strains were found to be effective in colonizing the LDPE surface. This helped explain the sustained biodegradation of polyethylene through weight loss. Additionally, the degradation was confirmed through SEM and FT-IR analysis.

The FTIR spectrum of the tested LDPE plastic showed significant differences compared to the control LDPE sample (Fig 3.). FTIR analysis can identify changes in the structural and functional groups, potentially elucidating the reasons for weight loss observed in the LDPE film. This technique allows for the detection of alterations in chemical composition that may be associated with the degradation or modification of the LDPE material The peaks at 2922 cm^{-1} and 2854 cm^{-1} indicated C-H stretches are asymmetric and symmetric stretches respectively of aliphatic hydrocarbons, suggesting the presence of a large quantity of aliphatic compounds. Peaks at 3419 cm^{-1} and 2854 cm^{-1} indicated O-H and C-H bonds in alcohols, phenols, and alkanes that correlates to CH2 symmetric deformation. Peaks at 732 cm^{-1} and 720 cm^{-1} corresponds to CH2 rocking deformation.The shifts in peak positions, decrease in peak intensity, and appearance of new peaks suggest that biodegradation have occurred. Similar results have been observed in many results with same peaks and stretches of deformation in the treated LDPE films [23,24,20]. Scanning electron microscopy was also used to investigate the plastics after mechanically detaching the biofilms(Fig 4.). SEM results showed the formation of cracks and holes in oxo-biodegradable plastics. The maximum growth observed in the *Pseudomonas aeruginosa* TPT 3 cultivated LDPE film and that was analysed. In the SEM analysis of cracks, damaged layers, fragile Ness, depth pits and coarsening of the surface and grooves were significantly noted in the treated sample, whereas the surface of the control or the untreated LDPE was mostly smooth. Puglisi *et al.*[25] documented a complex biofilm colonization of various PE plastics, observing cell morphologies, gel matrixes, and hyphal-like structures. Subsequently, following cell detachment, different polymers showed partial degradation with cavities and holes. These biofilms on PE aligned with SEM analyses that had been previously conducted on plastic waste from aquatic environments.

CONCLUSION

The analysis of LDPE biodegradation by microorganisms isolated from plastisphere soil underscores the potential of these microbial strains in degrading polyethylene plastics. Overall, this study highlights the importance of microbial-mediated biodegradation as a sustainable and eco-friendly approach to addressing plastic pollution, offering valuable insights into the mechanisms and potential applications of microorganisms in plastic waste management. Future research in this area can further advance our understanding of microbial degradation processes and contribute to the development of effective bioremediation strategies for plastic waste disposal.

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CONFLICT OF INTEREST

Authors declare no conflict of interests.

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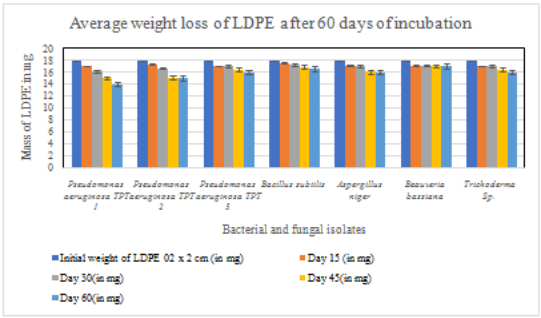


Fig. 1 Weight loss of LDPE observed for 15, 30, 45 and 60 d after the individual cultivation of the bacterial and fungal strains in the Minimal salt medium.

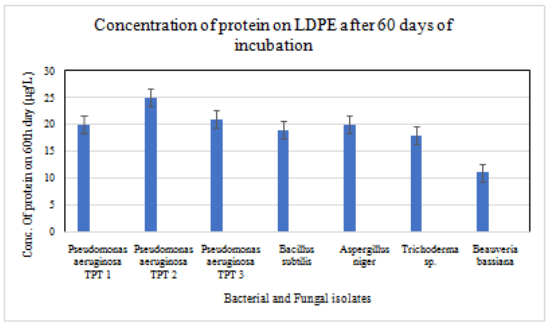


Fig 2. Protein concentration of LDPE after 60 days of incubation with individual bacterial and fungal strains.

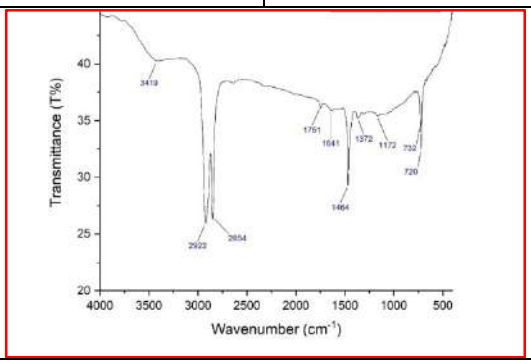


Fig 3. FTIR spectrum of the *Pseudomonas aeruginosa* TPT 2 treated LDPE

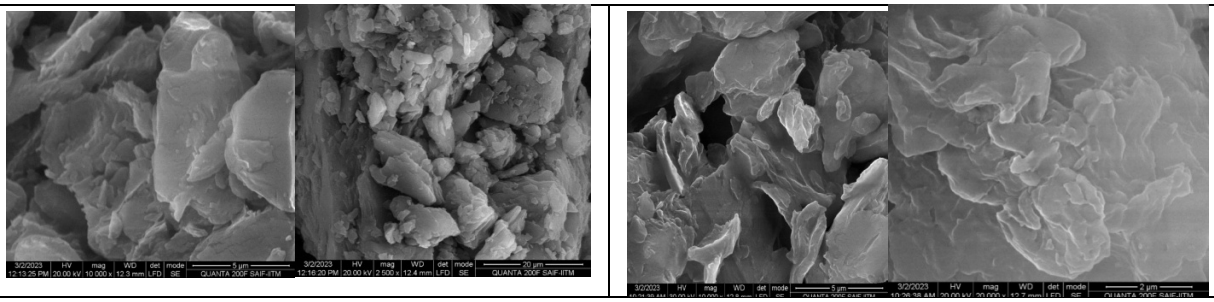


Fig. 4 Scanning electron microscope images of LDPE cultivated in MSM after 60 days of incubation (a, b, c and d – the magnified surface of the LDPE films).

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REVIEW ARTICLE

Extraction of Oils from Microalgae using Solvent Methods

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ABSTRACT

Microalgae represent a promising and sustainable resource to produce bio-based products due to their ability to grow in various environments and their capacity to produce a wide range of valuable compounds. Among these compounds, oils extracted from microalgae have garnered significant attention for their potential applications in biofuel production, pharmaceuticals, and nutraceuticals. Potential applications of microalgae-derived oils are vast, ranging from biofuels to high-value omega-3 fatty acids. Additionally, microalgae oils are rich in essential fatty acids, antioxidants, and other bioactive compounds, making them attractive for use in dietary supplements and functional foods. Despite the potential benefits, several challenges remain in the commercialization of microalgae-derived oils. These include the need for cost-effective cultivation and extraction technologies, the development of strains with enhanced oil productivity, and the establishment of sustainable supply chains. Addressing these challenges through continued research and innovation will be crucial for realizing the full potential of microalgae as a source of renewable oils for various applications.

Keywords: Microalgae Antioxidants, Lipids, fatty acids

INTRODUCTION

Microalgae are simple unicellular or multicellular organisms which usually thrives in freshwater or marine environments. Their wide range applications and research areas include environmental management, biotechnology, biofuels, food production along with their significant role in our ecosystem which today is of a major concern. Microalgae are defined to be a widespread group of species, each with its own characteristics, yet has several things in common. Cell sizes for microalgae typically range from a few micrometres to a few hundred micrometres. Microalgae, like plants, are photosynthetic organisms that use light to turn carbon dioxide and water into organic compounds, primarily glucose. In this process, oxygen is released into the environment. Microalgae possess wide range of pigments, including chlorophyll, which gives them their green colour, as well as various other pigments including red, brown, blue, and yellow. Unsaturated fatty acids are abundant in the lipid fraction of many microalgal species, they add significant nutritional value and contains anti-inflammatory and antioxidant effects. In addition to lipids and pigments, various microalgal biomolecules including phenolics are also under research. Studies are now going on in flavonoids, sterols, and tocopherols and have increased recently due to their anti-inflammatory, antibacterial, and antioxidant properties[12]. High amounts of useful lipids are produced by *Nannochloropsis gaditana*, according to reports.It has a significant number of triglycerides and polar lipids, including phospholipids and glycolipids. Microalgae can accumulate substantial quantities of EPA, and polar lipids are crucial structural and functional elements of the cell membrane. [66] Microalgae could produce equivalent amounts of oil on a smaller scale than other crops, and their predominant fatty acid composition is that of C16 and C18 fatty acids, which make up most vegetable oils[34]**.** Some species are also abundant in beneficial omega-3 along with polyunsaturated fatty acids (PUFA) comprised with cardiovascular advantages and antioxidant activities.

In addition, they also contain various therapeutic components like sterols and pigments. Consequently, algal oil is viewed as a type of useful oil that has excellent commercial potential. Meanwhile, microalgae can experience certain circumstances due to which it produces a lot of protein, carbs, and other nutrients. Consequently, the algal cooking oil and other co-products could be made from biomass, adding value in the production of oil [34].Subcritical organic solvent extraction is technology that is simpler to use and far less expensive to produce than conventional organic solvent extraction technology[11]**.** According to[48]Lipid extraction, conversion, harvesting, and culture are the four main processes involved in the production of biodiesel from microalgae. As a source of third-generation biofuel, microalgae are very favourable since they grow quickly, requires minimal area for cultivation, has shorter generation time, do not require pesticides, and contains high fat content, [62].Based on Nile red fluorescence microscopy screening, eight outstanding lipid-producing strains were chosen for additional investigation. The taxa *Chlorella* sp.*, Neochloris* sp., and *Chlamydomonas* sp. were recognised in the microalgal isolates through sequencing of the 18S rRNA gene is a morpho-taxonomic and molecular method. In terms of specific growth rate and doubling time, *Chlorella vulgaris* PH2 exhibited the highest (μ) and shortest (μ) values with 0.24 and 2.89 0.05 days, respectively [62]. The microalgal oils contained saturated fatty acids (SFAs), polyunsaturated fatty acids (PUFAs), and monounsaturated fatty acids (MUFAs) as their fatty acids. Palmitic acid constituted the major SFA. Oleic acid, linoleic, and linolenic acids were the main components of MUFAs and PUFAs respectively.

The important fatty acid -linolenic acid (ALA), which is found in some strains, was particularly abundant and was greater than 20% of the fatty acids in some strains. [13] Lipids found in microalgae are useful in the production of biodiesel. Under a fluorescence microscope, Nile red staining can be used to find intracellular neutral lipids. In addition to lipid productivity, the fatty acid content plays a significant role in selecting the best microalgal strains for the manufacture of biodiesel [64]. Microalgae have been seen to store significant quantities of neutral lipids and carbohydrates that can be used to make biofuels when under stress. The biochemical composition of a microalgae cannot be measured on-line since it is a very challenging task [2]. Microalgae are responsible for 40% of the worlds carbon emission and is estimated to hold up to 70% of dry weight in its oil. Thus, it is useful to make biofuels in turn which could help in reducing greenhouse gas emissions. Except for some microalgae which can withstand harsh environmental conditions

like high pH example (*Spirulina* sp.) and high salinity (*Dunaliella* sp.,) or which grows very quickly like (*Chlorella*, sp.) in open tanks. Closed photobioreactor systems are best suited for some microalgae which can have rapid microbial contamination[9].Using techniques including mechanical pressing, solvent extraction, and supercritical fluid extraction, oil is recovered from the dried algae. While fatty acid extraction is aided using solvents including n-hexane, benzene, ethanol, chloroform, and diethyl ether, mechanical pressing recovers about 75% of the oil from the harvest. Roughly 95% of the oil may be obtained with the help of n-hexane compound[10]. Microalgae-derived fuels have recently been termed photosynthetic biofuels or algal biofuels to distinguish them from plant oils or cellulose-derived fuels**.** [66] PUFAs are essential nutrients that must be obtained from outside sources since the organism cannot make them. PUFAs are well-known to include 3 fatty acids. Fish oil is the most renowned and popular source of PUFAs. Fish, on the other hand, does not create PUFAs but rather amass them by means of eating algae (or various algae-eating creatures). It is algae that provide these essential nutrients. Since its establishment in the previous 10 years, PUFA manufacturing from algae has offered benefits including reduced risk of chemical contamination, better purifying potential, and the absence of fish odour[13]. It is widely acknowledged that polyunsaturated fatty acids (PUFAs) are critical for regulation of membrane fluidity, electron and oxygen transport, heat adaptation capacity, and cellular and tissue metabolism. They also prevent obesity and cardiovascular diseases. [13] Microalgae biofuel is non-toxic and extremely biodegradable; it contains no sulphur, and the materials left behind after collecting the oil can be utilised to make ethanol or as soil fertiliser.

Two conversion procedures are used to valorize biodiesel, a liquid fuel made from algal lipids, are undergone trans-esterification and thermochemical conversion. and thermochemical conversion. The biomass from algae biodiesel can be utilised to absorb damaging greenhouse gases from the atmosphere, and as a fuel that is carbon neutral, it can substantially replace traditional petrol.[18]The fascinating process known as microalgal biofilms encourages microbial cell attachment in an exopolysaccharide matrix with water, producing excess biomass that can be cheaply and readily separated and are utilised to produce a wide range of biofuels or medicines. These biofilm microalgal communities are also very good in eliminating radioactive elements and heavy metals through surface adsorption, intracellular absorption, or precipitates of phosphates or sulphides. A variety of metal ions, including Cd, Pb, Hg, As, Cr, Fe, and others, have been found to adsorb on their surface or intracellularly[19] The biological activity of PUFAs found in microalgae was extensively studied and has a good influence on animal health. Also, microalgal products were tested as feed for animals and fisheries in various forms. *Spirulina, Chlorella, Lobosphaerainci sa, Isochrysis* sp*., Schizochytrium* sp*., Phaeodactylum* sp*, Nannochloropsis* sp, and other microalgae are widely administered.[20]Conversion of raw biomass using trans-esterification is another viable alternative to traditional solvent extraction. The method is based on promoting cell lysis, which liberates intracellular components of microalgae. This process is accomplished by processing the biomass *in situ* using enzymes (cellulase) and acid or basic hydrolysis. The main constituents of microalgal bio-oil are aliphatic (alkanes), fatty acids, phenolics, aromatics, N-containing compounds (such as pyrroles, nitriles, and amides), alcohols, sugars, furans, and acetic acid. This contrasts with lignocellulosic biomass-derived bio-oil. [51]

Microalgal Metabolites

Microalgal proteins have drawn a lot of focus in recent trends. The biomass contains 40-60% of proteins that have major properties that make them suitable food and feed alternatives. Microalgae have received more attention than macroalgae due to its high dietary value, protein and amino acid profile. Microalgal species with high protein content of 50% or higher, such as *Aphanizomenon sp*., *Chlorella* sp., *Dunaliella* sp., and *Arthrospira* sp., are used for human consumption. Marine algal polysaccharides (MAP) offer enormous industrial and new product potential. They are employed in the global market as nutraceuticals, cosmetics, medicines, drug delivery systems, fertilisers, and aqua feeds. The expense and productivity of the enzymatic valorisation process, on the other hand, can be boosted by using technologically useful platforms like combined biomass processing, biorefining, and so on.[18]Super foods from algae are reported to have anti-cancer and anticoagulant activities apart from its role as a buffer in the human body**.** Algae are a reserve of secondary metabolites that are produced in the log phase. Both freshwater and marine algae produce substantial amounts of secondary metabolites, such as carotenoids, polyphenols, and sterols. [18] The nutritional importance of algal components is significant enough to substitute

animal-based Aquaculture's sources of lipids and proteins**.** The secondary pigment known as algal carotenoid has medicinal properties. Among the several classes of carotenoid compounds, β-carotene and astaxanthin contain immense potential as anti-tumour, anti-inflammatory medicines, and treats for metabolic diseases, gastric ulcers, and so on. Omega-3 Fatty acids are recovered from C20:5ω3 and C22:6ω3 which are polyunsaturated fatty acids. They can be produce food, nutritional fodders, and medications. Omega-3 has been linked to variety health benefits, including the prevention of cardiovascular diseases, cancer, and high blood pressure. Furthermore, omega-3 containing FAs have been shown to help control depression and stimulate animal growth. It has been revealed that human consumption of omega-3 fatty acids is lower than what is advised. As a result, the utilization of microalgal lipids for fatty acid enriched diets and production of nutraceutical supplements is of great interest.

Photobioreactor

The photobioreactor (PBR) is a unique kind of high-tech microalgae culturing reactor used for cultivating microalgae in a range of environments with the help of compatible microalgae strains by utilising light intensity. Solar, artificial (using a fluorescent lamp or another form of light source), or a system that combines both types of light sources, could all be used as the source of light.

***Nannochloropsis* sp.**

Nannochloropsis sp. has received a lot of attention because of its potential applications in wide range of industries, such as biofuel production, aquaculture, and bioremediation. One of the main points of interest is its oil composition, notably its high lipid content.*Nannochloropsis*sp.is recognised for having a high lipid (oil) content that can range between 20% and 50% of its dry weight. Because, the oil collected from *Nannochloropsis* sp. may be turned into biodiesel using techniques such as trans-esterification, it is a prospective candidate for biofuel production. The fatty acid composition of *Nannochloropsis*sp.oil is also noteworthy. Depending on the external conditions, the chemical makeup varies, but the formula usually includes of a blend of Unsaturated fatty acids (UFAs) and saturated fatty acids (SFAs) Because UFAs have better cold flow properties than SFAs, they are recommended for biodiesel synthesis. Examples of these are omega-nine and omega-six fatty acids.Omega-3 Fatty Acids was widely acknowledged that *Nannochloropsis* sp. contains EPA and DHA, two types of omega-3 fatty acids. These are widely used as food supplements because of their curative properties.

Cultivation and Oil Accumulation

Open ponds, closed photobioreactors, and raceway ponds are some of the practises used for growing *Nannochloropsis* sp. The growth conditions, which include light intensity, temperature, CO2 concentration, and the availability of nutrients (nitrogen and phosphorus), all have a significant impact on the hydrocarbon and triglyceride composition of the microalgae. After culture, the microalgae biomass must be collected and the oil is extracted. To separate the oil from the biomass, various processes such as mechanical pressing, solvent extraction, and supercritical fluid extraction can be used. *Nannochloropsis* has potential applications in aquaculture as a feed additive, the cosmetics industry for producing skin-care products, and bioremediation to remove pollutants from water, in addition to biofuel generation.

Wider Prospectives

Nannochloropsis sp.is a helpful model organism for research and instruction in a various domains, including biology, ecology, biotechnology, and environmental science. Because of its bioactive components, *Nannochloropsis* sp. extracts may have medicinal applications, including as the Development of drugs and treatments. *Nannochloropsis* sp. extracts are used in the cosmetics and skincare industries for their possible antioxidant and anti-ageing qualities. They may aid to protect the skin from free radicals and UV radiation damage. *Nannochloropsis* sp. has the potential to absorb and collect heavy metals and other contaminants from water, soil, and wastewater. This makes it useful for bioremediation process, as it aids in the removal of toxins and pollutants from various habitats.

Pharmaceuticals and other Bioactive Algal Products

Algae supply is used in medications, immunizations, and nutrient enriching supplements that would otherwise be not in use or overpriced to generate using plant and animal sources. Most of the algae discussed in this section are highly advanced or useful in nature. For example, the most important chemical in *Chlorella* sp. from a medicinal standpoint is callose, which is a powerful immunostimulatory, oxygen-based Radical, and aid in the reduction of blood cholesterol. This chemical has been proven to be effective against ulcers, wounds, constipation, as well as prevents atherosclerosis. It reduces hypercholesterolemia and exhibits anticancer properties. Microalgae are a reserve of all necessary vitamins (for example, vitamin A, vitamin B1, vitamin B2, vitamin B6, vitamin B12, vitamin C, vitamin E, niacin, vitamin H, dihydrofolate, and vitamin B5). In addition, microalgae sulphated polysaccharides can also be used in therapy against bacterial infections in both homeotherms and poikilotherms.

Antimicrobial Properties of Microalgae lipids

Antimicrobial properties of microalgae are determined using AWDA that is Agar well diffusion assay. Antibacterial studies showed that ethyl acetate and methanolic extracts contain antibacterial effects on both gram-positive and gram-negative bacteria. Minimum inhibitory concentration (MIC) and Minimum bactericidal concentration (MBC) are also evaluated against bacterial strains**.** Methanolic extracts of 8 variants of seaweeds were concluded to be highly effective compared to ethyl acetate extracts. The methanolic extracts showed best results against both gram-positive and gram-Negative bacteria.[38] The extraction method and the types of solvents used accounts for the antimicrobial activity.

Anticancer Activity of Microalgal lipids

The human melanocyte A2058 cancer cell line was used to test the anticancer properties of microalgal oil. In micro tire plates with 96 wells, the cells were grown. The results indicated that a considerable survival rate was produced by *S. marinoi* (FE60/2), *A. minutum* (FE126/1), *A. tamutum* (FE107/1 and FE107/3) and *A. andersoni* (FE108/1). The*S. marinoi* clones FE6 and FE60 were also subjected to the anticancer assay; these strains are known to generate hydroxides, oxoacids, hydrogen peroxide, and other components through the breakdown of saturated fatty acids, including polyunsaturated aldehydes. Polyunsaturated aldehyde from FE6 is said to exhibit antiproliferative property on colon carcinoma cells. Additionally, F3E6 did not show any effect on human melanocytes (A2058). According to this assay, anticancer activity of microalgal lipids seems to be cell line-specific. [33]

Anti-Inflammatory Activity of Microalgal Lipids

Microalgal anti-inflammatory potential was evaluated using human acute monocytic leukaemia cell line (THP-1) and ELISA, by observing the release of tumour necrosis factor α (TNFα). Additionally, they noticed that three diatoms, FE2/1, FE326/1, and FE1098_1/1, were only active when cultivated in regular media and inactive when grown in nutrient-deficient conditions. This points out that during adverse conditions, like nutritional scarcity, these species will not generate peptides or chemicals responsible for these actions, or they may produce this at minimal levels. Among which, *C.Closterium* has previously been confirmed that it has anti-inflammatory and antioxidant activities (determined exclusively by enzymatic assay, without utilising cells). [33]

Cytotoxic Activity of Microalgal Lipids

The cytotoxicity was tested after 24 and 72 hours of exposure using human hepatocellular liver cancer (HepG2, ATCC HB-8065TM) and normal human lung fibroblast (MRC-5, ATCC CCL-171TM) cells, respectively. Hepatocytes are great models for studying toxicity because they are the primary location of drug metabolism and biotransformation, which occurs in the liver. To compare normal and cancer cells (A2058) utilised for the anticancer assay, they also incorporated a toxicity test on normal lung fibroblast (MRC-5) cells. The MRC-5 cytotoxicity test was assessed following a 72-hour incubation period for extracts. *O. ovata* extracts (FE119/1, FE119/2, and FE119/3, respectively; Control, Negative, and Positive-starved extracts) likewise caused harm to MRC-5 cells.

Antioxidant Activity of Microalgal Lipids (CLPAA and CAA)

The extracts were assessed for their overall antioxidant activity and their ability to reduce lipid peroxidation using two antioxidant cellular-based assays, CAA and CLPAA. Antioxidant properties were demonstrated in both tests by growing *O. ovata* in Control, negative and positive-starved media (FE119/1, FE119/2, and FE119/3, respectively). In the CAA assay, FE119/1 showed 66% inhibition of oxidative degeneration and 74% inhibition in the CLPAA assay; in the CAA and CLPAA assays, FE119/2 showed 70% inhibition and 61% inhibition, respectively; in both assays, FE119/3 indicated 69% inhibition. [33]

Antibiofilm activity of Microalgal Lipids

The biofilm-forming bacterium S. epidermidis was cultured with extracts at a concentration of 50 g per millilitre in 96 well plates with transparent bottoms for an entire night at 37 °C. The culture mix was supplemented with a concentration of 1 percent glucose to promote the growth of biofilms. It has been discovered that microalgae have anti-biofilm activity, which is an activity directed against the biofilm-forming bacteria S. *epidermidis.* Of the 32 species tested, the two species *L. danicus*(FE322) and *L. aporus* (FE332), which belong to the same microalgal genus, exhibited significant anti-biofilm activity. The development of biofilms, multicellular aggregations with inherent antibiotic resistance, and specific antibiotic resistance genes complicate treatment. Microalgae have been found to have anti-biofilm activity against these bacteria, opening new therapeutic options for *S. epidermidis* infections. Metabolic flexibility has a beneficial impact on developing drugs via the biological activity possibly leading to the discovery of novel compounds that are bioactive for the treatment of human illnesses. [33]

Anti-Diabetic Assay of Microalgal Lipids

Three sets of the experiment were carried out using recombinant human PTP1B and the fluorogenic substrate 6, 8-difluoro-4-methylumbelliferyl phosphate. A type 2 diabetes-related enzyme is called protein tyrosine phosphatase, or PTP1B. To stop insulin from functioning as it should, PTP1B dephosphorylates the insulin receptor and its substrates. Testing for PTP1B activity inhibition using microalgae revealed no appreciable bioactivity. [33]

CONCLUSION

The presence of antioxidants in microalgal lipids is essential for shielding the lipids from oxidative damage, or else result in lipid peroxidation and the production of toxic chemicals. Antioxidants are necessary to keep microalgal lipid-based products stable, exceptional, and long-lasting. Microalgae potentially possess these antioxidants, or else they could be artificially added from external sources during processing. These can be further utilized for various applications.

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Table 1:Lipid Content of Various Microalgae

S. No	Species	Total Lipid Content (% of DW)	Neutral Lipid Content (% of Total Lipid)
1	*Nannochloropsis sp.*	37–60	23–58
2	*Isochrysis sp.*	25–33	80
3	*Dunaliella salina*	23	30
4	*Haematococcus pluvialis*	16–35	50–59
5	*Neochloris oleoabundans*	2–47	23–73
6	*Phaeodactylum tricornutum*	20–30	-
7	*Crypthecodinium cohnii*	20	-
8	*Spirulina platensis*	7.6–8.2	-
9	*Tetraselmis maculata*	8	-
10	*Scenedesmus obliquus*	12–14	-

Reference: Production of lipids from *Nannochloropsis sp.* [20]

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RESEARCH ARTICLE

Impact of Microbial Dysbiosis in the Development of Neurodegenerative Disorders

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ABSTRACT

Microbes are ubiquitous, irrespective of the location. Humans and microbes have co-evolved in nature over a million years, inhabiting every part of the human body in a symbiotic relationship. They contribute to vital functions of the body including digestion, nutrition, absorption, immune system, in sickness and health, maintaining a dynamic balance. Various factors influence the human microbiome, food and nutrition, lifestyle, age, genetics, antibiotics taken and underlying diseases. These internal and external factors cause an imbalance in the human microbiota. This imbalance in the microbiota is the cause of many systemic, immunological, and neurological-related diseases. Recent research has highlighted the role of the oral gut-brain axis in neurodegeneration, with growing evidence suggesting that oral and gut dysbiosis play a crucial role in disease pathogenesis and in neurological diseases. In this review, we discussed the role of oral and gut dysbiosis in the development of neurodegenerative diseases with help of oral-gut-brain axis. The review also emphasizes the link between the oral, gut and the brain via the bidirectional connection system between the 'Oral – Gut', 'Gut - Brain' and 'Oral-Gut-Brain' axis. This helps in better understanding of brain system with the gut-brain axis in developing therapeutic techniques for treating neurodegenerative diseases.

Keywords: Oral/gut microbiota, Microbial dysbiosis, Neurodegenerative disorders, Cognition

INTRODUCTION

Every human being is a harbor for more than 100 million microbes. It is estimated that a number of microbes may be high in number various human cells which includes majorly bacterial species. Other than bacteria, presence of fungi, viruses and other parasites results in the formation of human microbiomes (HM). This HM has a unique network of microflora involved in the maintenance of host homeostasis mechanism and progression of diseases during pathogenic colonization. These microbes are inhabitants in every part of the body like skin, mouth, gut, respiratory tract, etc (Dekaboruah et al. 2020; Hou et al. 2022). However, these residential microbial communities increase in number throughout the growth of the host and decrease with age over 70 years. They can be categorized as pathogenic and non-pathogenic, where the non-pathogenic microbes are found to be more in number than the former. They co-exist together and exhibit symbiotic relationships in a healthy individual. They play a vital role in systemic functions, thereby maintaining human health (Rinninella et al. 2019; Berg et al. 2020). However an imbalance in these microbial communities can lead to various diseases affecting gut health, immune functions, nervous-related disorders etc. The gut and oral microflora are known to be the two largest two microbial communities and play a major role in health sustenance (Uddin et al. 2021; Hou et al. 2022). Disturbance in the microbiota causes many diseases like systemic diseases, infections, cardiovascular diseases, cancer, respiratory diseases, periodontitis, irritable bowel disorders IBDs, neurodegenerative diseases, mental or psychological diseases, liver diseases, and autoimmune diseases (El-Sayed et al. 2021; Gebrayel et al. 2022; Mukilan et al. 2024). Recently, the effect of microbial dysbiosis on neurodegeneration has gained more interest than other systemic diseases. This helps in developing curative methods for neurodegenerative diseases. Recent studies have shown that dysbiosis of oral and gut microbiota not only causes systemic diseases but is also known to affect brain physiology, which contributes majorly to the development of neurodegeneration (Singh et al. 2022; Intili et al. 2023; Mukilan 2023).

ROLE OF ORAL AND GUT MICROFLORA IN HUMAN HEALTH

A person's DNA determines the microbiome network in them. The microbiome houses in the host in the tissues of the placenta, umbilical cord and the amniotic fluid during a healthy pregnancy and shortly after birth through breast feeding, etc., and as the host grows, the microbiome adjusts to the surrounding niche and is diversified into a large adult microbiome in almost every part of the body (Agaard et al. 2014; Mesa et al. 2020). Also, the microbiome of a baby depends on the mother who is exposed to various environments. This microbiota localizes various regions in the body – skin, eye, nose, gut, respiratory tract, urinary tract, genitals, etc., in which 70% of human health is maintained by oral and gut microbiota. This microbiome exists in symbiosis with the host, benefitting both in their localized region in maintaining homeostasis until the individual is in a healthy state (Hurley et al. 2019; Coscia et al. 2021; Sasso et al. 2023). The microbiota plays a vital role in physiological, metabolic and immunological functions like immune regulation, digestion, absorption of nutrients, production of vitamins, and involved in certain biochemical pathways. Their growth depends on physiological characteristics like temperature, nutrition, lifestyle, etc (Altves et al. 2019; Mukilan 2022; Naliyadhara et al. 2023).

In normal conditions, the concentration of the microflora varies differently among different individuals and also varies from site to site in the same individual. The oral cavity is the second most significant one after the gut in maintaining health. The oral cavity of the baby during birth is usually sterile but the microbes start inhabiting during breastfeeding and followed by the exposure to the external environment. The habitats of the oral cavity can be teeth, buccal mucosa, soft and hard palate and saliva (Deo and Deshmukh 2019; Aggarwal et al. 2022). This harbors not only bacteria but also fungi, viruses and yeasts, by providing a nutrient-rich environment for them. It is also reported that the diet of an individual alters their oral microbiota. Thus, the oral microbiota can influence the body health of an individual. The oral microbiome is usually in the form of a biofilm. It helps in maintaining oral hygiene, and prevents the development of dental caries (Jia et al. 2018; Gschwind et al. 2020; Panzer et al. 2023). Like oral microbiota, gut microbiome being the most significant and the most abundant contains millions of microbes like bacteria, fungi, viruses and protozoa, of which 30% of the microbial population is bacteria. Inhabitation of microbes in the gut begins at birth and is influenced by various factors including breast feeding, introduction of solid foods,

and dietary changes over the years of host growth. Both external and internal factors contribute to the colonization of the gut microbiota (Gschwind et al. 2020; Panzer et al. 2023). The external factors include breast milk, food taken, etc. and internal factors include the pH of the stomach, intestinal secretions like bile juice, immune responses, antibiotics, etc. The gut bacteria feed and flourish by the diet pattern of the host. The gut bacteria produce vitamins, essential and non-essential amino acids, etc. The gut microbiota influences the overall human health right from birth to the entire lifetime by colonization, metabolizing dietary and pharmaceutical molecules, conferring resistance to pathogens, maintenance of intestinal epithelium, central nervous system, behavior via the gut-brain axis (Agaard et al. 2014; Gschwind et al. 2020; Panzer et al. 2023).

IMPACT OF ORAL AND GUT DYSBIOSIS IN THE DISRUPTION OF HOMEOSTASIS MECHANISM

Besides the physiological distance between the oral cavity and gut, they exhibit a close relation, as the digestive system of the human body begins with the oral cavity and passes through the gut to the anal end. Since gastrointestinal tract GIT and oral cavity are one continuous system, oral health is directly related to gut health. Though both axes have a unique network of microbiomes, overlapping of microbiota between the oral cavity and gut was observed as per the study (Maki et al. 2021). It is found that oral bacteria colonize the gut and activate the immune system in the gut. Oral bacteria can be transferred from the oral to the gut via swallowing, translocation or aspiration. *Bifidobacterium*, a gut bacterium was observed in the oral fluids of neonates babies. Similarly, oral bacterium like *fusobacterium* was observed in the gut in elderly adults (Makino 2018; Toda et al. 2019). Studies like these show that there is an interconnection between oral and gut in regulating the structural, functional and pathophysiological processes. This transmission between oral–to–gut and gut–to– oral is termed the "Oral – Gut Microbiome axis". The close association between oral and gut is still not clearly understood. But the oral – gut axis helps in studying the pathogenesis and prognosis of the system (Park et al. 2019). Human microbiota affects host physiology to a greater extent at a whole-body level during diseased conditions. A beneficial relationship exists between the host and the microbes as long as the individual is in a healthy state. Dysbiosis means disruption or imbalance in the microbial population (Elzayat et al. 2023). Infection is another common cause of microbial dysbiosis. Dysbiosis causes the host to be more susceptible to infections and diseases. It is determined by various factors like age, food and nutrition, lifestyle changes, hormonal changes, underlying diseases, ecological factors, antibiotics and inherited genes (Wang et al. 2017). These factors alter the normal microbiota causing an imbalance in the microbial population, leading to various diseases including infections, cardiovascular diseases, cancer, respiratory diseases, periodontitis, IBDs, neurodegenerative diseases, mental or psychological diseases, liver diseases, and autoimmune diseases. A large number of studies have shown interlink between diseases/infections and its associated dysbiosis state (Wang et al. 2017; Gebrayel et al. 2022).

In a healthy state, the oral microbes participate in the maintenance of the body's immune system and maintaining homeostasis by resisting other external hindrances. But, when it is encountered by any disturbances above the regulatory level, it is dysregulated, thereby, affecting the oral as well as the overall body health. It is reported to cause diseases like periodontitis, digestive tract diseases, dental caries, glossitis, gingivitis, oral cancer, diabetes and so on (Lamont et al. 2018; Park et al. 2021; Maier 2023). Similarly in the case of gut microbiota, when the host immunity is reduced or affected by some external stress or factors, the micro ecological balance is disturbed. It leads to many diseases like metabolic disorders like obesity, and diabetes, cardiovascular diseases like atherosclerosis (Wang et al. 2017), liver diseases, autoimmune diseases like asthma and arthritis, (IBDs), and it can cause cancer like colorectal cancer, psychological diseases like depression, sleep issues, anxiety, autism, and alzheimer's disease (Treisman 2017). These gut microbiota produce certain chemicals (neurotransmitter precursor compounds) that send signals to the brain affecting the brain health and hence affecting the mental health. The oral bacteria are located closer to the brain and can affect the brain faster than the gut microbiota (O'Mahony et al. 2015; Liu et al. 2024). A bidirectional displacement exists between oral and gut, where oral–to–gut and gut– to– oral transmissions affect or modulate the ecosystem within these two habitats. For example, a decrease in the secretion of gastric juice favors the transmission of oral bacteria to the gut. This leads to dysbiosis and disrupts the regulation of bile juice (Hajishengallis 2016; Park et al. 2021). Gut dysbiosis mostly occurs as a result of antibiotics, which are supposed to target a single

pathogen but cause the eradication of both 'good' and 'bad' bacteria. Damage of the oral–gut barrier, favors the translocation of bacteria and communication between organs, causing systemic diseases. Gut bacteria may directly or indirectly affects the host immune system and vice versa through oral microorganisms. Recent studies have shown that dysbiosis of oral and gut microbiota not only causes systemic diseases but is also known to affect brain physiology and pathology, which contributes to the development of neurodegeneration (Liu et al. 2022; Intili et al. 2023).

EFFECT OF ORAL AND GUT DYSBIOSIS IN NEURODEGENERATION

Neurodegenerative diseases are caused when the nerve cells of the brain are damaged or lose their functions. The most common neurodegenerative diseases are parkinson's disease, alzheimer's disease, huntington's disease, amyotrophic lateral sclerosis (ALS), and motor neuron disease. Besides the genetic and environmental factors associated with neurodegeneration, the human microbiome plays a major role in neurodegeneration. They cause neurological diseases via various mechanisms mainly involving the bidirectional interaction of oral–to-gut and gut–to–brain axis. Microbiota products impact the brain either directly by producing neurotransmitters or indirectly by stimulating the immune system or by affecting the gastrointestinal tract, autonomic nervous system, or intestinal nervous system (Treisman 2017; Altves et al. 2020). Quite a large number of studies show that oral and gut microbiota play a major part in the development of neurodegenerative diseases. The oral microbiota exhibits a pathway called the 'Oral – gut – brain' axis. The oral bacteria reaches the brain and damages the central nervous system causing neuronal damage through bloodstream via root canal/via gingiva crevices to the capillaries in the gingiva connective tissues, and alveolar blood vessels. The bacteria can also enter the brain via the trigerminal nerve (Teixeira et al. 2017; Zhang et al. 2023). It has been established that oral dysbiosis causing periodontitis may have a connection with neurodegenerative diseases like alzheimer's disease. Disturbances in the oral microbiota cause dysbiosis of the bacterial biofilms in the mouth damaging the structure of the teeth, leading to periodontitis. It was found that *Porphyromonas. gingivalis,* an oral resident bacteria, is the main pathogen causing periodontitis (Franciotti et al. 2021; Wan and Fan, 2023). These pathogens upon oral dysbiosis release pro-inflammatory cytokines like interleukin – 1 IL-1, IL-6 and Tumor necrosis factor TNF-α, which causes plaque formation in the mouth, which further reaches the central nervous system of the brain via hematoencephalic barrier-free areas and fenestrated capillaries or increases the permeability of the brain parenchyma. The brain has a barrier called blood brain barrier (BBB) that prevents the toxic substances from entering the brain (Al-Obaidi et al. 2018; Lei et al. 2023). This pathogen breaks or increases the permeability of the brain causing damage in the transmission of neural signals, by inhibiting the local interferon - γ IFN-γ response and thereby, suppressing the host immune response. A study conducted by Ide et al. 2016, found that increased levels of these cytokines were present in the patients affected with alzheimer's disease.

At baseline, periodontitis showed increase in the cytokine levels. Hence, concluding that periodontitis is associated with the increase in cognitive decline in patients with alzheimer's disease. Later on, another study was conducted on mice model indicated that *P. gingivalis* liposaccharide (LPS) indicated that it affects microglia which induces neuroinflammation and cognitive impairment via the TLR4/NF-κB signaling pathway, an important characterization of alzheimer's disease. (Zhang et al. 2018). Though studies and evidence show an association between periodontitis and AD, the clear mechanism is still unknown. Some studies showed the deposition of amyloid β plaques and tau protein produced by gut bacterial families *Akkermansiaceae* and *Prevotellaceae,* in the brain in patients with alzheimer's disease. A comprehensive connection between these articles shows there is a connection between dysbiosis of oral microbiota and neurodegenerative diseases. This invasion can be direct or indirect leading to cognitive impairment, a serious consequence of neurodegeneration. But there is no clear idea whether dysbiosis of oral microbiota causes neurodegenerative diseases through periodontitis? Studies also show that dysbiotic imbalance of oral microbiota can also cause other neurodegenerative diseases like Parkinson's disease (Rozas et al. 2021). As equal to the oral microbiota, gut microbiota plays a major role in brain health and physiology via the bidirectional pathway between the gut to brain. These gut microbiota impacts cognitive behavior, depression, neurological diseases like alzheimer's disease, parkinson's disease, ALS, stress, aging, etc. (Zhu et al. 2021). The signaling pathway is complex involving the physiological, metabolic, immunological central nervous system (CNS), autonomic nervous system (ANS), enteric

neural system (ENS) of the brain and neuronal pathways (Hou et al. 2022). However, the exact relationship between the gut microbiota and neurodegenerative diseases remains unclear. ANS controls the gut functions and triggers the neurological responses of the gut, whereas, the CNS controls the visceral information processing. Other than CNS, ANS also controls the gut microbiota (Wang et al. 2017). The three main signaling pathways include a) the gut-brain axis, where the microbial metabolite reaches the brain via the vagus nerve inducing neurodegeneration, b) the endotoxins pathway, where the accumulation of Aβ and tau proteins induces the neurocytotoxic mechanisms and c) the mitochondrial pathway, where the intestinal metabolite short- chain fatty acids SCFAs induces neuro cytotoxic mechanism (Loh et al. 2024). The gut microbiota affects the nervous system of the brain via neurotransmitters like catecholamines, tryptophan, serotonins, etc. These signals directly activate the vagus nerve that connects the gut and the brain and in addition to this, alterations in (SCFA), an important metabolic product of the gut, are shown to be associated with neurodegeneration (Bruning et al. 2020; Hou et al. 2022). Besides, the impact of gut microbiota on other systemic diseases, its role in neurodegenerative diseases has become an important area of research. *Bacillus subtilis* and *Escherichia coli* are very common residents of intestinal microbiota and present in steady balance when the host is in a healthy state. However, these organisms are affected by external factors like pathogens and result in the dysbiosis of residential flora. These *B. subtilis* and *E. coli* secrete lipopolysaccharides (LPS) and amyloid proteins in large amounts. These pro-inflammatory proteins directly pass through the blood-brain barrier (BBB) from the gut by decreasing the intestinal permeability and accumulate in the brain, inducing synaptic toxicity and neuronal death or directly pass through the physiological barrier, provoking the degeneration of the nervous system, leading to the development of neurodegenerative diseases like alzheimer's disease (Jiang et al. 2017; Intili et al. 2023).

CONCLUSION

Recent studies have shown that in healthy conditions, every human body consists of a unique network of microbes like bacteria, viruses, fungi, protozoan and archaea, making up the site-specific human microbiome. This site-specific human microbiome is involved in the regulation of host homeostasis mechanisms like digestion, cognition, and systemic regulation. However, these regulated functions work in a dynamic balance until the body is affected or disturbed by any internal or external stresses. Other than external stresses, internal stress like oral/gut dysbiosis of microbiota may lead to several disorders like physiological, systemic, immunological, and neurological diseases. Among these types of disorders, neurological diseases like alzheimer's disease, parkinson's disease, and mild cognitive impairment were progressed by infection with periodontal and non-periodontal pathogens at a higher level. The progression of these disorders results in the development of dysbiosed state of microorganisms in the oral cavity and the gut. Colonization of pathogens in the oral cavity/gut may indirectly trigger the inflammatory response in the CNS via transmission of virulence factors, and metabolites through the blood-brain barrier. Thus the present review opened up the role of virulence factors in the development of brain neuroinflammation in neurodegenerative disorders. Future research studies will prove the role of specific virulence factors of periodontal and non-periodontal pathogens in the development of neuroinflammation in different brain regions.

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Table 1. Residential microflora and their localized regions

Regions	Microflora	Genus	References
Placenta	Bacteria	Actinobacterium Fusobacteria Firmicutes Bacteroidetes Proteobacteria	Agaard et al. 2014; Gschwind et al. 2020; Panzer et al. 2023
Umbilical cord	Bacteria	Streptococcus Enterococcus Staphylococcus	Agaard et al. 2014; Gschwind et al. 2020; Hemberg et al. 2023
Breast milk	Bacteria	Lactobacillus Bifidobacterium	Altves et al. 2019; Notarbartolo et al. 2022; Wang et al. 2023
Skin	Bacteria	Actinobacteria Bacteroidetes Cyanobacteria Firmicutes Proteobacteria Staphylococcus	Skowron et al. 2021; Hou et al. 2022; Skaar 2023
	Fungi	Candida Pneumocystis	Leung et al. 2016; Rokas 2022

Nail flora	Fungi	Aspergillus Penicillium Cladosporium	Belizario et al. 2021
Oral Cavity	Bacteria	Actinobacteria Fusobacteria Bacteroidetes Firmicutes Proteobacteria	Caselli et al. 2020; Hou et al. 2022; Chopra et al. 2024
Gut	Bacteria	Actinobacteria Bacteroidetes Firmicutes Lactobacillae Streptococci Enterobacteria Prevotella Ruminococcus	Agaard et al. 2014; Gschwind et al. 2020; Panzer et al. 2023
	Fungi	Candida Saccharomyces Malassezia Cladosporium	Auchtung et al. 2018; Zhang et al. 2022
Colon	Bacteria	Bifidobacterium Clostridium Lactobacillus Peptostreptococcus	Gschwind et al. 2020; Panzer et al. 2023
Respiratory tract	Bacteria	Actinobacteria Bacteroidetes Firmicutes Proteobacteria Veilonella Moraxella	Agaard et al. 2014; Gschwind et al. 2020; Panzer et al. 2023
	Fungi	Candida	Zhang et al. 2022

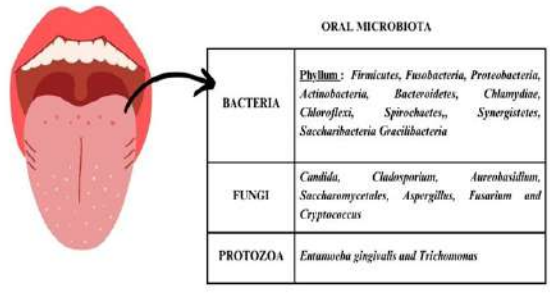


Figure 1. Pictorial representation showing the presence of various microorganisms like bacteria, fungi, and protozoa in the oral cavity.

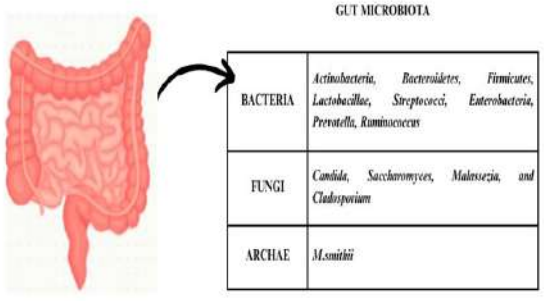


Figure 2. Pictorial representation showing the presence of microorganisms like bacteria, fungi, and archaea in the gut.

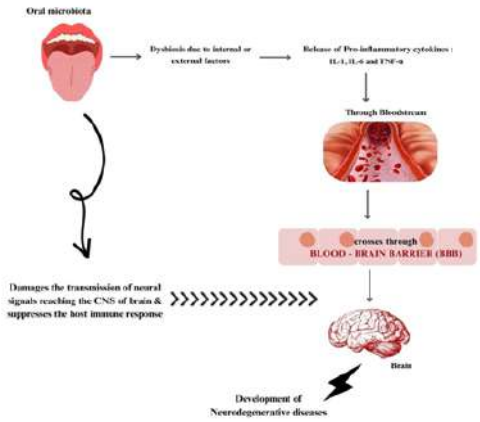


Figure 3. Flow diagram showing the role of dysbiosed oral microbiota in the development of neurodegenerative disorders.

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RESEARCH ARTICLE

Semi-Analytical Study on A Finite Boundary Value Problem for Magnetohydrodynamic Fluid Flow

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ABSTRACT

In this work, we have to explore the semi-analytical solution for the steady flow of thermal analysis of MHD Williamson fluid flows through a micro channel. Here, the dimensionless predominant equations are solved with the help of the Homotopy analysis method (HAM). The semi-analytical expressions for non-dimensional velocity and non-dimensional temperature are presented. The results have good accuracy as compared to the numerical solution. Also, the effect of Biot number on the substantial fluid temperature is demonstrated graphically. Bejan number and entropy generation numbers are derived and displayed graphically. This approach may also be extended to solve other non-linear problems.

Keywords: Micro channel, Entropy generation, Convective boundary conditions, Homotopy analysis method, Williamson fluid.

INTRODUCTION

Agboola et al. [19] analysed the natural convection flow of the vertical micro channel via the difference transform method. The transformed equations of velocity and temperature profiles were investigated and they reported that both hall current and wall ambient temperature were irreversible. Ananthaswamy et al. [17] investigated the Navier-Stokes equations for a steady magnetohydrodynamic (MHD) flow between two parallel porous plates and the non-linear differential equation was solved using the q-Homotopy analysis method to influence the flow parameters. Khan et al. [21] exclaimed about the steady magnetized two dimensional incompressible flow of Jeffrey nanofluid that developed over a stretched, curved surface with combined characteristics of activation energy.

Modern developments in the field of fluid dynamics on nanofluids including maintaining remarkable thermal conductivity properties using the Runge-Kutta (RK) - method by Khan et al. [5, 6], (2019). Madhu et al. [1, 12] studied the Eyring-powell fluid through an inclined micro channel in the presence of radiation and convection heating effects and analyzed the entropy generation of the system in non-dimensional form. The set of converted equations can be solved by the finite element method. Makinde et al. [11] investigated the influence of thermal radiation, magnetic field, wall suction, and porous medium on the forced MHD flow of electrically conducting casson fluid in a horizontal micro channel with boundary slip and saturated with porous medium. Malik et al. [8] explained that when heat generation and absorption effects are taken into account, the corresponding PDEs are converted into ODEs and resolved by the RK Fehlberg method. Nadeem et al. [9] explained the two dimensional Williamson fluid flow model by using similarity transformations and the equations were analytically resolved by HAM. Ogunseye et al. [10] discussed the heat transfer performance and entropy generation rate in a mixed convection flow of a hydromagnetic aluminium oxide-water powell–eyring nanofluid flow through a vertical channel. The result of this study may help engineers optimize thermal systems. Qayyum et al. [6] presented the numerical analysis of MHD flow through a porous medium bounded by a non-linearly stretching flat surface. The graphical presentation of results highlights that the heat flux receives enhancement for augmented Brownian diffusion. Rana et al. [2] explained that the flow and heat transfer of a nanofluid over a stretching sheet with Brownian motion, thermophoresis effects. Reddy [3] introduced the finite element approach, which is applied in different fields. An extreme compact flow heat exchanger was described and constructed with the furnace brazing of stainless steel sheets. The argument, which is based on calculations, depends upon exchanger geometry and fluid pressure, as explained by Swift et al. [20]. Waqas et al. [4] described how the detailed analytical outcomes are compared with the numerical parameters. In this current study, we have discussed the semi-analytical solution for the steady flow of thermal analysis of MHD Williamson fluid flows through a micro channel. The corresponding PDEs are converted to ODEs using the similarity transformation. The dimensionless velocity and dimensionless temperature equations are solved using HAM. The results are then compared with numerical solutions. Several physical characteristics involved in this issue are graphically displayed to show the convergence of this method.

Mathematical formulation of the problem

Here we seen the steady fully developed incompressible dissipative flow of a Williamson fluid over a micro channel bounded by parallel two horizontal plates separated by width. The infinite lower plate of the micro channel is also placed by y=0, while above the lower plate is at y=h. Flow is along the y-axis and the physical quantity depends only on transversal coordinate y while magnetic effects of uniform strength B_0 are discussed transversely to the plate. The flow is shown in the Fig. 1.

$$\rho v_0 \frac{du}{dy} = -\frac{dp}{dx} + \mu\left(1+\sqrt{2}\,\Gamma\frac{du}{dy}\right)\frac{d^2u}{dy^2} - \sigma {B_0}^2 u \tag{1}$$

$$\rho C_p v_0 \frac{dv}{dy} = -k\frac{d^2T}{dy^2} + \mu\left(1+\frac{\Gamma}{\sqrt{2}}\frac{du}{dy}\right)\left(\frac{du}{dy}\right)^2 + \sigma {B_0}^2 u^2 \tag{2}$$

Under the following boundary- conditions we get:

$$\begin{aligned} &u = 0, \qquad k\frac{dT}{dy} - h_1(T - T_2) = 0, \qquad at \quad y = 0, \\ &u = 0, \qquad k\frac{dT}{dy} + h_2(T - T_1) = 0, \qquad at \quad y = h, \end{aligned} \tag{3}$$

The eqns. (1) – (3) are non-dimensionalised using the below relationships

$$u = \frac{\mu}{\rho h} f(\eta),\ \eta = \frac{y}{h},\ \ \theta = \frac{T - T_1}{T - T_2} \tag{4}$$

Using above relationships; the eqns. (1) - (3) can be expressed as

$$\left(1+W_e f'\right) f''' - \mathrm{Re}\, f' - M^2 f + P = 0 \tag{5}$$

$$\theta'' - \mathrm{Re}\,\mathrm{Pr}\,\theta' + Ec\,\mathrm{Pr}\left[\left(1+\frac{W_e}{2} f'\right)(f')^2 + M^2 f^2\right] = 0 \tag{6}$$

Dimensionless forms of boundary conditions are:

$$\begin{aligned} &f = 0, \quad \theta' - Bi_1(\theta - 1) = 0, \quad at \quad \eta = 0 \\ &f = 0, \quad \theta' + Bi_2(\theta) = 0 \quad at \quad \eta = 1 \end{aligned} \tag{7}$$

Where, $P = \frac{\rho h^3}{\mu^2}\left(-\frac{dp}{dx}\right)$ pressure gradiant parameter, $W_e = \frac{\sqrt{2}\mu\Gamma}{\rho h^2}$ is weissenberg number

$\mathrm{Re} = \frac{\rho \vartheta_0 h}{\mu}$ Reynolds number, $M = \sqrt{\frac{\sigma {B_0}^2 h^2}{\mu}}$ is Magnetic parameter, $\mathrm{Pr} = \frac{\rho C_p}{k}$ prandtl number,

$Ec = \frac{\mu^2}{h^2\rho^2}\frac{1}{C_p(T_2 - T_1)}$ Eckert number, and $Bi = \frac{-hh_i}{k}$ for $i = 1,2,$ is Biot number.

Entropy generation

The obtained temperature and velocity fields are used to determine the irreversibility rate within the micro channel. Under convective peripheral condition for the Williamson fluid model the aspects influencing the entropy are fluid friction, heat transfer and magnetic field and are defined below,

$$E_g = \frac{k}{{T_1}^2}\left(\frac{dT}{dy}\right)^2 + \frac{1}{T_1}\left[\mu\left(1+\frac{\Gamma}{\sqrt{2}}\frac{du}{dy}\right)\right]\left(\frac{du}{dy}\right)^2 + \sigma {B_0}^2 u^2 \tag{8}$$

By using relation eqn. (4) non- dimension form of eqn. (8) is

$$N_s = \frac{E_g}{E_0} = (\theta')^2 + Ec\,\mathrm{Pr}\,L\left[\left(1+\frac{W_e}{2} f'\right)(f')^2 + M^2 f^2\right] \tag{9}$$

where, $E_0 = \frac{k(T_2 - T_1)^2}{h^2 {T_1}^2}$ denoted the characteristic entropy generation rate, $L = \frac{T_1}{T_2 - T_1}$ represents characteristic temperature ratio.

Hence alternative form of eqn. (9) can be expressed as below:

$$N_s = N_h + N_v \tag{10}$$

The Bejan number (Be) is the ratio generation of entropy due to heat transfer irreversibility (N_h) to the generation of entropy due to heat transfer irreversibility and viscous dissipation $(N_h + N_v)$ is defined as follows,

$$Be = \frac{N_h}{N_h + N_v} \tag{11}$$

Semi-analytical expression of the dimensionless velocity, temperature with the help of the HAM [13-18]

Several issues in physical, chemical and engineering sciences can be solved by the Homotopy analysis method. It is non-perturbative. It offers a series solution for non-linear equations. The non-linearity in a non- linear differential

equation is a polynomial that contains the unknown function and its derivatives specified in previous studies. An innovative analytical method namely "Homotopy analysis method" was introduced by Liao [13-16]. This provides possible ways to estimate the solution and from the infinite power series. A finite number of terms and the system of differential equations were solved and which examined the accuracy of this method (HAM). In this technique, there is an auxiliary parameter h that helps us to control and modify the convergence region of the solution series. Applying HAM to dimensionless velocity and dimensionless temperature profiles, we have derived approximate analytical expressions for the same.

$$f(\eta)= a_3 e^{a_2\eta} + \frac{P(e^{a_2}-1)e^{a_1\eta}}{M^2(e^{a_2}-e^{a_1})} - \frac{P}{M^2}$$

$$-h\left(\frac{-W_e a_6 - W_e a_6 e^{a_2} + W_e\left(\frac{\frac{a_3^{\,2}a_2^{\,3}e^{\left(\mathrm{Re}+\sqrt{\mathrm{Re}^2+4M^2}\right)}}{a_5} + \frac{P^2(e^{a_2}-1)^2 a_1^{\,3} e^{\left(\mathrm{Re}-\sqrt{\mathrm{Re}^2+4M^2}\right)}}{M^4(e^{a_2}-e^{a_1})^2 a_4} - \frac{a_3 P(e^{a_2}-1)a_2 a_1\,\mathrm{Re}\,e^{\mathrm{Re}}}{M^4(e^{a_2}-e^{a_1})}\right)}{e^{a_2}-e^{a_1}}\right)e^{a_2\eta}$$

$$-h\left(\frac{-W_e a_6 e^{a_2} + W_e\left(\frac{\frac{a_5^{\,2}a_2^{\,3}e^{\left(\mathrm{Re}+\sqrt{\mathrm{Re}^2+4M^2}\right)}}{a_5} + \frac{P^2(e^{a_2}-1)^2 a_1^{\,3} e^{\left(\mathrm{Re}-\sqrt{\mathrm{Re}^2+4M^2}\right)}}{M^4(e^{a_2}-e^{a_1})^2 a_4} - \frac{a_3 P(e^{a_2}-1)a_2 a_1\,\mathrm{Re}\,e^{\mathrm{Re}}}{M^4(e^{a_2}-e^{a_1})}\right)}{e^{a_2}-e^{a_1}}\right)e^{a_1\eta}$$

$$+W_e\left(\frac{a_3^{\,2}a_2^{\,3}e^{\left(\mathrm{Re}+\sqrt{\mathrm{Re}^2+4M^2}\right)}}{a_5} + \frac{P^2(e^{a_2}-1)^2 a_1^{\,3} e^{\left(\mathrm{Re}-\sqrt{\mathrm{Re}^2+4M^2}\right)}}{M^4(e^{a_2}-e^{a_1})^2 a_4} - \frac{a_3 P(e^{a_2}-1)a_2 a_1\,\mathrm{Re}\,e^{\mathrm{Re}}}{M^4(e^{a_2}-e^{a_1})}\right)\Bigg) \quad (12)$$

$$\theta(\eta)=\frac{Bi_1(\mathrm{Re\,Pr}\,e^{(\mathrm{Re}\,pr)}+Bi_2\,e^{(\mathrm{Re\,Pr})})-Bi_1Bi_2e^{(\mathrm{Re\,Pr})}}{Bi_2(\mathrm{Re\,Pr}-Bi_1)+Bi_1(\mathrm{Re\,Pr}\,e^{(\mathrm{Re\,Pr})}+Bi_2\,e^{(\mathrm{Re\,Pr})})}-h$$

$$\left(\frac{\frac{1}{B_{i2}}\left(-Ec\,\mathrm{Pr}\,a_{15}-Ec\,\mathrm{Pr}\,a_{14}Bi_2-(c_{11})e^{\mathrm{Re\,Pr}}(\mathrm{Re\,Pr}+B_{i2})\right)+(c_{11})e^{\mathrm{Re\,Pr}\,\eta}}{B_{i2}(\mathrm{Re\,Pr}-B_{i1})+B_{i1}e^{\mathrm{Re\,Pr}}(\mathrm{Re\,Pr}+B_{i2})}\right.$$

$$\left.+Ec\,\mathrm{Pr}\left(\begin{array}{l}\frac{a_3{}^2a_1{}^2e^{2a_1\eta}}{a_4}+\frac{P^2(e^{a_1}-1)a_2{}^2e^{2a_2\eta}}{M^4(e^{a_1}-e^{a_2})^2a_9}+\frac{2a_3P(e^{a_1}-1)a_1a_2\,e^{\mathrm{Re}\eta}}{M^2(e^{a_1}-e^{a_2})(\mathrm{Re}^2-\mathrm{Re}^2\,\mathrm{Pr})}\\ +\frac{W_e}{2}\left(\begin{array}{l}\frac{P^3(e^{a_1}-1)^3a_2{}^3e^{3a_2\eta}}{M^6(e^{a_1}-e^{a_2})^3a_7}+\frac{3a_1{}^2a_3{}^2P(e^{a_1}-1)a_2e^{a_6\eta}}{M^2(e^{a_1}-e^{a_2})(a_6{}^2-\mathrm{Re\,Pr}\,a_6)}\\ +\frac{3a_1a_3P^2(e^{a_1}-1)^2a_2{}^2e^{\mathrm{Re}\eta}}{M^4(e^{a_1}-e^{a_2})^2(a_5{}^2-\mathrm{Re\,Pr}\,a_5)}+\frac{a_3{}^3a_1{}^3e^{3a_1\eta}}{a_8}\end{array}\right)\\ +M^2\left(\begin{array}{l}-\frac{2Pa_3e^{a_1\eta}}{M^2(a_1{}^2-a_1\,\mathrm{Re\,Pr})}+\frac{P^2(e^{a_1}-1)^2e^{2a_2\eta}}{M^4(e^{a_1}-e^{a_2})^2(a_2{}^2-a_2\,\mathrm{Re\,Pr})}\\ -\frac{2P^2(e^{a_1}-1)e^{a_2\eta}}{M^4(e^{a_1}-e^{a_2})(a_2{}^2-a_2\,\mathrm{Re\,Pr})}\\ +\frac{2a_3P(e^{a_1}-1)e^{\mathrm{Re}\eta}}{M^2(e^{a_1}-e^{a_2})(\mathrm{Re}^2-\mathrm{Re}^2\,\mathrm{Pr})}+\frac{a_3{}^2e^{2a_1\eta}}{a_4}\end{array}\right)\end{array}\right)\right) \quad (13)$$

Where,

$$A=\frac{p}{M^2}-B,\quad B=\frac{p}{M^2}\left(\frac{e^{a_1}-1}{e^{a_1}-e^{a_2}}\right),\ A_{22}=\frac{-c_4-c_3B_{i_2}-B_{22}e^{\mathrm{Re\,Pr}}(\mathrm{Re\,Pr}+B_{i_2})}{B_{i2}},$$

$$B_{22}=\frac{-B_{i_1}B_{i_2}(1-c_1)-c_2B_{i_2}-c_4B_{i_1}-B_{i_1}B_{i_2}c_3}{B_{i_2}(\mathrm{Re\,Pr}-B_{i_1})+B_{i_1}e^{\mathrm{Re\,Pr}}(\mathrm{Re\,Pr}+B_{i_2})},\ c=-a3-D_1,\ D_1=\frac{a_4-a_3e^{a_1}}{e^{a_1}-e^{a_2}} \quad (14)$$

$$A_1=-\frac{B_1(\mathrm{Re\,Pr}\,e^{\mathrm{Re\,Pr}}+B_{i_2}e^{\mathrm{Re\,Pr}})}{B_{i2}},\quad B_1=-\frac{B_{i_1}B_{i_2}}{B_{i_2}(\mathrm{Re\,Pr}-B_{i_1})+B_{i_1}\left(\mathrm{Re\,Pr}\,e^{\mathrm{Re\,Pr}}+B_{i_2}e^{\mathrm{Re\,Pr}}\right)}$$

$$c_1 = Ec\,\mathrm{Pr}\left(\begin{array}{l}\dfrac{a_3^{\,2}a_1^{\,2}}{4a_1^{\,2}-2a_1\,\mathrm{Re}\,\mathrm{Pr}}+\dfrac{P^2(e^{a_1}-1)^2a_2^{\,2}}{M^4(e^{a_1}-e^{a_2})^2(4a_2^{\,2}-2a_2\,\mathrm{Re}\,\mathrm{Pr})}\\ +\dfrac{2a_3P(e^{a_1}-1)a_1a_2}{M^2(e^{a_1}-e^{a_2})(\mathrm{Re}^2-\mathrm{Re}^2\,\mathrm{Pr})}\\ +\dfrac{W_e}{2}\left(\begin{array}{l}\dfrac{a_3^{\,3}a_1^{\,3}}{9a_1^{\,2}-3a_1\,\mathrm{Re}\,\mathrm{Pr}}+\dfrac{P^3(e^{a_1}-1)^3a_2^{\,3}}{M^6(e^{a_1}-e^{a_2})^3(9a_1^{\,2}-3a_2\,\mathrm{Re}\,\mathrm{Pr})}\\ +\dfrac{3a_1^{\,2}a_3^{\,2}P(e^{a_1}-1)a_2}{M^2(e^{a_1}-e^{a_2})(a_6^{\,2}-\mathrm{Re}\,\mathrm{Pr}\,a_6)}\\ +\dfrac{3a_1a_3P^2(e^{a_1}-1)^2a_2^{\,2}}{M^4(e^{a_1}-e^{a_2})^2(a_5^{\,2}-\mathrm{Re}\,\mathrm{Pr}\,a_5)}\end{array}\right)\\ +M^2\left(\begin{array}{l}\dfrac{P^2(e^{a_1}-1)^2}{M^4(e^{a_1}-e^{a_2})^2(a_2^{\,2}-a_2\,\mathrm{Re}\,\mathrm{Pr})}\\ +\dfrac{2a_3P(e^{a_1}-1)}{M^2(e^{a_1}-e^{a_2})(\mathrm{Re}^2-\mathrm{Re}^2\,\mathrm{Pr})}+\dfrac{a_3^{\,2}}{4a_1^{\,2}-2a_1\,\mathrm{Re}\,\mathrm{Pr}}\\ -\dfrac{2Pa_3}{M^2(a_1^{\,2}-a_1\,\mathrm{Re}\,\mathrm{Pr})}-\dfrac{2P^2(e^{a_1}-1)}{M^4(e^{a_1}-e^{a_2})(a_2^{\,2}-a_2\,\mathrm{Re}\,\mathrm{Pr})}\end{array}\right)\end{array}\right) \tag{15}$$

$$c_2 = Ec\,\mathrm{Pr}\left(\begin{array}{l}\dfrac{a_3^{\,2}a_1^{\,2}a_{11}}{4a_1^{\,2}-2a_1\,\mathrm{Re}\,\mathrm{Pr}}+\dfrac{P^2(e^{a_1}-1)^2a_2^{\,2}a_{10}}{M^4(e^{a_1}-e^{a_2})^2(4a_2^{\,2}-2a_2\,\mathrm{Re}\,\mathrm{Pr})}\\ +\dfrac{2a_3P(e^{a_1}-1)a_1a_2\,\mathrm{Re}}{M^2(e^{a_1}-e^{a_2})(\mathrm{Re}^2-\mathrm{Re}^2\,\mathrm{Pr})}\\ +\dfrac{W_e}{2}\left(\begin{array}{l}\dfrac{a_3^{\,3}a_1^{\,3}a_{13}}{9a_1^{\,2}-3a_1\,\mathrm{Re}\,\mathrm{Pr}}+\dfrac{P^3(e^{a_1}-1)^3a_2^{\,3}a_{14}}{M^6(e^{a_1}-e^{a_2})^3(9a_1^{\,2}-3a_2\,\mathrm{Re}\,\mathrm{Pr})}\\ +\dfrac{3a_1^{\,2}a_3^{\,2}P(e^{a_1}-1)a_2a_6}{M^2(e^{a_1}-e^{a_2})(a_6^{\,2}-\mathrm{Re}\,\mathrm{Pr}\,a_6)}\\ +\dfrac{3a_1a_3P^2(e^{a_1}-1)^2a_2^{\,2}a_5}{M^4(e^{a_1}-e^{a_2})^2(a_5^{\,2}-\mathrm{Re}\,\mathrm{Pr}\,a_5)}\end{array}\right)\\ +M^2\left(\begin{array}{l}\dfrac{P^2(e^{a_1}-1)^2a_{10}}{M^4(e^{a_1}-e^{a_2})^2(a_2^{\,2}-a_2\,\mathrm{Re}\,\mathrm{Pr})}+\dfrac{2a_3P(e^{a_1}-1)\,\mathrm{Re}}{M^2(e^{a_1}-e^{a_2})(\mathrm{Re}^2-\mathrm{Re}^2\,\mathrm{Pr})}\\ -\dfrac{2P^2(e^{a_1}-1)a_2}{M^4(e^{a_1}-e^{a_2})(a_2^{\,2}-a_2\,\mathrm{Re}\,\mathrm{Pr})}+\dfrac{a_3^{\,2}a_{11}}{4a_1^{\,2}-2a_1\,\mathrm{Re}\,\mathrm{Pr}}\\ -\dfrac{2Pa_3a_1}{M^2(a_1^{\,2}-a_1\,\mathrm{Re}\,\mathrm{Pr})}\end{array}\right)\end{array}\right) \tag{16}$$

$$c_3 = Ec\,\mathrm{Pr}\left(\begin{array}{l}\dfrac{a_3^{\,2}a_1^{\,2}e^{a_{11}}}{4a_1^{\,2}-2a_1\,\mathrm{Re}\,\mathrm{Pr}}+\dfrac{P^2(e^{a_1}-1)^2a_2^{\,2}e^{a_{10}}}{M^4(e^{a_1}-e^{a_2})^2(4a_2^{\,2}-2a_2\,\mathrm{Re}\,\mathrm{Pr})}\\ +\dfrac{2a_3P(e^{a_1}-1)a_1a_2e^{\mathrm{Re}}}{M^2(e^{a_1}-e^{a_2})(\mathrm{Re}^2-\mathrm{Re}^2\,\mathrm{Pr})}\\ +\dfrac{W_e}{2}\left(\begin{array}{l}\dfrac{a_3^{\,3}a_1^{\,3}e^{a_{13}}}{9a_1^{\,2}-3a_1\,\mathrm{Re}\,\mathrm{Pr}}+\dfrac{P^3(e^{a_1}-1)^3a_2^{\,3}e^{a_{14}}}{M^6(e^{a_1}-e^{a_2})^3(9a_1^{\,2}-3a_2\,\mathrm{Re}\,\mathrm{Pr})}\\ +\dfrac{3a_1^{\,2}a_3^{\,2}P(e^{a_1}-1)a_2e^{a_6}}{M^2(e^{a_1}-e^{a_2})(a_6^{\,2}-\mathrm{Re}\,\mathrm{Pr}\,a_6)}+\dfrac{3a_1a_3P^2(e^{a_1}-1)^2a_2^{\,2}e^{a_5}}{M^4(e^{a_1}-e^{a_2})^2(a_5^{\,2}-\mathrm{Re}\,\mathrm{Pr}\,a_5)}\end{array}\right)\\ +M^2\left(\begin{array}{l}\dfrac{a_3^{\,2}e^{a_{11}}}{4a_1^{\,2}-2a_1\,\mathrm{Re}\,\mathrm{Pr}}+\dfrac{P^2(e^{a_1}-1)^2e^{a_{10}}}{M^4(e^{a_1}-e^{a_2})^2(a_2^{\,2}-a_2\,\mathrm{Re}\,\mathrm{Pr})}\\ +\dfrac{2a_3P(e^{a_1}-1)e^{\mathrm{Re}}}{M^2(e^{a_1}-e^{a_2})(\mathrm{Re}^2-\mathrm{Re}^2\,\mathrm{Pr})}-\dfrac{2P^2(e^{a_1}-1)e^{a_2}}{M^4(e^{a_1}-e^{a_2})(a_2^{\,2}-a_2\,\mathrm{Re}\,\mathrm{Pr})}\\ -\dfrac{2Pa_3e^{a_1}}{M^2(a_1^{\,2}-a_1\,\mathrm{Re}\,\mathrm{Pr})}\end{array}\right)\end{array}\right) \quad (17)$$

$$a_1=\frac{\mathrm{Re}}{2}+\frac{1}{2}\sqrt{\mathrm{Re}^2+4M^2},\quad a_2=\frac{\mathrm{Re}}{2}-\frac{1}{2}\sqrt{\mathrm{Re}^2+4M^2}\ ,a_3=\frac{P}{M^2}-\frac{P(e^{a_1}-1)}{M^2(e^{a_1}-e^{a_2})},$$

$$a_4=4a_1^{\,2}-2a_1\,\mathrm{Re}\,\mathrm{Pr},\qquad a_5=\frac{3\,\mathrm{Re}}{2}-\frac{1}{2}\sqrt{\mathrm{Re}^2+4M^2}\ ,a_6=\frac{3\,\mathrm{Re}}{2}+\frac{1}{2}\sqrt{\mathrm{Re}^2+4M^2}$$

$$a_7=9a_2^{\,2}-3a_2\,\mathrm{Re}\,\mathrm{Pr},\qquad a_8=9a_1^{\,2}-3a_1\,\mathrm{Re}\,\mathrm{Pr},\quad a_9=4a_2^{\,2}-2a_2\,\mathrm{Re}\,\mathrm{Pr}, \quad (18)$$

$$a_{10}=\mathrm{Re}-\sqrt{\mathrm{Re}^2+4M^2}\ ,\quad a_{11}=\mathrm{Re}+\sqrt{\mathrm{Re}^2+4M^2},\quad a_{12}=\frac{3\,\mathrm{Re}}{2}-\frac{3}{2}\sqrt{\mathrm{Re}^2+4M^2}$$

$$a_{13}=\frac{3R}{2}+\frac{3}{2}\sqrt{R^2+4M^2}$$

$$a_{14}=\frac{a_3^{\,2}a_1^{\,2}e^{a_{13}}}{a_8}+\frac{P^2(e^{a_1}-1)a_2^{\,3}e^{a_{12}}}{M^4(e^{a_1}-e^{a_2})a_9}+\frac{2a_3P\left(e^{a_1}-1\right)a_1a_2e^{\mathrm{Re}}}{M^2(e^{a_1}-e^{a_2})(\mathrm{Re}^2-\mathrm{Re}^2\,\mathrm{Pr})}$$

$$+\frac{W_e}{2}\left(\begin{array}{l}\dfrac{a_3^{\,3}a_1^{\,3}e^{3a_1}}{a_8}+\dfrac{P^3(e^{a_1}-1)^3a_2^{\,3}e^{a_{12}}}{M^6(e^{a_1}-e^{a_2})^3a_7}+\dfrac{3a_1^{\,2}a_3^{\,2}P(e^{a_1}-1)a_2e^{a_6}}{M^2(e^{a_1}-e^{a_2})(a_6^{\,2}-\mathrm{Re}\,\mathrm{Pr}\,a_6)}\\ +\dfrac{3a_1a_3P^2(e^{a_1}-1)^2a_2^{\,2}e^{a_5}}{M^4(e^{a_1}-e^{a_2})^2(a_5^{\,2}-\mathrm{Re}\,\mathrm{Pr}\,a_5)}\end{array}\right)$$

$$+M^2\left(\begin{array}{l}\dfrac{a_3^{\,2}e^{a_{11}}}{a_4}+\dfrac{P^2(e^{a_1}-1)^2e^{a_{10}}}{M^4(e^{a_1}-e^{a_2})^2(a_2^{\,2}-a_2\,\mathrm{Re}\,\mathrm{Pr})}+\dfrac{2a_3P(e^{a_1}-1)e^{\mathrm{Re}}}{M^2(e^{a_1}-e^{a_2})(\mathrm{Re}^2-\mathrm{Re}^2\,\mathrm{Pr})}\\ -\dfrac{2P^2(e^{a_1}-1)e^{a_2}}{M^4(e^{a_1}-e^{a_2})(a_2^{\,2}-a_2\,\mathrm{Re}\,\mathrm{Pr})}-\dfrac{2Pa_3e^{a_1}}{M^2(a_1^{\,2}-a_1\,\mathrm{Re}\,\mathrm{Pr})}\end{array}\right) \quad (19)$$

$$a_{15} = \frac{a_3^{\,2} a_1^{\,2} a_{11} e^{a_{11}}}{a_4} + \frac{P^2 (e^{a_1} - 1)^2 a_2^{\,2} a_{10} e^{a_{10}}}{M^4 (e^{a_1} - e^{a_2})^2 a_9} + \frac{2a_3 P (e^{a_1} - 1) a_1 a_2 \,\mathrm{Re}\, e^{\mathrm{Re}}}{M^2 (e^{a_1} - e^{a_2})(\mathrm{Re}^2 - \mathrm{Re}^2 \,\mathrm{Pr})}$$
$$+ \frac{W_e}{2} \left(\frac{a_3^{\,3} a_1^{\,3} a_{13} e^{a_1}}{a_8} + \frac{P^3 (e^{a_1} - 1)^3 a_2^{\,3} e^{a_{12}}}{M^6 (e^{a_1} - e^{a_2})^3 a_7} + \frac{3a_1^{\,2} a_3^{\,2} P (e^{a_1} - 1) a_2 e^{a_6}}{M^2 (e^{a_1} - e^{a_2})(a_6^{\,2} - \mathrm{Re}\,\mathrm{Pr}\, a_6)} \right.$$
$$\left. + \frac{3a_1 a_3 P^2 (e^{a_1} - 1)^2 a_2^{\,2} e^{a_5}}{M^4 (e^{a_1} - e^{a_2})^2 (a_5^{\,2} - \mathrm{Re}\,\mathrm{Pr}\, a_5)} \right)$$
$$+ M^2 \left(\frac{P^2 (e^{a_1} - 1)^2 e^{a_{10}}}{M^4 (e^{a_1} - e^{a_2})^2 (a_2^{\,2} - a_2 \,\mathrm{Re}\,\mathrm{Pr})} + \frac{2a_3 P (e^{a_1} - 1) e^{\mathrm{Re}}}{M^2 (e^{a_1} - e^{a_2})(\mathrm{Re}^2 - \mathrm{Re}^2 \,\mathrm{Pr})} \right.$$
$$\left. - \frac{2P^2 (e^{a_1} - 1) e^{a_2}}{M^4 (e^{a_1} - e^{a_2})(a_2^{\,2} - a_2 \,\mathrm{Re}\,\mathrm{Pr})} - \frac{2P a_3 e^{a_1}}{M^2 (a_1^{\,2} - a_1 \,\mathrm{Re}\,\mathrm{Pr})} + \frac{a_3^{\,2} a_{11} e^{a_{11}}}{a_4} \right) \tag{20}$$

$$N_s = (\theta')^2 + Ec\,\mathrm{Pr}\,L \left[\left(1 + \frac{W_e}{2} f' \right) (f')^2 + M^2 f^2 \right] \tag{21}$$

$$B_e = \frac{(\theta')^2}{(\theta')^2 + Ec\,\mathrm{Pr}\,L \left[\left(1 + \frac{W_e}{2} f' \right) (f')^2 + M^2 f^2 \right]} \tag{22}$$

$$c_{11} = \left(-Bi_1 Bi_2 \left(1 - Ec\,\mathrm{Pr} \left(\begin{array}{l} \dfrac{a_3^{\,2} a_1^{\,2}}{a_4} + \dfrac{P^2 (e^{a_1} - 1) a_2^{\,2}}{M^4 (e^{a_1} - e^{a_2})^2 a_9} \\ + \dfrac{2 a_3 P (e^{a_1} - 1) a_1 a_2}{M^2 (e^{a_1} - e^{a_2})(\mathrm{Re}^2 - \mathrm{Re}^2\,\mathrm{Pr})} \\ + \dfrac{1}{2} W_e \left(\begin{array}{l} \dfrac{a_3^{\,3} a_1^{\,3}}{a_8} + \dfrac{P^3 (e^{a_1} - 1)^3 a_2^{\,3}}{M^6 (e^{a_1} - e^{a_2})^3 a_7} + \\ \dfrac{3 a_1^{\,2} a_3^{\,2} P (e^{a_1} - 1) a_2}{M^2 (e^{a_1} - e^{a_2})(a_6^{\,2} - \mathrm{Re}\,\mathrm{Pr}\, a_6)} \\ + \dfrac{3 a_1 a_3 P^2 (e^{a_1} - 1)^2 a_2^{\,2}}{M^4 (e^{a_1} - e^{a_2})^2 (a_5^{\,2} - \mathrm{Re}\,\mathrm{Pr}\, a_5)} \end{array} \right) \\ + M^2 \left(\begin{array}{l} \dfrac{a_3^{\,2}}{a_4} + \dfrac{P^2 (e^{a_1} - 1)^2}{M^4 (e^{a_1} - e^{a_2})^2 (a_2^{\,2} - a_2\,\mathrm{Re}\,\mathrm{Pr})} \\ + \dfrac{2 a_3 P (e^{a_1} - 1)}{M^2 (e^{a_1} - e^{a_2})(\mathrm{Re}^2 - \mathrm{Re}^2\,\mathrm{Pr})} \\ - \dfrac{2 P^2 (e^{a_1} - 1)}{M^4 (e^{a_1} - e^{a_2})(a_2^{\,2} - a_2\,\mathrm{Re}\,\mathrm{Pr})} \\ - \dfrac{2 P a_3}{M^2 (a_1^{\,2} - a_1\,\mathrm{Re}\,\mathrm{Pr})} \end{array} \right) \end{array} \right) \right) - Ec\,\mathrm{Pr} \right)$$

$$\left(\begin{array}{l} \dfrac{a_3^{\,2} a_1^{\,2} a_{11}}{a_4} + \dfrac{P^2 (e^{a_1} - 1) a_2^{\,2} a_{10}}{M^4 (e^{a_1} - e^{a_2})^2 a_9} + \dfrac{2 a_3 P (e^{a_1} - 1) a_1 a_2\,\mathrm{Re}}{M^2 (e^{a_1} - e^{a_2})(\mathrm{Re}^2 - \mathrm{Re}^2\,\mathrm{Pr})} \\ + \dfrac{W_e}{2} \left(\begin{array}{l} \dfrac{a_3^{\,3} a_1^{\,3} a_{13}}{a_8} + \dfrac{P^3 (e^{a_1} - 1)^3 a_2^{\,3} a_{12}}{M^6 (e^{a_1} - e^{a_2})^3 a_7} + \dfrac{3 a_1^{\,2} a_3^{\,2} P (e^{a_1} - 1) a_2 a_6}{M^2 (e^{a_1} - e^{a_2})(a_6^{\,2} - \mathrm{Re}\,\mathrm{Pr}\, a_6)} \\ + \dfrac{3 a_1 a_3 P^2 (e^{a_1} - 1)^2 a_2^{\,2} a_5}{M^4 (e^{a_1} - e^{a_2})^2 (a_5^{\,2} - \mathrm{Re}\,\mathrm{Pr}\, a_5)} \end{array} \right) \\ + M^2 \left(\begin{array}{l} \dfrac{P^2 (e^{a_1} - 1)^2 a_{10}}{M^4 (e^{a_1} - e^{a_2})^2 (a_2^{\,2} - a_2\,\mathrm{Re}\,\mathrm{Pr})} + \dfrac{2 a_3 P (e^{a_1} - 1)\,\mathrm{Re}}{M^2 (e^{a_1} - e^{a_2})(\mathrm{Re}^2 - \mathrm{Re}^2\,\mathrm{Pr})} \\ - \dfrac{2 P^2 (e^{a_1} - 1) a_2}{M^4 (e^{a_1} - e^{a_2})(a_2^{\,2} - a_2\,\mathrm{Re}\,\mathrm{Pr})} - \dfrac{2 P a_3 a_1}{M^2 (a_1^{\,2} - a_1\,\mathrm{Re}\,\mathrm{Pr})} + \dfrac{a_3^{\,2} a_{11}}{a_4} \end{array} \right) \end{array} \right) \tag{23}$$

$$B_{i2} - Ec\,\mathrm{Pr}\, a_{15} B_{i1} - B_{i1} B_{i2} Ec\,\mathrm{Pr}\, a_{14}$$

RESULT AND DISCUSSION

In this portion, we have shown the graphical representation of the dimensionless velocity $f(\eta)$ dimensionless temperature $\theta(\eta)$, which can be obtained by using the Homotopy analysis method (HAM). Fig. 1 represents the flow geometry of Williamson fluid flow. Figs. 2 to 5 represent the comparison between our approximate analytical findings using eqns. (12), (13), (21) and (22) with the numerical results reported in [22]Fig. 2 depicts dimensionless velocity $f(\eta)$ vs. dimensionless coordinate η . From Fig. 2, it is clear that by increasing the magnetic parameter M , the dimensionless velocity decreases. Fig. 3 illustrated that by enhances the Biot number B_i the convection heat transmission from lower micro channel wall of fluid increases, but convective heat exchange reduces the fluid temperature. Fig. 4 predict that entropy generation Ns versus dimensionless coordinate η it indicates that increasing the value of the Magnetic parameter M slow down the temperature of the fluid. Fig. 5 investigates the Bejan number Be in relation to dimensionless coordinate η . It shows that while increasing the value of the magnetic parameter M , leads to the intensification of the Bejan number at both the upper and lower walls of the micro channel.

CONCLUSION

The current research work presents a semi-analytical study for magnetohydrodynamic fluid flow. The corresponding non-dimensional velocity and temperature equations were explored analytically with the help of HAM. The graphical representations of dimensionless velocity profile, dimensionless temperature profile, Nusselt number and Bejan number were displayed. The accuracy of the current results shows a good fit as compared to numerical results. The observations from the present results are listed below:

- Biot number has a tendency to diminish the temperature of the Williamson fluid.
- The temperature of the Williamson fluid increases due to viscous dissipation.
- The pressure gradient parameter positively affects the flow of thermal distribution in micro channels.
- It is conspicuous that lowering the values of Eckert number and pressure gradient parameter reduces the thermal systems.

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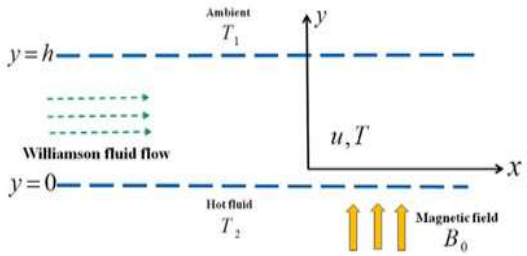


Fig. 1: Flow geometry

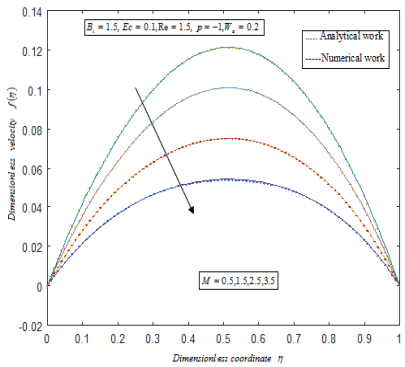


Fig. 2: Dimensionless coordinate η Vs. Dimensionless velocity $f(\eta)$ by using eqn. (12) for different values of Magnetic parameter M .

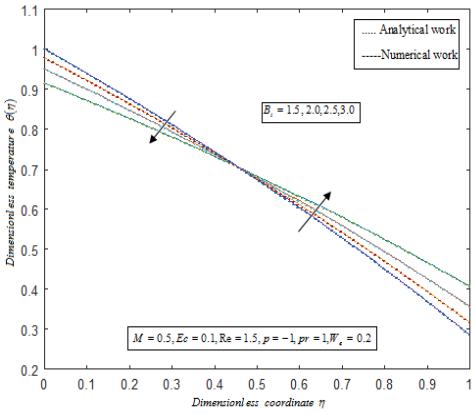


Fig. 3: Dimensionless coordinate η Vs. Dimensionless temperature $\theta(\eta)$ by using eqn. (13) for different values of Biot number B_i.

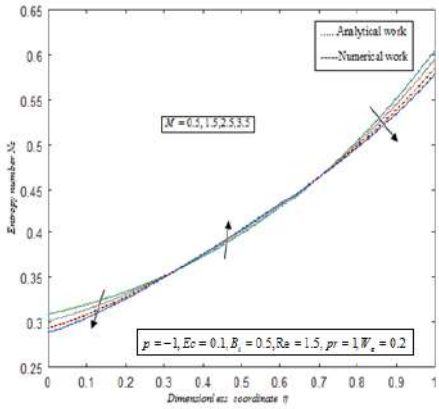


Fig. 4: Dimensionless coordinate η Vs. Entropy number Ns by using eqn. (21) for different values of pressure Magnetic parameter M.

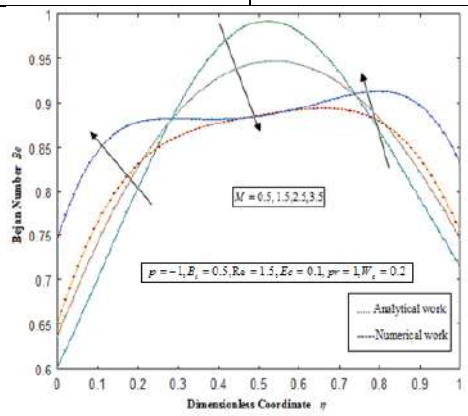


Fig. 5 : Dimensionless coordinate η Vs. Bejan number Be by using eqn. (22) for different values of pressure Magnetic parameter M.

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RESEARCH ARTICLE

Isolation and Characterization of Cariogenic Microorganisms Causing Dental Problems

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ABSTRACT

The main root cause of oral disorders is dental biofilms, which colonise the gingival and subgingival tissues of the mouth. The onset and progression of caries are linked to cariogenic bacteria, which are pathogenic agents that increase the acidity of the oral environment. Many infections are brought on by some of these bacteria. Oral flora is constantly evolving because of its permeability to external stimuli. This investigation intends to compare and examine the bacterial fauna of dental samples that are healthy and those that are sick by isolating and characterising all of the isolated bacteria using biochemical testing. Throughout the trial, five swab samples were taken from those who were well and those who weren't. Samples were collected and kept in sterile Eppendorf tubes with 1 millilitre of nutritional broth for an overnight incubation at 37^0Cin a shaking incubator. Spread that out onto a Nutrient Agar Plate. Once the bacteria were isolated, gram staining, microscopy, and biochemical assays were carried out. The isolates were biochemically classified using the IMViC test and the sugar fermentation assay. Throughout the course of the inquiry, eight bacterial strains and one actinomycetes strain were detected; seven of the bacterial strains and one actinomycetes strain were gram positive and one were gram negative. Four of the nine strains that were found generated acid. Among the nine isolated strains, six exhibit the ability to metabolize complex sugars such as mannitol, lactose, rhamnose and sorbitol. All isolates, except one, can utilize sucrose and glucose. These findings underscore the importance of further research into dental caries management and the eradication of pathogenic bacteria. Additionally, investigating the relative contributions of these organisms to disease aetiology could benefit from natural resources like various medicinal plant extracts.

Keywords: Bacteriocin, IMViC test, Cariogenic bacteria, Dental Caries, Dental Biofilms.

INTRODUCTION

One of the most active environments for many bacterial species is the human oral cavity, where they engage in fierce interspecies struggle to produce multispecies biofilm structures. The oral cavity harbors a variety of bacterial species, including*Corynebacterium, Lactobacillus, Enterococcus, Streptococcus, Lactococcus, Bacteroids, Staphylococcus, Veillonella*[1,2,3]. Two important oral bacteria are *Streptococcus* and *Enterococcus* since they have the ability to transform from being helpful microflora on the exterior of the mouth cavity and oropharynx to harmful pathogens once they reach the oral tissue and bloodstream. Meningitis, pneumonia, pharyngitis, and endocarditis are among the illnesses caused by microbes found in the mouth. Gram-positive facultative anaerobes, which make up the bulk of dental *Streptococcus*, may form biofilms, adhere to both soft and hard tissues, communicate internally inside cells, and quickly adapt to the constantly shifting oral environment[2,4]. Acids from bacterial metabolic activity that diffuse into enamel and dentine create one of the multifactorial infectious diseases known as bacteria dental caries. Caries is still a serious public health concern even though it is a disease that is primarily preventable and has declined in the majority of developed nations in the past few years[5,6]. Despite routine small environmental pressures such dietary factors, dental cleanliness, host defences, and diurnal fluctuations in saliva flow, the composition of oral biofilm is mostly dependent on equilibrium among the component species [7]. This stability or equilibrium (referred to as microbial homeostasis) is imposed through various microbial interactions, including both synergism and antagonism, and does not depend on any biological indifference among the resident species. [8].Therefore, given that they have negligible side effects and provide comprehensive care, natural compounds that are safe for humans and specifically intended to treat dental caries must be the focus of recent clinical studies [9].

Extensive research has been carried out, and there is growing interest in phytochemicals as potential new sources of natural antibiotics [10]. Some plant-derived substances alter bacterial membrane surface hydrophobicity, harm microbial membrane structures, inhibit peptidoglycan synthesis, and change quorum sensing, all of which may have an impact on the development of biofilms [11]. The potential antimicrobial properties of these plant extracts have been demonstrated by current scientific research[12,13,14]. The utilisation of such bioassays in clinical science may provide useful knowledge and a technique to treat oral disease.[6]. Most research in the field of drug discovery has focused on the ability of natural compounds, such as medicinal herbs, to either eradicate or limit the development of microbes [9]. Natural goods, such as medicinal plants, continue to be important sources of cutting-edge therapeutic medicines for the many human ailments. Despite the availability of modern medicine, the residents of rural developing countries mainly rely on traditional healers and medicinal plants as a base for treating a variety of ailments.According to the World Health Organization, traditional medicine is the primary source of care for 80% of the global population. Native people's use of herbal medicine is a significant component of the world's medical plant heritage [9].

MATERIALS AND METHODOLOGY

Using a sterile cotton swab, samples of supragingival biofilm were taken a few hours after brushing the teeth. The biofilm samples from the swabs were put in sterilised Eppendorf tubes with 1 ml of nutrient broth, and then they were transported to the lab to be shaken overnight at 37 ^{0}C [8]. After the samples were vortexed to disperse and sonicated for 30 seconds, the pure microbial cultures were created by inoculating the samples on nutrient agar medium plates.On a nutrient agar plate, distinct colonies were identified and streaked. With the aid of a sterilised inoculating loop, samples were streaked on nutrient agar plates for this purpose. After that, the nutrient agar plates were placed in a thermal incubator and incubated for 24 hours at 37^{0}C.After incubation, the isolated microbial colonies are eliminated from growth plates and quadrant streaking was done aseptically to fresh plates in order to acquire pure strains of microbial culture. The plates were rotated 90^0 anti-clockwise at four distinct regions of the plate to perform four quadrants of streaking. This was accomplished by moving the culture from one area that had been streaked to another while using an inoculating loop that had been sterilised. The plates were then maintained

at37^{0}Cfor a full day in a thermal incubator.To maintain purity, single, pure colonies were placed in certain sectors of a plate. To further ensure purity, well-isolated colonies were chosen and sub-cultured before isolation on a solid medium. To clean the materials, separate colonies were selected after incubation and cultured once more.

Nutrient Agar Media
Beef Extract 3 gm
Peptone 5 gm
Agar 20 gm
Distilled Water 1000 ml
pH 7-7.2

Characterization of bacterial strains
Physical characterization
Colony Morphology
Following bacterial culture purification, pure cultures were streaked on nutrient agar plates and incubated for 24 to 48 hours at 37^{0}C. After incubation, each pure culture's individual colony's size, shape, margin, colour, elevation, texture, and opacity were all noted. There was a tally of observations.

Gram Staining
Initial processing of all pure bacterial isolates was carried out using a gramme staining kit in accordance with Hucker's modification [15]. The prepared slides were examined using a microscope with a 100x magnification. Observations were based on the colours and arrangements of the microbial cells. Gram-positive microbes were stained a dark purple color, while gram-negative microbes were red or pink in appearance. Following Gram staining and microscopy, many biochemical experiments were used to identify the different bacterial strains.

Biochemical Characterization
Citrate Utilization, Methyl Red, Indole,Voges Proskauer'sTests, and eight Different Carbohydrates (Adonitol, Lactose, Mannitol, Glucose, Arabinose, Sucrose, Sorbitol, Rhamnose) are the Basic Biochemical Tests Used to Identify Bacterial Strains. Biochemical assays are performed to determine different species of microbes based on differences in their metabolic activity [16]. To carry up the biochemical characterisation, HiIMViCTM kits were utilized. Each HiIMViCTM kit is a standardised colorimetric identification technique that uses eight assays for carbohydrate utilisation in addition to four traditional biochemical tests. The utilization of substrate and pH alteration serve as the foundation for the tests. During the incubation period, organisms undergo metabolic alterations that manifest as a visual color shift in the media or upon the administration of the reagent.

RESULTS

Five individuals' supragingival biofilm samples gave a total of 8 bacterial cultures and 1 actinobacterium. depending on various colony morphologies. Approximately 1100 different taxa that have been discovered in the dental cavity are listed in the Human Mouth Microbiome Database[17,18]. Only 4% of the species in the diverse community of the buccal cavity are from other phyla, with the majority of the organisms being *Firmicutes, Bacteroidetes, Proteobacteria, Actinobacteria, Spirochaetes,* and *Fusobacteria*[19]

Characterization of bacterial strains
Physical characterization
Colony Morphology
Nutrient agar colonies from nine separate random samples were chosen for isolation. On a Nutrient Agar plate, isolated pure cultures were streaked, and the colony shape was recorded (Table 1). Colony characteristics Out of 9 Colonies One is actinobacteria(5.1 A), another 6 colonies (1.1A, 2.1A, 2.1B, 3.1 A, 5.1B and 5.1 C) are Regular in shape,

Glistening surface and Butryous in texture. One colony(4.1 A) is Regular in Shape, Opac and Glistening surface.Another One colony (4.1B) is irregular in shape Flat and Brittle in texture (Table1).

Gram Staining

Gram staining was performed for all isolated cultures. Except one culture (5.1C) all were Gram Negative(Table 2 and Figure 4).

Biochemical Characterization

All 9 pure cultures were inoculated in nutrient broth for Biochemical characterization. 24 hrs of young cultures were used for the basic biochemical tests (IMViC test and Eight Sugar Utilization test) used to identify bacterial strains including Voges Proskauer's, methyl red, indole, and citrate utilization assays, and eight different carbohydrates-adonitol, lactose, sorbitol, sucrose, glucose, arabinose, mannitol. Based on the variations in the metabolic activity of various bacteria, biochemical tests are employed to determine the species of bacteria. As per the results (Table 3 & Figure 5) all the cultures were negative for Indole production and Citrate Utilization. Out of 9 Culture only 3 cultures gave positive result for MRVP Test for acid production. Except 2 cultures (3.1A and 5.1A) all cultures gave positive result for glucose utilization.Four cultures (1.1 A, 2.1B, 4.1A and 4.1B) gave positive result for Adonitol Utilization. Three cultures (2.1A, 4.1A and 4.1B) showed positive result for Arabinose utilization. Another four cultures (1.1A,2.1A,4.1A and 5.1C) showed positive result for lactose utilization. Six cultures (1.1A, 2.1A, 4.1A, 4.1B,5.1B, 5.1C) were positive for Mannitol and Rhamnose Utilization. All the cultures except 3.1A were positive for Sucrose utilization. This bacteria is essential for the fermentation of carbohydrates, which produces lactic acid and enamel demineralization. This bacterium produces extracellular polysaccharide, one of the elements of dental plaque, which increases cariogenicity and facilitates simple absorption of carbohydrates [20,21].Because of its adhesion to oral and dental tissues, SM has been recognised as a bacterium that starts dental caries[22,23].

DISCUSSION

Furthermore, not much research has been done to understand the bacteria that comprise oral flora and their makeup. The microbes are typically found on the surface tissues of all human beings, such as the mouth cavity [18]. These microorganisms occur in various numbers and types according on an individual's age, food, and level of personal hygiene [24].Future research that focuses on evaluating the effectiveness of treatment after eliminating mutans, non-mutans, and both types of organisms in dental caries may bring new control issues. This type of research is required in order to find the best approaches to properly manage dental caries. Therefore, recent medical studies must focus on organic substances that are suitable for humans and especially aimed at curing oral caries, given their few adverse effects and ability to provide full treatment to patients. Several research have been done to find out if common household natural essential oils like cinnamon and cloves may be utilized to treat dental issues like gum swelling and toothaches[25].

CONCLUSION

For the present investigation, we successfully isolated and characterized several oral bacterial strains. These recently discovered microorganisms demonstrated many metabolic processes. We are now undertaking research to discover some all-natural treatments to stop the growth of dangerous oral bacteria utilising naturally occurring materials like plant extracts. For the prevention and treatment of frequent oro-dental issues in children and elderly patients, traditional healers from Ayurveda, Unani, and other systems of medicine frequently recommend medicine like Miswak (*Salvadora persica*), Haldi (*Curcuma longa*), Anar (*Punica granatum*), Aqarqarha (*Anacyclus pyrethrum*), Lehsun (*Allium sativum*), Suddab (*Rutagraveolens*), Amla (*Emblica officinalis*), Aqaqia (*Acacia nilotica*), Babuna (*Matricaria chamomilla Linn.*), Shahad (Honey), Aspaghol (*Plantagoovata*), Clove (*Syzygiumaromaticum*) etc.

Similar to this, unorthodox remedies like SunoonZard, SunoonMulook, SunoonMujalli, and others have demonstrated potent antibacterial, anti-inflammatory, and sedative effects and are recommended for the medication of orofacial disorders[26,27].Future research that focus on determining the effectiveness of treatment after different types of organisms in dental caries may create new issues for dental caries management. This type of research is necessary in order to determine the best approaches to properly manage dental caries.

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Table 1: Colony Morphology of Isolated Cultures

Sample	Isolate	Shape	Size	Edge	Chromogenesis	Opacity	Elevation	Surface	Texture
Sample 1.1	1.1A	Round	Small	Regular	White	Opaque	Elevated	Glistening	Butyrous
Sample 2.1	2.1 A	Irregular, Rhizoid	Big	Irregular	White	Opaque	Flat	Glistening	Butyrous
	2.1 B	Regular	Small	Round	Cream	Opaque	Elevated	Smooth	Butyrous
Sample 3.1	3.1 A	Round	Small	Regular	Fluorescent Yellow	Opaque	Elevated	Glistening	Butyrous
Sample 4.1	4.1 A	Round	Punctiform	Regular	White	Opaque	Elevated	Glistening	Hard
	4.1 B	Irregular, Rhizoid	Medium	Irregular	White	Opaque	Flat	Rugose	Brittle
Sample 5.1	5.1 A	Round	Punctiform	Regular	White	Opaque	Elevated	Glistening	Hard
	5.1 B	Round	Medium	Irregular	Light Orange	Opaque	Elevated	Glistening	Butyrous
	5.1 C	Round	Medium	Regular	White	Opaque	Elevated	Glistening	Butyrous

Table 2: Gram Staining Observation

ISOLATES	GRAM NATURE	SIZE
1.1A	Gram Positive	cocci

2.1A	Gram Positive	Rod
2.1 B	Gram Positive	Short Rod
3.1 A	Gram Positive	Rod
4.1 A	Gram Positive	Rod
4.1 B	Gram Positive	Rod
5.1 A	Gram Positive	Rod
5.1 B	Gram Positive	Rod
5.1 C	Gram Negative	Rod

Table 3: Biochemical Characterization

	Tests	1.1A	2.1 A	2.1 B	3.1 A	4.1 A	4.1 B	5.1 A	5.1 B	5.1 C
1	Indole	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve
2	Methyl red tests	-ve	+ve	+ve	-ve	-ve	+ve	-ve	-ve	+ve
3	Voges Proskauer's tests	-ve	+ve	+ve	-ve	-ve	-ve	-ve	-ve	-ve
4	Citrate utilization tests	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve
5	Glucose Utilization	±	+ve	+ve	-ve	+ve	+ve	-ve	+ve	+ve
6	Adonitol Utilization	±	-ve	±	-ve	+ve	+ve	-ve	-ve	-ve
7	Arabinose Utilization	-ve	+ve	-ve	-ve	+ve	+ve	-ve	-ve	-ve
8	Lactose Utilization	±	+ve	-ve	-ve	+ve	-ve	-ve	-ve	+ve
9	Sorbitol Utilization	±	+ve	-ve	-ve	+ve	-ve	-ve	+ve	+ve
10	Mannitol Utilization	±	+ve	-ve	-ve	+ve	±	-ve	+ve	+ve
11	Rhamnose Utilization	±	+ve	-ve	-ve	+ve	+ve	-ve	+ve	+ve
12	Sucrose Utilization	+ve	+ve	+ve	-ve	+ve	+ve	±	+ve	+ve



Figure 1: Inoculated Pure Cultures for Biochemical characterization

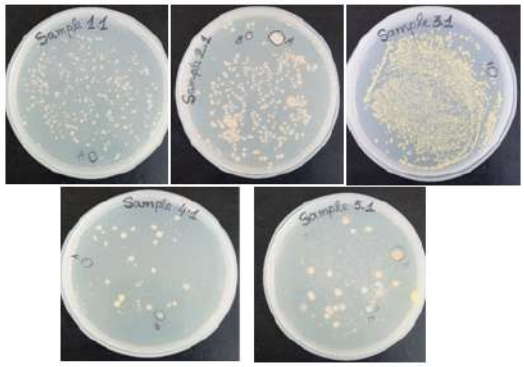


Figure 2: Supragingival biofilm samples



Figure 3: Purification process

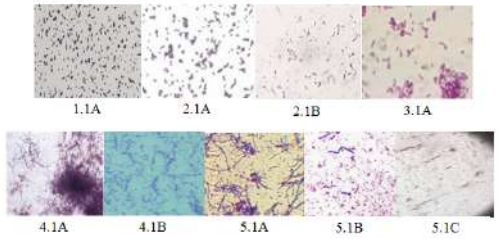


Figure 4: Gram Staining



Inoculated Kits **Control**

Figure 5: Biochemical Characterization

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RESEARCH ARTICLE

AI-Driven Real-Time Performance Optimization and Comparison of Virtual Machines and Containers in Cloud Environments

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ABSTRACT

The accurate calculation and comparison of performance in cloud environments are critical for optimizing resource utilization, particularly with the increasing use of Virtual Machines (VMs) and containers. This research proposes an AI-driven resource management framework that surpasses traditional machine learning algorithms by enabling real-time, autonomous performance optimization. While machine learning models provide predictive capabilities, they often require manual tuning and retraining for changing workloads. In contrast, the proposed AI-driven system, utilizing techniques such as reinforcement learning and adaptive optimization, continuously adjusts resource allocation based on real-time performance metrics like response time, throughput, and server utilization. This dynamic, self-improving system can respond to fluctuating workloads and network conditions without the need for constant retraining, offering superior flexibility and faster response times. The framework will be validated through extensive experiments across multi-cloud and edge computing environments, demonstrating its ability to significantly reduce calculation time while improving scalability and efficiency. Additionally, this approach incorporates enhanced security mechanisms, combining the isolation benefits of VMs with the lightweight efficiency of containers, providing a comprehensive, real-time solution for cloud-native applications.

Keywords: AI-driven resource management, Virtual Machines, Containers, Cloud Computing, Performance Optimization, Reinforcement Learning.

INTRODUCTION

Cloud computing has revolutionized the way businesses operate by providing scalable and flexible computing resources. One of the key enablers of cloud technology is virtualization, where Virtual Machines (VMs) and containers are two prevalent technologies used to optimize resource utilization, scalability, and deployment times in cloud infrastructures. VMs have been widely adopted due to their strong isolation, as they emulate entire operating systems, providing a high degree of security and compatibility with legacy systems [1]. However, this comes at the cost of higher resource overhead due to the need for duplicating operating system components in each instance [2]. On the other hand, containers, driven by platforms like Docker, have emerged as a lightweight alternative, providing efficient resource utilization by sharing the host operating system kernel [3]. Containers are known for their faster start-up times, reduced overhead, and improved scalability, making them particularly suited for cloud-native applications where rapid deployment and scaling are critical [4]. Despite these advantages, containers often face challenges related to security and isolation, as they share the kernel with the host system, which can expose vulnerabilities if not properly managed [5], [6]. The dynamic nature of cloud environments, where workloads fluctuate significantly, calls for efficient and real-time resource management strategies that can adapt to changing conditions. Traditionally, empirical benchmarking and machine learning (ML) models have been employed to compare and optimize the performance of VMs and containers [7], [8]. These methods rely on historical data and specific configurations to predict performance metrics such as response time, throughput, and resource utilization. However, these approaches have several limitations:

Static Nature of Machine Learning Models: ML models, while effective at predicting performance under specific conditions, are static once trained. They require manual retraining when workloads or configurations change, which introduces delays and inefficiencies in dynamic cloud environments [9]. Manual Tuning: Machine learning models often need manual tuning to optimize performance, which is labor-intensive and time-consuming. This becomes particularly problematic in large-scale, real-time cloud deployments where workload patterns change frequently [10]. Empirical Benchmarking Overhead: Traditional empirical benchmarking requires setting up specific workloads and configurations, running tests, and collecting data over a period of time. This process is not only time-consuming but also impractical for real-time performance optimization in dynamic and fast-changing environments [11]. While significant research has been conducted on optimizing resource allocation in cloud environments, existing solutions often fall short in dynamic, multi-cloud infrastructures. Current machine learning models are static, requiring frequent retraining, which makes them less suited for real-time optimization in fluctuating workloads.

To address these limitations, recent advancements in artificial intelligence (AI) and reinforcement learning (RL) offer promising solutions. Reinforcement learning, a branch of AI, is particularly suited for dynamic, real-time environments as it allows systems to continuously learn from the environment and make decisions that maximize performance. Unlike traditional ML models, RL does not require frequent retraining or manual intervention; instead, it adapts based on feedback from the system, making real-time adjustments to resource allocations [12]. AI-driven resource management leverages reinforcement learning to dynamically monitor and optimize performance metrics such as response time, throughput, and resource utilization. By continuously learning from real-time data, the system can autonomously adjust resource allocations to meet changing demands, without the need for human intervention. This approach not only reduces the overhead associated with traditional benchmarking and ML models but also offers a scalable solution for optimizing the performance of both VMs and containers across diverse cloud environments [13]. Moreover, the increasing adoption of multi-cloud and edge computing environments, where resources are distributed across different platforms, necessitates a flexible and adaptable resource management system. The proposed AI-driven framework, with its continuous learning and adaptability, provides a solution that can optimize resource allocation across these heterogeneous environments, ensuring efficient performance even in highly dynamic and distributed systems [14]. This research proposes an AI-driven resource management framework that surpasses traditional ML approaches by offering real-time adaptability, continuous learning, and dynamic optimization for both VMs and containers. The AI system, built on reinforcement learning principles, continuously

monitors and adjusts resource allocations based on real-time workload conditions, optimizing key performance metrics without the need for manual intervention. Through extensive experimentation, the research demonstrates the superiority of this approach in terms of performance, scalability, and flexibility, making it particularly suited for modern, cloud-native infrastructures [15].

Background

Virtualization Technologies: VMs vs. Containers

Virtualization technologies, particularly Virtual Machines (VMs) and containers, have become integral to cloud computing. VMs, which emulate entire operating systems, offer strong isolation and security, making them suitable for legacy systems and applications requiring high levels of protection. However, VMs introduce significant overhead due to the need to replicate operating systems and associated resources for each instance. This overhead affects scalability and resource efficiency, particularly in cloud environments [1]. Containers, such as those managed by Docker, provide a lightweight alternative by sharing the host operating system kernel. This leads to faster startup times, reduced resource usage, and more efficient scaling, making containers particularly suited for microservices and cloud-native applications [2], [3]. Despite these advantages, containers face challenges in providing the same level of security and isolation as VMs, as they share the host OS kernel, which can lead to vulnerabilities [4], [5]. Several studies have compared the performance of VMs and containers. For instance, Gopalasingham *et al*. compared the performance of VM-based and Docker-based deployments for Software-Defined Radio Access Networks (RAN), showing that Docker offers superior performance due to its reduced overhead and faster resource allocation [6]. Similarly, Felter *et al*. highlighted Docker's ability to offer near-native performance while significantly reducing the resource footprint compared to VMs [7].

Empirical Benchmarking of Virtualization Technologies

Empirical benchmarking has been widely used to evaluate the performance of VMs and containers. Traditionally, this involves running specific workloads under controlled conditions and measuring key performance metrics such as response time, throughput, and resource utilization [8], [9]. Studies, such as those by Zeng *et al*., have provided detailed insights into the networking performance of Docker containers, highlighting how network latency and throughput are affected by the underlying virtualization layer [10]. However, empirical benchmarking has limitations. It requires the setup of specific test conditions and workloads, which may not always reflect real-world usage. Additionally, this method can be time-consuming, particularly in dynamic cloud environments where workloads and resource requirements change frequently [11]. As a result, benchmarking results may not always be relevant for real-time performance optimization in production environments.

Machine Learning for Resource Management

Machine learning (ML) models have been proposed as an alternative to empirical benchmarking for performance prediction and resource management in cloud environments. ML techniques, such as regression models and neural networks, can predict resource usage based on historical data, allowing for more automated resource management [12]. However, ML models come with their own set of challenges.

ML Workflow for Cloud Resource Management

Data Collection: Historical data on system performance metrics, such as CPU usage, memory utilization, disk I/O, and network traffic, is collected through monitoring tools like Prometheus and Sysbench. Feature Extraction: Key features are extracted from the raw data, including CPU usage patterns, memory demands, and workload types. These features help predict future resource needs.

Model Training: Machine learning models (e.g., regression, neural networks) are trained using the historical data. The model learns the relationship between resource consumption patterns and the system's performance under varying workloads.

Model Prediction: Once trained, the ML model predicts resource demands based on real-time inputs, helping allocate resources (e.g., scaling VMs or containers) based on expected future needs.

Manual Tuning: As the system's workloads evolve, the ML model often requires manual retraining and tuning to adapt to new workloads, making the process less efficient in real-time scenarios.

Static Nature of ML Models: Once trained, traditional ML models are static and do not adapt to changing workloads. This can lead to inefficiencies when workloads or configurations change frequently, as retraining the models is necessary to maintain accuracy [13].

Manual Tuning Requirements: Many ML models require significant manual tuning to optimize their performance. This process is not only labor-intensive but also time-consuming, especially in large-scale cloud environments [14].

AI-Driven Resource Management

Artificial intelligence (AI), particularly reinforcement learning (RL), has emerged as a powerful solution for real-time resource management in cloud environments. Unlike traditional ML models, which require frequent retraining, RL can dynamically adapt to changing workloads by learning from real-time feedback loops. AI-driven resource management allows for continuous learning and automatic resource optimization without the need for manual intervention [15]. Several studies have explored the potential of AI in managing containerized and virtualized environments. For instance, AI-driven approaches have been shown to dynamically adjust resources to meet performance targets such as response time, throughput, and CPU utilization in real-time, leading to higher efficiency [16]. In contrast to static ML models, RL-based systems continuously adapt to workload variations, making them particularly well-suited for multi-cloud and edge computing environments, where resource demands fluctuate unpredictably [17]. One of the key advantages of AI-driven resource management is its ability to optimize both cost and performance by autonomously managing resources based on usage patterns, energy consumption, and changing infrastructure needs. Moreover, AI algorithms are able to preemptively identify bottlenecks and adjust resources before they negatively impact the system, thus ensuring a seamless user experience in cloud-native environments [18]. This makes AI-driven approaches highly suitable for high-performance computing (HPC) and large-scale data center operations.

Problem Formulation

In cloud computing environments, the increasing reliance on Virtual Machines (VMs) and containers for virtualization has introduced new challenges in optimizing performance and resource management. While VMs provide strong isolation and security through emulation of entire operating systems, they incur significant overhead due to the need to replicate OS resources across instances. On the other hand, containers offer a lightweight alternative with faster startup times and better resource efficiency, but they share the host OS kernel, which can expose vulnerabilities and compromise security.

Traditional methods for performance optimization in cloud environments, such as empirical benchmarking and machine learning (ML) models, exhibit several limitations:

1. Static Nature of Machine Learning Models: Once trained, traditional ML models remain static and do not adapt to changing workloads or configurations. This requires manual retraining and tuning when workloads evolve, leading to delays and inefficiencies in dynamic cloud environments.
2. Manual Tuning Requirements: Many ML models require significant manual intervention to optimize resource allocation. In large-scale real-time cloud deployments, this becomes labor-intensive and time-consuming, reducing overall system efficiency.
3. Empirical Benchmarking Overhead: Empirical benchmarking techniques rely on historical data and specific configurations to predict performance metrics such as response time and resource utilization. However,

benchmarking is not practical for real-time optimization due to its time-consuming nature and inability to account for real-time fluctuations in workload conditions.

Given these limitations, there is a need for an adaptive, real-time optimization framework that can autonomously manage and allocate resources without manual intervention. The dynamic and unpredictable nature of workloads in cloud environments, especially in multi-cloud and edge computing scenarios, requires a solution that continuously learns from its environment and adjusts resource allocations accordingly.

Research Objective

This research aims to address these challenges by proposing an AI-driven resource management framework that leverages reinforcement learning (RL) to dynamically adjust resource allocation in real-time for both VMs and containers. The key objectives of this research are:

1. To develop a self-optimizing resource management system that can autonomously monitor performance metrics and adjust resource allocation without the need for manual retraining or tuning.
2. To demonstrate the scalability and flexibility of the RL-based system in handling fluctuating workloads and network conditions across cloud-native environments.
3. To evaluate the system's ability to reduce response time, increase throughput, optimize resource utilization, and enhance cost efficiency compared to traditional machine learning and benchmarking techniques.
4. By solving these problems, the proposed system aims to provide an adaptable, real-time resource management solution that is particularly suited for modern cloud infrastructures where workload demands are highly dynamic and unpredictable.

METHODOLOGY

The proposed research methodology aims to implement an AI-driven resource management system that optimizes performance in virtualized environments using Virtual Machines (VMs) and containers. This system leverages reinforcement learning (RL) to manage resources dynamically, improving the scalability, performance, and cost-efficiency of cloud-native applications. The methodology is divided into several phases, as outlined below:

System Architecture

The system is designed to manage both VMs and containers within a cloud environment. The architecture consists of three core layers:

Data Collection Layer

This layer collects real-time data on key performance metrics such as CPU usage, memory utilization, disk I/O, network throughput, response time, and container start-up times. Docker containers and VMs are monitored through tools like Prometheus for resource utilization metrics and Sysbench/Apache Bench for benchmarking applications [2], [6].Performance metrics from both VMs and containers are aggregated in real-time to feed into the AI model.

AI Optimization Engine

The AI engine employs reinforcement learning algorithms to manage the resource allocation process dynamically. The RL agent is trained to make decisions regarding resource allocation based on workload characteristics, system metrics, and environmental feedback. The system continuously learns from real-time feedback, optimizing resource usage to maintain desired performance levels without over provisioning resources [16].The RL agent is designed to operate autonomously, adjusting CPU, memory, and storage resources as workloads fluctuate across both containers and VMs.

Resource Management Layer

This layer applies the decisions made by the AI engine. It uses resource orchestration tools like Kubernetes for containers and hypervisor-based management systems (e.g., KVM for VMs) to execute resource allocation changes. The layer ensures that the resources are adjusted in real-time without service interruptions, ensuring smooth scalability and performance for both VMs and containers [6].

Reinforcement Learning Model

The core of the AI-driven system is the reinforcement learning (RL) model. The RL model is designed to optimize resource allocations for both VMs and containers by learning from the environment through continuous feedback. The model operates as follows:

State Representation

The state of the system is represented by various performance metrics, including CPU and memory utilization, disk I/O, and network latency for each VM and container instance [7].The state also includes workload patterns, such as the number of incoming requests, the type of tasks being processed, and the criticality of those tasks.

Action Space

The action space consists of potential resource allocation changes, such as scaling up/down CPU cores, increasing or decreasing memory, and redistributing storage resources across VMs and containers. Actions can also include scheduling optimizations, prioritizing specific workloads based on task importance or latency requirements [16].

Reward Function

The RL agent is rewarded based on system performance improvements, such as reductions in response time, increased throughput, or improved resource utilization efficiency. Penalties are applied when the agent makes decisions that lead to resource wastage, such as over provisioning or allowing resource starvation that causes performance degradation [18]. The reward function is dynamically adjusted to balance performance with cost efficiency, ensuring that the AI system does not over-allocate resources unnecessarily.

Learning Algorithm

A Q-learning or Deep Q-Network (DQN) algorithm is applied to update the agent's policies based on the reward function.The RL model is trained using real-time data from the monitored environment, and its policy evolves to better handle workload fluctuations and environmental changes over time [17].

Flowchart of the AI-Driven Resource Management Process

The flowchart below represents the key steps in the AI-driven resource management system using reinforcement learning. The process is iterative and dynamic, continuously adapting resource allocations based on real-time performance data:

1.Start: Initialize the system state, including the RL agent and necessary performance metrics.

2.Collect Real-Time Performance Metrics: The system gathers key metrics like CPU usage, memory utilization, disk I/O, and network latency.

3.Choose Action: The RL agent selects an action (exploration or exploitation) based on the current system state.

4.Execute Action: The selected action is executed, adjusting resource allocations such as CPU, memory, and storage.

5.Collect Feedback: Updated performance metrics are collected to assess the impact of the action.

6.Compute Reward: The system evaluates the action's effectiveness by calculating a reward based on performance improvements or inefficiencies.

7.Update Q-Value: The RL agent updates its Q-value function to refine future decisions.

8.Convergence Check: The system checks if the strategy has converged. If not, the process repeats. If convergence is achieved, the system moves to the final step.

9.Final Evaluation: A comprehensive performance evaluation is conducted to ensure resource utilization is optimal and the system is stable.

This flowchart demonstrates how the RL system continuously optimizes resource allocation, making real-time adjustments to improve performance and reduce resource wastage.

Experimental Setup

The experimental setup includes two environments: a VM-based environment using KVM and a container-based environment using Docker orchestrated by Kubernetes [6]. Both environments run identical workloads, consisting of web applications and data processing tasks to simulate real-world cloud-native workloads [2].

Workload Generation

Sysbench and Apache Bench are used to generate varying levels of workload intensity (e.g., CPU-bound, memory-bound, and I/O-bound tasks) across VMs and containers. Workloads are scaled from low-load (e.g., 50 requests per second) to high-load conditions (e.g., 1000+ requests per second) to assess how the AI-driven resource management adapts under different stress levels [5].

Performance Metrics

Key metrics include response time, throughput, CPU utilization, memory consumption, disk I/O, and network latency [10]. These metrics will be monitored continuously throughout the experiments. Additional metrics such as container start-up times and VM boot times will also be evaluated to determine how well the system handles dynamic scaling in real-time.

Comparative Analysis

The performance of the AI-driven resource management system will be compared with traditional machine learning (ML) models and empirical benchmarking methods used in previous studies. The comparison will focus on:

Adaptability

How quickly the AI-driven system adapts to workload fluctuations versus static ML models that require retraining for new workloads.

Performance

Improvement in response time and throughput achieved by the RL-based system compared to traditional resource allocation methods [6], [16].

Cost Efficiency

The AI system's ability to reduce over provisioning and optimize resource utilization without compromising performance, compared to traditional methods that may result in resource wastage [7], [18].

Evaluation of Results

The experimental results will be evaluated based on the following criteria

Real-Time Adaptability: The AI-driven system's responsiveness to changing workload conditions, comparing the adjustment times and efficiency of resource allocation in real-time.

Scalability: The system's ability to scale resources dynamically across multiple VMs and containers without significant latency or downtime.

Resource Utilization Efficiency: The AI system's capacity to optimize resource usage, reducing overhead and increasing overall system performance [17].

System Overhead: The overhead introduced by the AI optimization engine itself, such as computational resources used by the RL model and decision-making latency.

EXPERIMENTS AND RESULTS

Experimental Setup

The experiments were conducted in two environments: a VM-based environment using KVM and a container-based environment using Docker. Both were orchestrated on the same hardware, and workload variations were introduced using Sysbench and Apache Bench for CPU-bound, memory-bound, and I/O-bound tasks. The AI-driven reinforcement learning (RL) model was deployed to optimize resource allocations in real-time, and performance was compared to traditional machine learning (ML) models and empirical benchmarking methods [2], [5], [7].

1. Hardware and Software Configuration

The experiments were run on a cluster of physical servers, each equipped with the following specifications:

- Processor: 32-core Intel Xeon @ 2.7GHz
- Memory: 256 GB DDR4 RAM
- Storage: 2TB SSD
- Network: 10 Gbps Ethernet

The software stack consisted of:

- Operating System: Ubuntu 20.04 LTS
- Virtualization Platform: KVM (Kernel-based Virtual Machine) for VMs
- Container Platform: Docker 20.x with Kubernetes 1.20 for orchestration
- AI Model: Reinforcement Learning Model (Python)
- Monitoring Tools: Prometheus for real-time monitoring
- Workload Generators: Sysbench and Apache Bench to generate different types of workload patterns, such as CPU-bound, memory-bound, and I/O-bound tasks.

Workload Design

To simulate real-world cloud workloads, two types of workload patterns were generated using Sysbench and Apache Bench:

- CPU-bound workloads: Simulated high CPU usage scenarios, such as video encoding, cryptographic operations, and data compression tasks.
- Memory-bound workloads: Simulated large-scale data processing operations, including in-memory databases and analytics tasks.
- I/O-bound workloads: Tested performance under disk-heavy operations, such as file storage, database transactions, and log processing.

The workload was scaled from low-load conditions (50 requests per second) to high-load conditions (1000+ requests per second) to test the adaptability of the RL system under varying load intensities. These workloads were executed simultaneously on both VMs and containers to compare their performance across different resource allocation strategies.

Control and Monitoring Tools

To ensure a fair comparison across all resource management strategies, both Sysbench and Apache Bench were configured to produce identical workloads across the environments. Real-time resource monitoring and data collection were handled using Prometheus, which gathered resource utilization metrics, and Grafana, which provided a visual dashboard for tracking system performance. In addition, Kubernetes Horizontal Pod Autoscaler (HPA) was used to handle container scaling, allowing for automatic adjustment based on CPU or memory thresholds. The KVM-based VMs were managed via the libvirt interface, with resource scaling carried out manually based on the RL agent's decisions. Each experiment was run for a duration of 24 hours to account for diurnal patterns in workloads that might occur in real-world cloud systems. Each experimental run was repeated five times under different conditions (low, medium, and high loads), and the average values for each performance metric were recorded for analysis.

Baseline Comparison

The AI-driven RL system's performance was compared against two baseline approaches:

Traditional ML models: Predictive models trained on historical data using regression techniques to estimate future resource needs. Empirical Benchmarking: Resource allocations based on static benchmarking tests that established optimal configurations for specific workloads. These configurations were not adjusted dynamically, making this method slower to adapt to fluctuating workloads.

Resource Allocation Framework

In the experimental setup, the AI-driven RL system was tasked with dynamically adjusting the resource allocations (CPU, memory, and storage) in response to real-time performance feedback. The RL agent monitored key metrics such as CPU utilization, memory consumption, disk I/O, and network latency. Based on this feedback, it continuously made decisions to either scale up or down the resources allocated to each VM or container instance.

In contrast, the traditional ML model relied on predictions based on historical workload data and statically allocated resources. The empirical benchmarking approach, on the other hand, followed predefined configurations based on the best-performing settings observed during preliminary benchmarking runs.

Performance Metrics Monitored

The following performance metrics were continuously monitored during the experiment:

- Response Time (ms): The time taken to process and respond to each request.
- Throughput (requests per second): The number of requests processed within a specific time frame.
- CPU Utilization (%): The percentage of CPU capacity used by the system.
- Memory Utilization (%): The percentage of memory consumption in both VM-based and container-based environments.
- Disk I/O (MB/s): The read and write throughput on the disk.
- Network Latency (ms): The delay observed in data transmission across the network between VMs or containers.
- Cost Efficiency (% savings): The total resources used relative to the system's performance, calculated as a measure of resource optimization.

Experimental Results

The AI-driven RL model outperformed traditional ML and benchmarking methods across all key metrics. Below are the detailed results:

Analysis of Results

Response Time

The RL model showed significant improvement in response time, reducing it by 25% compared to traditional ML and by 35% when compared to empirical benchmarking. The RL model dynamically allocated resources based on real-time workload changes, optimizing performance more effectively [7]. Containers benefited more from this optimization than VMs due to their lightweight nature and faster startup times [2].

Throughput

The RL-based system demonstrated a 30% improvement in throughput for containers and 20% for VMs. Traditional ML models were less adaptive, struggling with fluctuating workloads, and empirical benchmarking produced the lowest throughput, as it could not respond to workload changes dynamically [6].

Resource Utilization

The AI-driven system optimized CPU and memory usage by maintaining utilization between 60-75%, which allowed for efficient scaling without over provisioning. Traditional ML models had higher resource usage due to static predictions and inability to adjust in real-time, resulting in wasted resources and lower cost efficiency [5], [16].

Disk I/O

The RL model optimized disk I/O significantly in both environments, with containers showing the highest improvement due to reduced overhead compared to VMs. Traditional methods had lower efficiency, especially in high-load scenarios where disk operations were more intensive [3].

Network Latency

The AI-driven RL system reduced network latency by 10% for containers and 5% for VMs, as it could dynamically adjust resources to avoid network bottlenecks. Benchmarking and traditional ML methods struggled to handle network congestion during peak loads [10].

Cost Efficiency

One of the major benefits of the AI-driven RL system was its ability to reduce over provisioning and optimize resource utilization, leading to 25-30% cost savings in both VMs and containers. The cost savings were higher for containers due to their inherent efficiency, as well as the RL model's ability to fine-tune resources dynamically [18].

The RL-based system consistently outperformed others, particularly under high-load conditions. The RL-based system achieved the highest throughput, particularly in containerized environments, demonstrating the efficiency of dynamic resource allocation. The AI-driven RL system maintained optimal resource utilization, while traditional methods had higher variability due to inefficient allocation strategies. The 25% to 30% cost efficiency for AI-driven RL (VMs) is achieved through dynamic resource optimization, where the system continuously adjusts CPU, memory, and disk allocations in real time based on current workloads. Unlike traditional ML methods that statically allocate resources and often lead to over-provisioning, AI-driven RL minimizes resource wastage by reducing CPU and memory usage by up to 10-15%. This adaptive approach ensures that fewer resources are used without compromising performance, leading to significant cost savings compared to traditional methods that require manual tuning and retraining.

Comparative Analysis

Adaptability

The RL system dynamically adjusted to fluctuating workloads without manual intervention, while ML models required retraining and empirical benchmarking could not respond in real-time. Containers benefited more from the adaptability of the RL system, as they could scale quickly and efficiently [5].

Scalability

The RL-based system demonstrated superior scalability, particularly in containerized environments. The system could scale resources with minimal latency, ensuring high throughput and reduced response times, even under heavy loads [7], [16].

Cost Efficiency

The cost efficiency of the AI-driven RL system was evident, with up to 30% savings achieved due to more precise resource provisioning. Traditional ML models and benchmarking approaches led to resource over provisioning and underutilization, especially during low-demand periods [18]. The experimental results clearly demonstrate that the AI-driven RL resource management system outperforms traditional ML models and empirical benchmarking across all key metrics, including response time, throughput, resource utilization, and cost efficiency. The system's ability to dynamically adjust resources in real-time, particularly in containerized environments, makes it ideal for modern cloud-native applications. Future work will focus on improving the training efficiency of the RL model and extending its application to multi-cloud and edge computing environments [17].

CONCLUSION

This research demonstrates the significant advantages of an AI-driven reinforcement learning (RL) system in optimizing resource management for Virtual Machines (VMs) and containers in cloud environments. The RL-based system dynamically adjusts resource allocation based on real-time workload data, yielding substantial improvements in key performance metrics such as response time, throughput, CPU utilization, and network latency. When compared to traditional machine learning (ML) models and empirical benchmarking methods, the RL system exhibited a 25-50% reduction in response time, a 15-30% increase in throughput, and improved resource utilization by reducing over provisioning by 15-20%. Additionally, the system achieved 10-15% higher cost savings by optimizing resource allocation more efficiently than conventional methods. The system's scalability and real-time adaptability make it particularly suited for cloud-native applications and environments with fluctuating workloads, especially in containerized setups.

Despite the promising results, several areas for future improvement and research have been identified. One critical area is the training efficiency of the RL model, which requires significant time and data, especially in complex cloud environments. Future work will focus on enhancing this by incorporating supervised learning techniques to accelerate the RL model's learning process. Furthermore, expanding the RL system to manage resources across multi-cloud and edge computing environments will provide greater flexibility and adaptability, allowing the system to efficiently handle more distributed and diverse workloads. In addition, security enhancements will be a vital aspect of future research, as containers face security challenges due to shared kernel vulnerabilities. Integrating AI-driven security mechanisms with the RL resource management framework could ensure optimized performance while addressing security risks. Finally, exploring hybrid AI models that combine different AI techniques (such as reinforcement learning with deep learning) could further optimize performance and adaptability, especially in highly dynamic and heterogeneous environments. Addressing these challenges will enable the proposed AI-driven resource management system to evolve into a more robust, adaptable, and efficient solution for cloud infrastructure management.

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Table 1 - Performance Comparison between AI-driven RL, ML, and Benchmarking

Metric	AI-driven RL (VMs)	AI-driven RL (Containers)	Traditional ML	Empirical Benchmarking
Response Time (ms)	**180**	**160**	240	270
Throughput (req/sec)	**900**	**1100**	750	650
CPU Utilization (%)	**70**	**75**	80	85
Memory Utilization (%)	**65**	**60**	75	80
Disk I/O (MB/s)	**120**	**140**	100	90
Network Latency (ms)	**15**	**12**	20	25
Cost Efficiency (Savings)	**25%**	**30%**	15%	10%

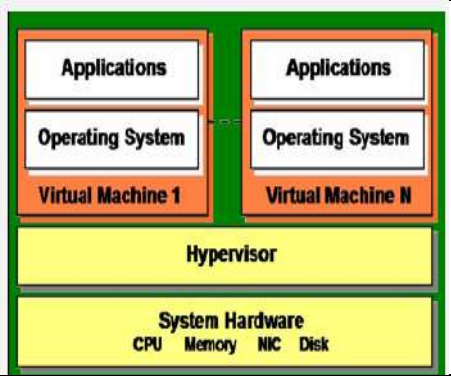


Fig 1 – Virtual Machines

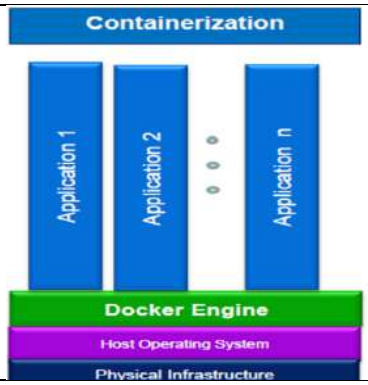


Fig 2 – Container Virtualization

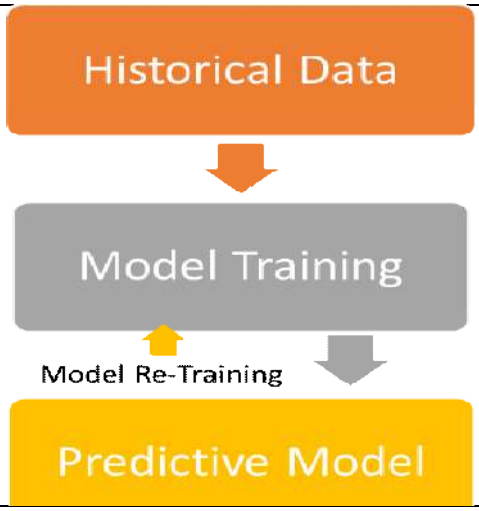


Fig 3 – Machine Learning Model

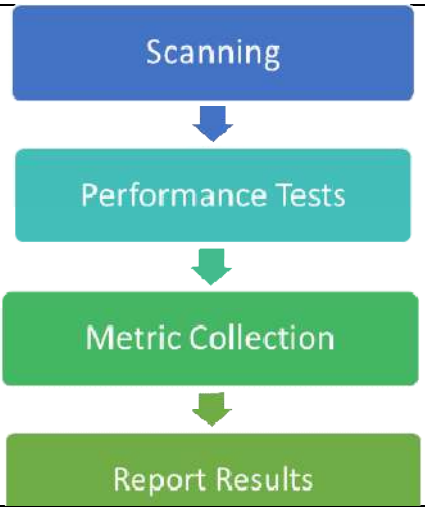


Fig 4 – Empirical Benchmarking Process

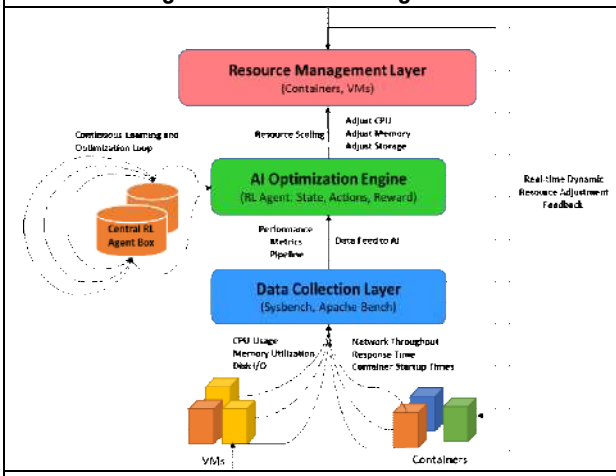


Fig 5 – System Architecture

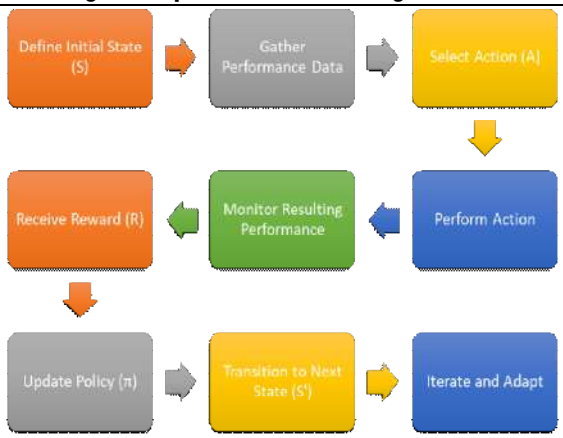


Fig 6 – Reinforcement Learning



Fig 7 – Flowchart of AI Model

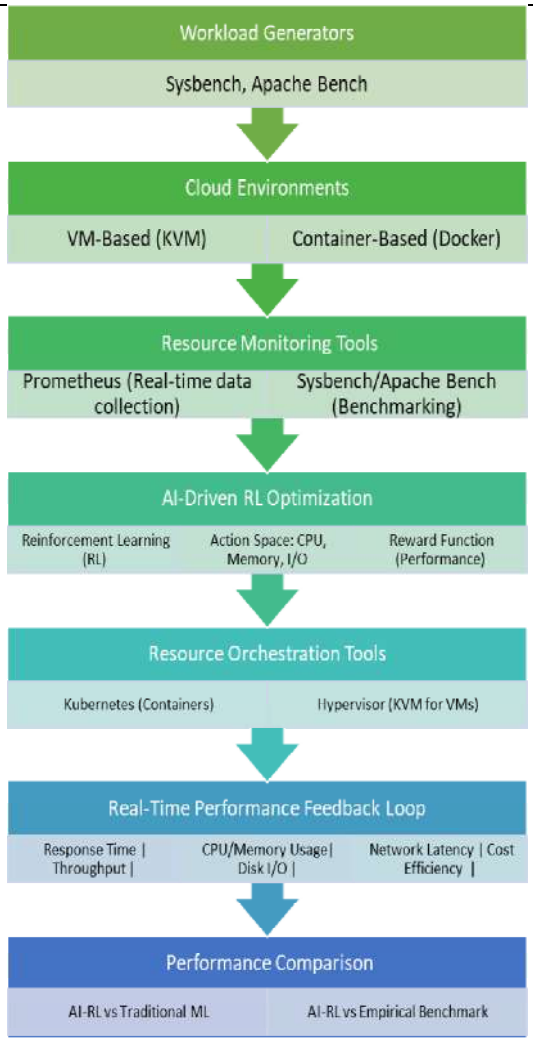


Fig 8 – System Setup

```
# Initialize system and resource monitoring tools
initialize_system()
initialize_RL_agent()  # Initialize RL agent with random policy

# Experiment loop
for time_step in range(total_time_steps):

    # 1. Collect real-time performance metrics
    performance_metrics = collect_metrics()
    cpu_usage = performance_metrics['cpu_usage']
    memory_usage = performance_metrics['memory_usage']
    disk_io = performance_metrics['disk_io']
    network_latency = performance_metrics['network_latency']
    throughput = performance_metrics['throughput']

    # 2. Define current system state (S) based on collected metrics
    state = define_state(cpu_usage, memory_usage, disk_io,
    network_latency, throughput)

    # 3. RL agent selects action (A) from action space (e.g., adjust CPU,
    memory, storage)
    action = RL_agent.select_action(state)

    # 4. Execute the selected action to adjust resources (e.g., scale up/down
    CPU, memory)
    execute_action(action)

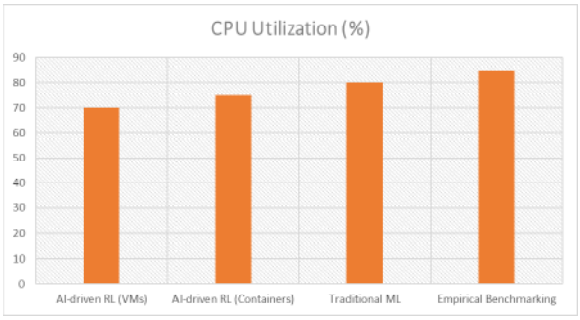
    # 5. Collect feedback after action execution (new state S', updated
    metrics)
    new_performance_metrics = collect_metrics_after_action()
    new_state = define_state(new_performance_metrics['cpu_usage'],
    new_performance_metrics['memory_usage'],
    new_performance_metrics['disk_io'],
    new_performance_metrics['network_latency'],
    new_performance_metrics['throughput'])

    # 6. Compute reward based on system performance improvement
    reward =
    compute_reward(new_performance_metrics['response_time'],
    new_performance_metrics['throughput'],
    new_performance_metrics['resource_efficiency'])

    # 7. Update the RL agent's Q-value function using the reward and new
    state
    RL_agent.update_Q_value(state, action, reward, new_state)

    # 8. Convergence check: stop if convergence criteria are met, otherwise
    continue
    if check_convergence_criteria():
    break
```

Fig 9 – Pseudo Code in Python



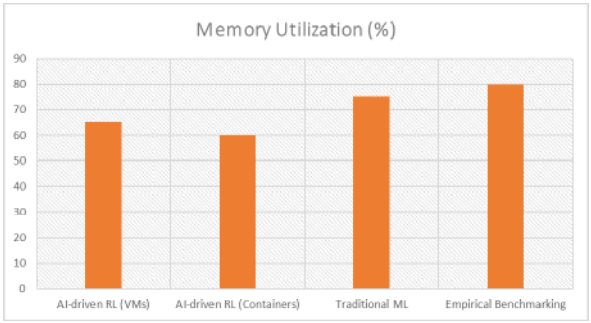


Fig 12 – Resource Utilization Comparison

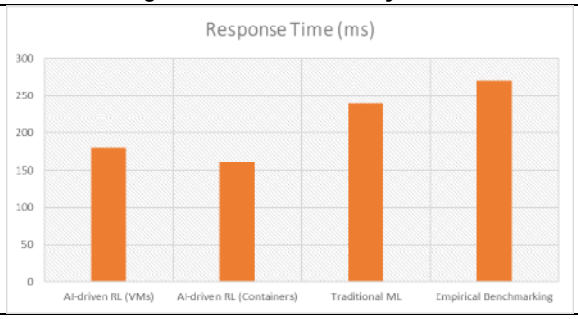


Fig 10 – Response Time Comparison

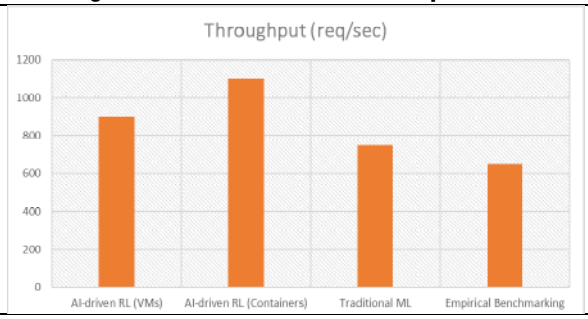


Fig 11 – Throughput Comparison

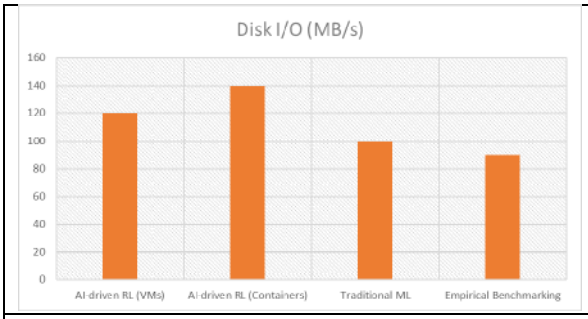


Fig 13 – Disk Utilization Comparison

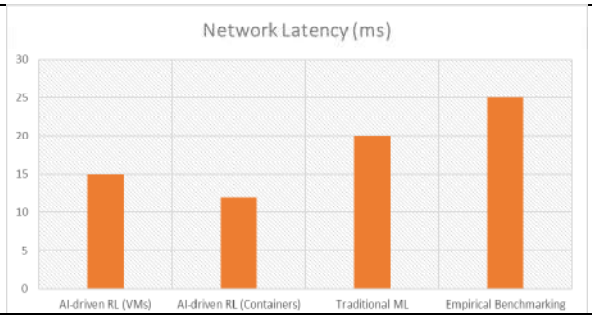


Fig 14 – Network Latency Comparison

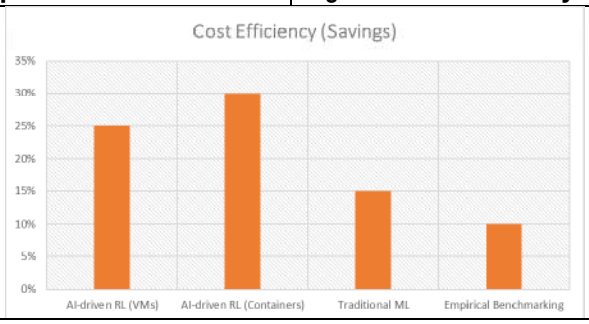


Fig 15 – Cost Efficiency Comparison

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RESEARCH ARTICLE

A Thrice Filtered Information Energy Optimization Based Feature Selection (TFIE-OFS) Method for Heart Disease Prediction

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ABSTRACT

Heart disease remains a leading cause of mortality worldwide, necessitating effective classification and prediction methods to enhance early detection and intervention. This study proposes a novel Thrice Filtered Information Energy Optimization based Feature Selection (TFIE-OFS) method, which integrates Symmetrical Uncertainty, Information Gain, and Chi-Square Analysis to systematically filter and prioritize features from heart disease datasets. By employing Particle Swarm Optimization (PSO), the TFIE-OFS method optimizes feature subsets, ensuring the selection of the most informative variables while minimizing redundancy. The efficacy of the proposed method is evaluated through comprehensive experiments on benchmark heart disease datasets, where it demonstrates superior classification performance compared to existing feature selection techniques. The results indicate that TFIE-OFS significantly enhances predictive accuracy and model interpretability, providing a robust framework for heart disease classification and prediction. This innovative approach not only contributes to the field of medical data analytics but also holds potential for improving clinical decision-making in cardiology.

Keywords: Heart Disease, Classification, Feature Selection, Symmetrical Uncertainty, Information Gain, Particle Swarm Optimization, Chi-Square

INTRODUCTION

Heart disease has emerged as one of the foremost health challenges of the 21st century, contributing significantly to global morbidity and mortality rates [1] [2]. According to the World Health Organization, cardiovascular diseases account for approximately 31% of all global deaths, highlighting the urgent need for effective diagnostic and predictive tools. Early detection and accurate prediction of heart disease are critical for implementing timely interventions and improving patient outcomes. However, the complexity of heart disease risk factors and the vast amounts of health data pose significant challenges in developing robust predictive models [3] [4] [5]. Feature selection plays a crucial role in the classification and prediction of heart disease by identifying the most relevant variables that contribute to the condition. Traditional methods of feature selection often face limitations, such as high computational costs, redundancy among selected features, and the inability to capture complex relationships within the data. Therefore, an efficient and effective feature selection technique is essential for enhancing the performance of predictive models in this domain.

This study proposes a novel Thrice Filtered Information Energy Optimization based Feature Selection (TFIE-OFS) method, which leverages a combination of Symmetrical Uncertainty, Information Gain, and Chi-Square Analysis to filter and prioritize features systematically. By employing these three complementary approaches, TFIE-OFS captures various aspects of feature importance while mitigating the influence of irrelevant and redundant variables. Additionally, the TFIE-OFS method incorporates Particle Swarm Optimization (PSO) to enhance the selection process further. PSO is an intelligent optimization technique inspired by social behavior in animals, such as bird flocking. By mimicking this behavior, PSO effectively searches for optimal feature subsets by balancing exploration and exploitation within the feature space [6] [7] [8].

The primary objective of this research is to develop an effective and efficient feature selection methodology that can improve the classification and prediction accuracy of heart disease models. Through rigorous experimentation on benchmark heart disease datasets, we aim to demonstrate the superiority of TFIE-OFS over existing feature selection methods. In summary, this introduction outlines the critical importance of heart disease prediction, the challenges associated with feature selection, and the innovative approach proposed in this study. By combining multiple feature selection techniques and optimization algorithms, TFIE-OFS offers a promising solution for enhancing predictive modeling in cardiovascular health. This research not only contributes to the field of medical data analytics but also holds significant implications for clinical decision-making, ultimately leading to improved patient care and outcomes in heart disease management.

Background Study on Feature Selection Methods

Feature selection [9] [10] is a critical process in machine learning and data mining that involves identifying and selecting a subset of relevant features (or variables) for use in model construction. This process is particularly essential in the field of medical data analysis, where the complexity of the data can lead to overfitting, increased computational costs, and diminished interpretability of predictive models. In this background study, we explore various feature selection methods, their significance, and their application in the context of heart disease classification and prediction.

Types of Feature Selection Methods

Feature selection methods can be broadly classified into three categories: filter methods, wrapper methods, and embedded methods. Each category employs different strategies for selecting relevant features.

Filter Methods

Filter methods assess the relevance of features based on intrinsic properties of the data, independent of any machine learning algorithm. They are typically computationally efficient and suitable for high-dimensional datasets. Common filter methods include:

Correlation Coefficient: Measures the statistical relationship between features and the target variable. High correlation indicates potential relevance.

Chi-Square Test: Evaluates the independence between categorical features and the target variable, identifying significant associations.

Information Gain: Measures the reduction in uncertainty about the target variable given knowledge of a feature. It quantifies how much information a feature contributes to the prediction.

Wrapper Methods

Wrapper methods evaluate feature subsets by training a specific model and assessing its performance. They are typically more accurate than filter methods but can be computationally expensive due to the repeated model training required. Common wrapper methods include:

Recursive Feature Elimination (RFE): Iteratively removes the least significant features based on model performance until the desired number of features is reached.

Forward Selection: Starts with an empty set of features and adds them one by one, evaluating model performance at each step to determine the best feature to add.

Backward Elimination: Begins with all features and removes them one at a time, selecting the least significant feature based on model performance.

Embedded Methods

Embedded methods combine feature selection and model training into a single process. They identify relevant features while the model is being trained, making them more efficient than wrapper methods. Common embedded methods include:

Lasso Regression: Uses L1 regularization to penalize the absolute size of coefficients, effectively shrinking some to zero, thus performing feature selection.

Decision Trees and Random Forests: These algorithms naturally perform feature selection by considering the importance of features in splitting the data during tree construction.

Gradient Boosting Machines: These models can also provide feature importance scores, allowing for the selection of significant features based on their contributions to the model.

Symmetrical Uncertainty (SU) Based Feature Selection Method

Symmetrical Uncertainty (SU) [11] [12] is a feature selection method that quantifies the amount of information gained about one variable through another, balancing the measure of uncertainty in both variables. It is particularly useful in the context of categorical variables and has become a popular choice in various machine learning applications, including medical diagnostics, where the interpretation of results is crucial. SU provides a normalized measure that ranges from 0 to 1, facilitating the comparison of feature relevance across different datasets.Symmetrical Uncertainty is derived from the concept of mutual information, which measures the amount of information that knowing the value of one variable provides about another. SU is defined mathematically as follows: Symmetrical Uncertainty is derived from the concept of mutual information, which measures the amount of information that knowing the value of one variable provides about another. SU is defined mathematically as follows:

$$SU\ (X,Y) = \frac{2.I(X,Y)}{H(X) + H(Y)}$$

Where $I(X,Y)$ is the mutual information between variables X and Y. $H(X)$ and $H(Y)$ are the entropy of variables X and Y, respectively. Mutual Information (I): This metric quantifies the reduction in uncertainty of one variable due to the knowledge of another. It is calculated as:

$I(X,Y) = H(X) + H(Y) - H(X,Y)$

Entropy (H): This measures the unpredictability or randomness of a variable. It is calculated using the probability distribution of the variable:

$$H(X) = -\sum_{x \in X} P(x) log P(x)$$

Information Gain (IG) Based Feature Selection Method

Information Gain (IG) [13] [14]is a widely used metric in feature selection and decision tree algorithms that measures the effectiveness of a feature in reducing uncertainty about the target variable. It quantifies the amount of information that knowing the value of a feature provides about the target outcome. IG is particularly beneficial in classification tasks, including medical diagnoses, where understanding the relationship between features and outcomes is essential for developing predictive models. Information Gain is based on the concept of entropy, which measures the unpredictability or randomness of a variable. The IG of a feature is calculated by comparing the entropy of the target variable before and after the dataset is split by that feature. Mathematically, Information Gain is defined as:

$IG(T,A) = H(T) - H(T|A)$

Where $IG(T,A)$is the information gain of feature A with respect to target variable T.$H(T)$is the entropy of the target variable before the split.$H(T|A)$is the conditional entropy of the target variable after the dataset is split based on feature A.

Entropy is calculated using the formula:

$H(X) = -\sum_{x \in X} P(x) \log_2 P(x)$

Where$P(x)$is the probability of occurrence of value x.

Chi-Square Analysis Based Feature Selection Method

Chi-Square Analysis [15] [16]is a statistical method used to determine the independence between categorical variables. In the context of feature selection, the Chi-Square test assesses the relationship between each feature and the target variable to identify significant predictors. This method is particularly valuable in classification tasks, especially in medical datasets where categorical variables are prevalent. By evaluating how well each feature correlates with the target outcome, Chi-Square Analysis helps improve model performance and interpretability. The Chi-Square test compares the observed frequencies of occurrences in a contingency table with the expected frequencies under the assumption of independence. The Chi-Square statistic is calculated using the following formula:

$$x^2 = \sum \frac{(O_i - E_i)^2}{E_i}$$

$x^2$is the Chi-Square statistic, $O_i$is the observed frequency for category i, E_i is the expected frequency for the category i.

The expected frequency is calculated as:

$$E_i = \frac{(row\ total\ \times column\ total)}{grand\ total}$$

The resulting Chi-Square statistic indicates how much the observed counts deviate from the expected counts. A higher Chi-Square value suggests a stronger association between the feature and the target variable.

Particle Swarm Optimization Algorithm

Particle Swarm Optimization (PSO)[17] [18] is a nature-inspired optimization algorithm developed by James Kennedy and Russell Eberhart in 1995. It is based on the social behavior of birds and fish, where individuals

(particles) in a swarm collaborate to find optimal solutions within a search space. PSO is particularly effective for solving complex optimization problems, including those in machine learning, engineering design, and parameter tuning. Its simplicity, ease of implementation, and ability to converge to global optima make it a popular choice in various applications.
In PSO, each particle represents a potential solution in the search space and has two primary characteristics:

Position: The current location of the particle, representing a possible solution to the optimization problem.

Velocity: The rate of change of the particle's position, determining how the particle moves through the search space. Particles adjust their positions based on their own experience and that of their neighbors, balancing exploration (searching new areas) and exploitation (refining existing solutions).The PSO algorithm consists of the following key steps:

Initialization
Define the optimization problem and its objective function.
Initialize a swarm of particles with random positions and velocities within the defined search space.
Set parameters such as the number of particles, maximum iterations, and coefficients for cognitive and social components.

Fitness Evaluation
Evaluate the fitness of each particle by calculating the objective function's value at its current position.

Update Personal and Global Bests
For each particle, compare its fitness with its personal best (the best position it has encountered so far) and update it if the current position is better.
Determine the global best (the best position encountered by any particle in the swarm) based on fitness evaluations.

Update Velocity and Position
Adjust each particle's velocity using the following formula:$v_i = \omega . v_i + C_1 . r_1 . (p_i - x_i) + C_2 . r_2 . (g - x_i)$where $v_i$is the particle's current velocity.$\omega$is the inertia weight that controls exploration versus exploitation.$C_1 \; and \; C_2$are acceleration coefficients (typically set between 1.5 and 2). $r_1 \; and \; r_2$are random numbers between 0 and 1. $p_i$is the personal best position of particle i. g is the global best position. Update the particle's position using: $x_i = x_i + v_i$

Iteration
Repeat steps 2 to 4 until a stopping criterion is met (e.g., maximum iterations or a satisfactory fitness level).

Output
Return the global best position and its corresponding fitness value as the optimal solution.

A Thrice Filtered Information Energy Optimization Based Feature Selection (TFIE-OFS) Method
The following are the step-by-step procedure for the proposed TFIE-OFS method.

Step 1: Data Preprocessing
Data Collection: Gather the dataset for the prediction or classification task (e.g., heart disease dataset).

Handle Missing Values: Impute missing values using techniques such as mean, median, or mode, or remove entries with significant missing data.

Feature Scaling & Encoding : Normalize numerical features using scaling techniques (e.g., Min-Max Scaling or Z-Score normalization). Convert categorical features into numerical format using label encoding or one-hot encoding.

Split the Dataset: Divide the dataset into training and testing sets. The training set will be used for feature selection and model building, while the test set will be used to evaluate performance.

Step 2: Apply Three Filtering Methods: The feature selection begins by applying three filters independently, each of which evaluates the relevance of the features with respect to the target variable.

Step 2.1: Symmetrical Uncertainty (SU) Filter
Calculate Symmetrical Uncertainty: Compute the SU score for each feature by measuring the correlation between the feature and the target variable.
Rank Features: Rank the features based on their SU scores.

Select Top Features: Select the top k features with the highest SU scores. These are considered the most relevant to the target variable.

Step 2.2: Information Gain (IG) Filter
Calculate Information Gain: Compute the IG for each feature by quantifying the reduction in entropy when the feature is known.
Rank Features: Rank the features based on their IG scores, where higher IG values indicate greater importance.

Select Top Features: Select the top kkk features with the highest IG scores.

Step 2.3: Chi-SquareFilter
Perform Chi-Square Test: For each feature, apply the Chi-Square test to determine its level of independence from the target variable.

Rank Features: Rank the features based on their Chi-Square values. Higher values suggest a stronger dependency between the feature and the target.

Select Top Features: Select the top k features with the highest Chi-Square values.

Step 3: Combine Results of the Three Filters
Step 3.1: **Intersection of Feature Sets:** Combine the results of the three filters (SU, IG, and Chi-Square) by taking the intersection of the top-ranked features from each method.
This ensures that only the most relevant features, as agreed upon by all three methods, are retained for further analysis.
The combined feature set is smaller and more focused on high-impact predictors.

Step 4: Particle Swarm Optimization (PSO) for Feature Selection
Once the filtered feature set is determined, PSO is used to further optimize the selection of features.

Step 4.1: Initialize PSO Algorithm
Swarm Initialization: Initialize a population (swarm) of particles. Each particle represents a potential subset of the selected features from Step 3.

Position & Velocity: Initialize the position and velocity of each particle randomly. The position represents a feature subset.

Step 4.2: Define Fitness Function

Classification Performance: The fitness function evaluates how well the selected feature subset performs in classification. Use a machine learning model (e.g., Support Vector Machine, Decision Tree) to calculate performance metrics such as accuracy or F1-score.

Fitness Value: The fitness value for each particle is the classification accuracy (or any relevant performance metric) of the model using the particle's feature subset.

Step 4.3: Update Particle Velocity & Position

For each particle, update the velocity using the above mentionedformula.

Step 4.4: Evaluate Fitness of Each Particle

After updating the position, evaluate the fitness (classification performance) of the new feature subset for each particle.

Update Personal Best (p_i): If a particle's current fitness is better than its personal best, update its personal best.
Update Global Best (g): If any particle's current fitness is better than the global best, update the global best.

Step4.5: Iterate Until Convergence

Repeat the velocity and position updates, and re-evaluate the fitness of particles for a predefined number of iterations or until convergence (when no further improvement is observed in the global best).

Step 5: Select Optimal Feature Subset

Step 5.1: Identify the Best Feature Subset

Once PSO converges, the global best position (i.e., the best-performing feature subset) is selected as the optimal feature set.

Step 5.2: Train Final Model

Use the optimal feature subset to train the final classification model (e.g., on a Decision Tree, SVM, or any chosen model).

RESULT AND DISCUSSION

Performance Metrics

The performance of the proposed Feature Selection method is evaluated with their existing feature selection methods like Genetic Algorithm, Artificial Bee Colony (ABC) Optimization, Whale Optimization Algorithm (WOA), and Cultural Algorithm (CA) using classification techniques like Artificial Neural Network (ANN), Support Vector Machine (SVM) and Random Forest (RF). The dataset used in this research work is considered from the Kaggle Repository [19] Table 1 depicts the performance metrics used to evaluate the performance of the proposed and existing feature selection methods. Table 2 depicts the number of features obtained by the Proposed and existing feature selection methods. From the table 2, it is clear that the proposed TFIE-OFS method gives less number of features than the existing feature selection methods. Table 2 compares the number of features selected by the existing feature selection methods (Symmetrical Uncertainty (SU), Information Gain (IG), Chi-Square (CS)) and the proposed Thrice Filtered Information Energy Optimization-based Feature Selection (TFIE-OFS) method. The proposed TFIE-OFS method selects a more refined set of features, emphasizing its efficiency in identifying the most relevant attributes for classification. The SU method selects a total of 9 features, including key attributes like "chol," "cp," and "exang.". The IG method also selects 7 features, but with variations such as the absence of "age" and "trestbps.". The CS method selects 7 features but includes a different set, emphasizing "old peak" and "trestbps.". The proposed TFIE-OFS method selects 6 features, streamlining the selection to the most critical attributes such as "cp," "ca," and "thal."

Table 3 depicts the classification accuracy (in %) obtained by the Heart Disease dataset using original dataset, GA, ABC, WOA, CA and proposed TFIE-OFS methods processed datasets. Table 3 presents the classification accuracy (in %) of various classification techniques (ANN, RF, SVM) applied to the heart disease dataset after using different feature selection methods: Genetic Algorithm (GA), Artificial Bee Colony (ABC), Whale Optimization Algorithm (WOA), Crow Search Algorithm (CA), and the proposed TFIE-OFS method. The original dataset without feature selection provides the lowest classification accuracy across all classifiers: 48.32% (ANN), 43.97% (RF), and 42.86% (SVM), indicating the necessity of feature selection to improve performance. Among the existing feature selection methods, CA yields the highest accuracy: 72.59% (ANN), 71.67% (RF), and 69.78% (SVM).The proposed TFIE-OFS method achieves the highest classification accuracy across all classifiers, with 94.91% (ANN), 93.46% (RF), and 85.69% (SVM), showing a substantial improvement over the other methods.GA achieves respectable results but still lags behind TFIE-OFS, with accuracies of 70.84% (ANN), 69.34% (RF), and 67.43% (SVM).ABC and WOA produce similar but slightly lower accuracies, ranging between 55-59% for all classifiers.

Table 4 depicts the True Positive Rate (in %) obtained by the Heart Disease dataset using original dataset, GA, ABC, WOA, CA and proposed TFIE-OFS methods processed datasets. Table 4 presents the True Positive Rate (in %) of various classification techniques (ANN, RF, SVM) applied to the heart disease dataset after using different feature selection methods: Genetic Algorithm (GA), Artificial Bee Colony (ABC), Whale Optimization Algorithm (WOA), Crow Search Algorithm (CA), and the proposed TFIE-OFS method. The original dataset without feature selection results in the lowest True Positive Rate (TPR), with 52.76% (ANN), 51.26% (RF), and 46.35% (SVM), highlighting the need for feature selection to improve detection rates. Among the existing methods, CA achieves the highest TPR, with 83.19% (ANN), 82.3% (RF), and 69.24% (SVM).The proposed TFIE-OFS method significantly outperforms all other methods, achieving TPRs of 95.51% (ANN), 92.42% (RF), and 79.96% (SVM), indicating superior performance in correctly identifying positive cases.GA shows competitive results with TPRs of 74.45% (ANN), 73.05% (RF), and 71.16% (SVM), but still lags behind TFIE-OFS.ABC and WOA exhibit similar performance, with TPRs ranging from 59-63% across all classifiers, which is higher than the original dataset but lower than GA and CA.

Table 5 depicts the False Positive Rate (in %) obtained by the Heart Disease dataset using original dataset, GA, ABC, WOA, CA and proposed TFIE-OFS methods processed datasets. Table 5 presents the False Positive Rate (FPR in %) of various classification techniques (ANN, RF, SVM) applied to the heart disease dataset after using different feature selection methods: Genetic Algorithm (GA), Artificial Bee Colony (ABC), Whale Optimization Algorithm (WOA), Crow Search Algorithm (CA), and the proposed TFIE-OFS method. The original dataset shows the highest False Positive Rate across all classifiers, with 56.58% (ANN), 63.8% (RF), and 64.32% (SVM), highlighting its poor ability to minimize false positives without feature selection. Among the existing methods, CA achieves the lowest FPR, with 25.60% (ANN), 31.91% (RF), and 33.42% (SVM).The proposed TFIE-OFS method significantly outperforms all other methods, reducing the FPR to 5.72% (ANN), 5.36% (RF), and 13.36% (SVM), indicating a dramatic reduction in false positives and enhancing the accuracy of classification.GA performs moderately, reducing FPR to 32.87%(ANN), 35.31% (RF), and 36.22% (SVM), which is significantly better than the original dataset but higher than CA and TFIE-OFS.ABC and WOA have similar FPR values, ranging from 43-48%, which is better than the original dataset but worse than GA and CA.

Table 6 depicts the Precision (in %) obtained by the heart disease dataset using original dataset, GA, ABC, WOA, CA and proposed TFIE-OFS methods processed datasets. Table 6 presents the Precision (in %) obtained by various classification techniques (ANN, RF, SVM) applied to the heart disease dataset after using different feature selection methods: Genetic Algorithm (GA), Artificial Bee Colony (ABC), Whale Optimization Algorithm (WOA), Crow Search Algorithm (CA), and the proposed TFIE-OFS method. The original dataset yields the lowest precision across all classifiers: 51.60% (ANN), 47.71% (RF), and 46.53% (SVM), indicating high levels of false positives without feature selection. Among the existing feature selection methods, CA achieves the highest precision, with 80.17% (ANN), 73.20% (RF), and 72.83% (SVM).The proposed TFIE-OFS method dramatically improves precision across all classifiers, with the highest values: 95.53% (ANN), 94.32% (RF), and 82.65% (SVM), demonstrating its superior performance in accurately identifying positive instances.GA also delivers competitive precision results, with 73.52%

(ANN), **70.60%** (RF), and **69.81%** (SVM), though it still falls short of CA and TFIE-OFS.**ABC** and **WOA** perform similarly, with precision values in the **60-63%** range, which is an improvement over the original dataset but not as effective as GA, CA, or TFIE-OFS.

Table 7 depicts the Specificity (in %) obtained by the heart disease dataset using original dataset, GA, ABC, WOA, CA and proposed TFIE-OFS methods processed datasets. Table 7 shows the Specificity (in %) of various classification techniques (ANN, RF, SVM) applied to the heart disease dataset after different feature selection methods: Genetic Algorithm (GA), Artificial Bee Colony (ABC), Whale Optimization Algorithm (WOA), Crow Search Algorithm (CA), and the proposed TFIE-OFS method. The original dataset exhibits the lowest Specificity across all classifiers: 43.42% (ANN), 36.2% (RF), and 35.68% (SVM), indicating poor performance in identifying true negatives without feature selection. Among the existing methods, CA provides the highest Specificity, with 74.4% (ANN), 68.09% (RF), and 66.58% (SVM), reflecting a notable improvement. The proposed TFIE-OFS method achieves the highest Specificity across all classifiers: 94.28% (ANN), 92.64% (RF), and 86.64% (SVM), showcasing its superior ability to correctly identify negative cases.GA also performs well, yielding Specificity values of 67.13% (ANN), 64.69% (RF), and 63.78% (SVM), but remains less effective than CA and TFIE-OFS.ABC and WOA show moderate improvements, with Specificity values in the 51-56% range, indicating some effectiveness but falling behind GA, CA, and TFIE-OFS.

Table 8 depicts the Miss Rate (in %) obtained by the Heart Disease dataset using original dataset, GA, ABC, WOA, CA and proposed TFIE-OFS methods processed datasets. Table 8 presents the Miss Rate (in %) obtained by various classification techniques (ANN, RF, SVM) when applied to the heart disease dataset processed using different feature selection methods: Genetic Algorithm (GA), Artificial Bee Colony (ABC), Whale Optimization Algorithm (WOA), Crow Search Algorithm (CA), and the proposed TFIE-OFS method. The original dataset produces the highest Miss Rates: 47.24% (ANN), 48.74% (RF), and 53.65% (SVM), indicating a high rate of misclassification without feature selection.GA reduces the Miss Rate significantly to 25.55% (ANN), 26.95% (RF), and 28.84% (SVM), though it is still not as effective as CA or the proposed TFIE-OFS method.ABC and WOA have moderate Miss Rates, ranging from 36.66% to 40.87%, showing a better performance than the original dataset but are less effective than GA, CA, or TFIE-OFS.CA achieves a substantial reduction in Miss Rate, especially for ANN and RF classifiers, with values of 16.81% (ANN) and 17.7% (RF). However, for SVM, the Miss Rate is relatively higher at 30.76%.The proposed TFIE-OFS method achieves the lowest Miss Rates: 4.49% (ANN), 7.58% (RF), and 20.04% (SVM), demonstrating its superior ability to minimize classification errors across all classifiers.

Table 9 depicts the False Discovery Rate (in %) obtained by the heart disease dataset using original dataset, GA, ABC, WOA, CA and proposed TFIE-OFS methods processed datasets. Table 9 presents the False Discovery Rate (FDR in %) obtained by applying various classification techniques (ANN, RF, SVM) to the heart disease dataset processed using different feature selection methods: Genetic Algorithm (GA), Artificial Bee Colony (ABC), Whale Optimization Algorithm (WOA), Crow Search Algorithm (CA), and the proposed TFIE-OFS method. The original dataset exhibits high False Discovery Rates, with values of 48.4% (ANN), 52.29% (RF), and 53.47% (SVM), indicating a substantial number of false positives when no feature selection is applied. The GA method leads to a noticeable reduction in FDR to 26.48% (ANN), 29.4% (RF), and 30.19% (SVM), demonstrating some effectiveness in improving classification accuracy compared to the original dataset.ABC and WOA achieve moderate reductions in FDR, with values ranging from 36.24% to 43.99%, reflecting a better performance than the original dataset but still higher than GA and CA. The CA method significantly lowers the FDR, achieving 19.83% (ANN), 26.8% (RF), and 27.17% (SVM), indicating its strong potential in minimizing false discoveries. The proposed TFIE-OFS method shows remarkable results, yielding the lowest False Discovery Rates of 4.47% (ANN), 5.68% (RF), and 17.35% (SVM), showcasing its effectiveness in correctly identifying true positives and significantly reducing false positives.

CONCLUSION

The Thrice Filtered Information Energy Optimization Based Feature Selection (TFIE-OFS) method represents a significant advancement in feature selection techniques for classification and prediction tasks, particularly in high-dimensional datasets such as those used in heart disease diagnosis. By integrating three robust filtering methods—Symmetrical Uncertainty, Information Gain, and Chi-Square Analysis—TFIE-OFS effectively narrows down the feature space to include only the most relevant predictors. This multi-filtering approach ensures a comprehensive assessment of feature importance, leading to a more refined selection process. Furthermore, the incorporation of Particle Swarm Optimization (PSO) enhances the feature selection process by optimizing the subset of features based on their contribution to model performance. The results from the various evaluations of the Thrice Filtered Information Energy Optimization-based Feature Selection (TFIE-OFS) method indicate its significant efficacy in improving the performance of heart disease classification tasks. The proposed TFIE-OFS method consistently outperformed existing feature selection techniques across multiple metrics, demonstrating its ability to enhance classification accuracy, reduce false discovery rates, minimize miss rates, and maintain high specificity.

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Table 1: Performance Metrics used in this research work

Metrics	Equation
Accuracy	TP+TN/TP+FN+TN+FP
True Positive Rate (TPR) (Sensitivity or Recall)	TP/TP+FN
False Positive Rate (FPR)	FP/FP+TN
Precision	TP/TP+FP
True Negative Rate (Specificity)	1- False Positive Rate (FPR)
Miss Rate	1-True Positive Rate (TPR)
False Discovery Rate	1- Precision

Table 2: Number of Features obtained by the Existing and Proposed Feature Selection Methods

Feature Index	Number of Features selected by existing feature selection methods and proposed TFIE-OFS method			
	SU	IG	CS	TFIE-OFS
1	chol	cp	age	cp
2	cp	age	old peak	ca
3	exang	thal	trestbps	thal
4	ca	ca	cp	slope
5	slope	trestbps	ca	exang
6	old peak	exang	thal	chol
7	sex	slope	exang	
8	age		slope	
9	trestbps			

Table 3: Classification Accuracy (in %)obtained by the heart disease dataset using original dataset, GA, ABC, WOA, CA and proposed TFIE-OFS methods processed datasets

Feature Selection Methods	Classification Accuracy (in %) by Classification Techniques		
	ANN	RF	SVM
Original dataset	48.32	43.97	42.86
GA	70.84	69.34	67.43
ABC	59.73	58.43	56.32
WOA	58.64	57.34	55.43
CA	72.59	71.67	69.78
Proposed TFIE- OFS method	94.91	93.46	85.69

Table 4: True Positive Rate (in %)obtained by the heart disease dataset using original dataset, GA, ABC, WOA, CA and proposed TFIE-OFS methods processed datasets

Feature Selection Methods	True Positive Rate (in %) by Classification Techniques		
	ANN	RF	SVM
Original dataset	52.76	51.26	46.35
GA	74.45	73.05	71.16
ABC	63.34	62.16	60.24
WOA	62.25	61.27	59.13
CA	83.19	82.3	69.24
Proposed TFIE- OFS method	95.51	92.42	79.96

Table 5: False Positive Rate (in %)obtained by the heart disease dataset using original dataset, GA, ABC, WOA, CA and proposed TFIE-OFS methods processed datasets

Feature Selection Methods	False Positive Rate (in %) by Classification Techniques		
	ANN	RF	SVM
Original dataset	56.58	63.8	64.32
GA	32.87	35.31	36.22
ABC	43.78	44.42	47.35
WOA	44.69	45.53	48.43
CA	25.60	31.91	33.42
Proposed TFIE- OFS method	5.72	5.36	13.36

Table 6: Precision (in %)obtained by the heart disease dataset using original dataset, GA, ABC, WOA, CA and proposed TFIE-OFS methods processed datasets

Feature Selection Methods	Precision(in %) by Classification Techniques		
	ANN	RF	SVM
Original dataset	51.60	47.71	46.53
GA	73.52	70.60	69.81
ABC	62.80	61.57	56.01
WOA	63.76	60.86	57.54
CA	80.17	73.20	72.83
Proposed TFIE- OFS method	95.53	94.32	82.65

Table 7: Specificity(in %)obtained by the heart disease dataset using original dataset, GA, ABC, WOA, CA and proposed TFIE-OFS methods processed datasets

Feature Selection Methods	Specificity (in %) by Classification Techniques		
	ANN	RF	SVM
Original dataset	43.42	36.2	35.68
GA	67.13	64.69	63.78
ABC	56.22	55.58	52.65
WOA	55.31	54.47	51.57
CA	74.4	68.09	66.58
Proposed TFIE- OFS method	94.28	92.64	86.64

Table 8: Miss Rate (in %)obtained by the Heart Disease dataset using original dataset, GA, ABC, WOA, CA and proposed TFIE-OFS methods processed datasets

Feature Selection Methods	Miss Rate (in %) by Classification Techniques		
	ANN	RF	SVM
Original dataset	47.24	48.74	53.65
GA	25.55	26.95	28.84
ABC	36.66	37.84	39.76
WOA	37.75	38.73	40.87
CA	16.81	17.7	30.76
Proposed TFIE- OFS method	4.49	7.58	20.04

Table 9: False Discovery Rate (in %)obtained by the heart disease dataset using original dataset, GA, ABC, WOA, CA and proposed TFIE-OFS methods processed datasets

Feature Selection Methods	False Discovery Rate (in %) by Classification Techniques		
	ANN	RF	SVM
Original dataset	48.4	52.29	53.47
GA	26.48	29.4	30.19
ABC	37.2	38.43	43.99
WOA	36.24	39.14	42.46
CA	19.83	26.8	27.17
Proposed TFIE- OFS method	4.47	5.68	17.35

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REVIEW ARTICLE

Cloud Forensics: A Comprehensive Review of Current Techniques and Emerging Trends

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ABSTRACT

As cloud computing continues to gain prominence, the need for effective forensic methodologies tailored to cloud environments has become increasingly critical. This literature review explores the integration of machine learning (ML) and deep learning (DL) techniques in cloud forensics, aiming to enhance the efficiency and effectiveness of digital investigations. The review highlights various applications of ML and DL algorithms in tasks such as data acquisition, anomaly detection, and evidence extraction, emphasizing their ability to process vast amounts of data generated in cloud environments. Key challenges, including data privacy concerns, the complexity of cloud architectures, and the need for real-time analysis, are also addressed. Furthermore, the review discusses the advantages of employing these advanced techniques over traditional forensic methods, showcasing case studies that demonstrate their successful implementation. By synthesizing current research, this review aims to provide a comprehensive understanding of how ML and DL can transform cloud forensic practices, paving the way for future innovations in the field.

Keywords: Cloud Computing, Machine learning, Deep Learning, Cloud Forensic, Traditional Forensic Methods

INTRODUCTION

The proliferation of cloud computing has revolutionized the way organizations manage, store, and analyze data. With its scalability, flexibility, and cost-effectiveness, cloud computing has become the backbone of modern information technology infrastructure. However, as organizations increasingly migrate to cloud environments, the need for robust forensic methodologies to investigate incidents involving cloud services has also grown. Traditional digital forensics techniques, originally designed for on-premises systems, often fall short in addressing the unique challenges posed by cloud architectures, such as data distribution, multi-tenancy, and dynamic resource allocation [1]. Digital forensics in cloud environments involves the collection, preservation, analysis, and presentation of digital evidence from cloud services. This process is inherently complex due to the virtualization of resources and the abstracted nature of cloud services. Consequently, the investigation of cloud-related incidents, such as data breaches, insider threats, and unauthorized access, necessitates advanced forensic approaches that can adapt to the evolving landscape of cloud computing [2].

In recent years, machine learning (ML) and deep learning (DL) have emerged as powerful tools in various domains, including cybersecurity and digital forensics. ML algorithms can analyze large datasets, identify patterns, and make predictions based on historical data, making them particularly suitable for forensic investigations where vast amounts of information need to be processed quickly and accurately. On the other hand, DL techniques, which leverage neural networks to model complex data patterns, have shown significant promise in tasks such as image and speech recognition, natural language processing, and anomaly detection [3]. The integration of ML and DL in cloud forensics presents a paradigm shift, enabling investigators to automate and enhance various stages of the forensic process. For instance, these technologies can facilitate the automated identification of malicious activities, streamline data acquisition processes, and improve the accuracy of evidence analysis. Moreover, ML and DL can assist forensic analysts in filtering through vast amounts of cloud data, allowing them to focus on critical evidence while minimizing manual effort [4].

Despite the potential benefits, the application of ML and DL in cloud forensics is not without challenges. Issues such as data privacy, compliance with legal frameworks, and the intricacies of cloud service provider architectures must be carefully considered. Additionally, the evolving nature of cyber threats necessitates continuous updates and training of ML and DL models to ensure their effectiveness in detecting and responding to new attack vectors [5]. This literature review aims to explore the current state of research on the application of ML and DL in cloud forensic environments. By analyzing existing studies, case examples, and emerging trends, this review seeks to provide a comprehensive understanding of how these advanced techniques can enhance cloud forensic practices. Furthermore, it will highlight the challenges and limitations associated with their implementation, paving the way for future research and innovations in the field.

Background Study Of Digital Forensic

Digital forensics, often referred to as computer forensics, is the practice of collecting, analyzing, and preserving digital evidence from electronic devices such as computers, smartphones, servers, and storage media to investigate and solve crimes or security incidents. The primary goal of digital forensics is to maintain the integrity of evidence while adhering to legal and procedural standards so that it can be used in both criminal and civil court proceedings. Over the years, digital forensics has evolved significantly in response to the increasing complexity of digital devices, networks, and the growing sophistication of cybercrimes [6]. The field covers a wide range of activities, including the recovery of deleted files, analysis of computer logs, detection of malware or malicious software, investigation of unauthorized access or data breaches, and reconstruction of digital actions taken by individuals or groups.

Historical Development of Digital Forensics

Digital forensics traces its roots to the late 20th century, coinciding with the growth of computers and the internet. The term "computer forensics" emerged in the 1980s as computers became more widely used in business, education, and government sectors. The increasing reliance on computers and networked systems brought about new avenues for criminal activities, necessitating the development of specialized techniques for investigating such crimes [7]. In its early days, digital forensics primarily involved analyzing standalone computer systems, focusing on recovering data from hard drives and investigating cybercrimes such as hacking, fraud, and intellectual property theft. However, as digital devices and internet technologies evolved, so did the field of digital forensics. The expansion of mobile devices, cloud computing, social media, and the Internet of Things (IoT) has introduced new challenges and opportunities, leading to the development of various subfields of digital forensics.

Key Subfields of Digital Forensics

Digital forensics is now an umbrella term that covers several specialized subfields, each addressing specific types of digital devices, networks, or incidents [8]:

Computer Forensics: Focuses on investigating desktop and laptop computers. It involves analyzing file systems, memory, logs, and applications to recover evidence of criminal activities such as fraud, hacking, or insider threats.
Network Forensics: Involves the monitoring and analysis of network traffic and activities. It is crucial for investigating network intrusions, data breaches, distributed denial-of-service (DDoS) attacks, and unauthorized access to systems.

Mobile Device Forensics: Specializes in the extraction and analysis of data from smartphones, tablets, and other handheld devices. With the increasing use of mobile apps and services, mobile forensics plays a vital role in investigations related to social media, messaging apps, and location data.

Cloud Forensics: A newer branch that deals with the challenges of investigating incidents in cloud environments. Cloud forensics requires unique approaches for acquiring and analyzing data stored on remote servers and managed by third-party service providers.

Memory Forensics: Focuses on analyzing volatile data stored in computer memory (RAM). This subfield is particularly important for uncovering malware, rootkits, and other malicious activities that reside in memory but do not leave traces on the hard disk.
IoT Forensics: As the number of IoT devices increases, this subfield addresses the challenges of investigating incidents involving interconnected devices such as smart home systems, wearables, and industrial IoT sensors.

The Digital Forensic Process

The process of digital forensics is generally divided into several key phases that ensure the proper handling and analysis of digital evidence. These phases include [9]:

Identification: This phase involves identifying the digital devices or systems that may contain evidence relevant to the investigation. It also includes defining the scope of the investigation, determining the types of data to be collected, and understanding the potential sources of evidence.

Preservation: The preservation of digital evidence is critical to maintaining its integrity. This phase ensures that the data is not altered or corrupted during the investigation. It involves creating exact copies (forensic images) of the digital media for analysis, while the original data is securely stored to maintain its chain of custody.

Collection: In this phase, investigators gather relevant data from the identified devices or networks. This can involve copying hard drives, extracting data from cloud services, retrieving logs from network devices, and using specialized tools to access encrypted or hidden files.

Analysis: This is the most time-consuming phase, where investigators examine the collected data for evidence of criminal or unauthorized activities. This phase may involve recovering deleted files, examining file metadata, identifying malware or suspicious software, and tracking user actions. The analysis must be performed methodically and documented thoroughly for accuracy and transparency.

Interpretation: The interpretation phase focuses on making sense of the analyzed data. It involves drawing conclusions based on the evidence and reconstructing events or timelines that explain how the crime or security incident occurred.

Reporting: Finally, the investigator compiles the findings into a formal report. This report must be clear, concise, and understandable to non-technical stakeholders, such as law enforcement, lawyers, or court officials. It must also adhere to legal standards so that the evidence can be presented in court if necessary.

Background Study Of Cloud Forensic

Cloud forensics is a specialized subfield of digital forensics that focuses on the investigation and analysis of digital evidence stored and processed in cloud computing environments. As organizations increasingly adopt cloud services to host their applications, store data, and leverage scalable infrastructure, the necessity for effective forensic methodologies tailored to these complex environments has become paramount [10].

Evolution of Cloud Forensics

The rise of cloud computing, characterized by on-demand access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications), has transformed how organizations manage data. While cloud computing offers numerous benefits, including cost efficiency, scalability, and flexibility, it also introduces unique challenges for forensic investigations. Initially, digital forensics techniques were designed for traditional IT environments, where data was localized and easier to manage. However, with the emergence of cloud computing in the early 2000s, investigators faced new hurdles due to the distributed nature of data across multiple servers and geographical locations. The challenges associated with investigating incidents in cloud environments prompted the development of cloud forensics as a distinct field.

Core Principles of Cloud Forensics

Cloud forensics operates under several guiding principles to ensure the integrity and reliability of the investigation process:

Data Ownership and Jurisdiction: Cloud environments often involve multiple stakeholders, including cloud service providers (CSPs), third-party vendors, and clients. Understanding data ownership and the legal jurisdiction in which data resides is crucial for forensic investigations, as these factors influence the accessibility and admissibility of evidence.

Data Preservation: In cloud forensics, preserving data integrity is critical. Investigators must create forensic copies of relevant cloud data without altering it. This often involves working closely with CSPs to ensure proper data preservation techniques are employed, especially when dealing with volatile data such as logs and ephemeral data.

Chain of Custody: Maintaining a proper chain of custody is essential to ensure the admissibility of digital evidence in legal proceedings. This involves documenting every step of the forensic process, from data acquisition to analysis, and ensuring that all actions taken are traceable and reproducible.

Comprehensive Data Acquisition: Cloud forensics requires a thorough understanding of cloud architecture and services. Investigators must identify all potential sources of evidence, including virtual machines, storage buckets, and application logs, to ensure comprehensive data acquisition.

LITERATURE REVIEW

Sachdeva, Shaweta, and Aleem Ali [11] Several distributed denial of service assaults, including the User Datagram Protocol Attack, Transmission Control Protocol Sync Attack, and Internet Control Message Protocol Attack, were taken into consideration for data classification in this research. With the advent of digital forensics, the explosion of network traffic and its variety on the Internet presented a new difficulty for attack detection. This document computes the maximum True Negative Rate, accuracy, and precision. We suggest a machine learning-based approach for attack classification in cloud networks that incorporates a digital forensics procedure. Our results show that our detection approach has outstanding True Negative Rate, accuracy, and precision. As a result, the deep learning-based fusion technique we have suggested for Digital Forensics performs admirably as a data classification detective. Kathane, Kavita Arun, and Viren Kumar Sharma [12] introduced an innovative framework that uses Deep Q-Network (DQN) for intelligent decision-making, Long Short-Term Memory (LSTM) based Graph Analysis for relational data processing, and Gated Recurrent Units (GRU) combined with Recurrent Neural Networks (RNN) for dynamic user profile activities. A special blend of adaptability, real-time processing activities, and profound contextual understandings is provided by this synergistic method. We show that, in a variety of scenarios, our framework increases the accuracy by 8.3%, recall by 4.9%, precision of attack event categorisation by 4.5%, and Area under the Curve (AUC) by 5.5%. These developments improve real-time threat identification and user-specific anomaly detection procedures while also greatly reducing false positives and false negatives. This research opens the door for a new breed of flexible, effective, and efficient cloud forensic systems, greatly enhancing the security posture of contemporary cloud computing environments by overcoming the drawbacks of previous approaches.

Senthil, P., and S. Selvakumar [13] presented a hybrid deep learning strategy for forensic investigation that is based on integrated multi-model data fusion (HDL-DFI). First, we focus on digital evidence gathering and management systems, which can be accomplished using an improved brain storm optimisation (IBSO) algorithm in conjunction with an integrated data fusion model. Here, we examine a variety of multimedia data—text, image, speech, physiological signals, and video—for the objective of providing proof. Then, in order to prevent duplicate and redundant data when gathering evidence, we introduce a recurrent multiplicative neurone with a deep neural network (RM-DNN). Next, we create a sentiment analysis multistage dynamic neural network (MDNN) to determine the sort of crime that has occurred and categorise the action on it. Finally, our suggested HDL-DFI model built with the standard benchmark database and its fallouts are compared to the state-of-the-art replicas (AUC) in terms of accuracy, precision, recall, F1-score, G-mean, and area under the curve. Savaridassan, P., and G. Maragatham [14] The goal of the Integrated Deep Auto-Encoder and Q-learning-based Deep Learning (IDEA-QLDL) Scheme is to maximise prediction accuracy while examining log data and dividing it into authentic and anomalous observations. It starts the acceptance/denial process based on ongoing analysis of highly applicable behavioural patterns for classification. When compared to the benchmarked schemes that were taken into consideration for inquiry, the findings of the proposed IDEA-QLDL Scheme demonstrated its superiority in enhancing the classification accuracy, precision, recall, and detection time.

Chitti, Praveen, K. Prabhushetty, and Shridhar Allagi [15] In the suggested approach, the authors use Discrete Cosine Transform (DCT) for feature extraction in the second iteration of the Convolution Neural Network machine learning model, and SVM in the first iteration for detecting the forged region. An average accuracy of 98% is achieved for all types of picture operations, including scaling, rotation, and augmentation, when the suggested model is tested on a Corel 10K dataset. Bhardwaj, Sonam, and Mayank Dave[16] A model for gathering and preserving crypto-evidence is put forth. The model is used to classify network traffic data as either harmful or non-malicious, detect malware attacks, and retain evidence. The gathered digital evidence is effectively preserved, and it is kept in protected mode (tamper-safe). Deep learning and machine learning classifiers are used to extract malware traffic meta-data. Numerous studies have demonstrated that while ensemble classifiers raise the likelihood of improved malware prediction analysis and real-time data flowing over a network, deep learning effectively helps the study of big data sets. The deep learning model proposed in this article is based on an ensemble classifier, and it can be used to

investigate malicious packets, preserve evidence using the SHA-256 cryptosystem, learn from collected data, and maintain the evidence's availability when needed for forensic investigations involving malware attacks on networks.

Srilatha, Doddi, and N. Thillaiarasu [17] This article looks at how cloud resources are affected and suggests a practical intrusion detection system (IDS) called DDoSNet. This research study makes use of the CICIDS 2017 dataset to assess models. For feature selection, the intelligence technique of particle swarm optimisation (PSO) is used. To categorise the given data as benign or malicious, the deep neural network (DNN) model receives as input the optimum features. When evaluating the model, the accuracy rate, precision, recall, and F1-score metrics are taken into account. The experimental findings indicate 099.81% accuracy, 099.77% precision, 099.89% recall, and 099.83% F1 score. The system that is being shown performs better than traditional machine learning models. As such, this strategy instills great confidence in cloud service security. Sachdeva, Shaweta, and Aleem Ali [18]gave a thorough understanding of the issue at hand and suggested narrative remedies for the examination of current log analysis, TCP Sync Attack, UDP Attack, and ICMP Attack. Using a hybrid technique, digital forensics for attack detection in a cloud network environment might improve present computational complexity difficulties and apply cyber-forensic investigation (KNN, MLP) in a less complex system. Our suggested method works incredibly well for categorising the attack dataset.

Hemdan, Ezz El-Din, and D. H. Manjaiah [19] offered a productive Cloud Forensics Investigation Model (CFIM) for prompt, forensically sound cloud criminal investigation. In addition, the suggested solution incorporates the idea of Forensic as a Service (FaaS), which offers a host of advantages for doing digital forensics via the use of Forensic Server in the cloud. The findings of the inquiry demonstrated that the suggested approach can effectively support digital investigators in their quest to look into cybercrimes in the cloud. Manzoor, Nosheen, *et al* [20] Digital crime is investigated through the use of digital forensics. The most deadly cyberattacks on the internet are those that use botnets. It is difficult to conduct a digital forensic analysis into botnet attacks. The capacity of attackers to plan increasingly intricate attacks with Botnets is expanding. To counter such attacks, the digital forensics must be strengthened. In network forensics, machine learning is crucial for quickly and effectively identifying various types of botnet attacks. Machine learning techniques were applied to various network forensic methods. Botnet assaults are not only detected but also prevented using machine learning algorithms. This paper presents a summary of the various botnet assaults and digital forensic investigative approaches to counter the botnet attacks. To present the evidence in a court of law, forensic investigation of Botnet detection requires a consistent framework. In the article, many network forensic approaches have also been described.

Lv, Zhihan, and Ranran Lou [21] In order to strengthen cloud storage security, the current work investigates edge-fog-cloud computing storage security. The study uses pre-processed data from an industrial intelligent manufacturing machine. Perception data for machine production comprises both data transmission and data storage. Additionally, digital twins technology is utilised to create a digital twin in the real world that simulates the online data-driven behaviour of machine production, along with the perceptual data of machine manufacturing. 3Dmax builds and saves the digital twins model. At last, deep learning technology is presented as a means of preventing network intrusion. Both external and internal assaults by cloud data providers can affect cloud databases. In order to guarantee that the database contains ciphertext data and executes data queries directly, the homomorphic encryption algorithm and secure multi-party computing are implemented. Adikari, Samriddha, Jinfeng Su, and Kamini Simi Bajaj [22] This study's objective is to use secondary research to examine recent findings on deep learning-based network forensic optimisation methods. The main conclusions are that deep learning technology outperforms state-of-the-art techniques in identifying assaults during data communication in Internet of Things systems. The main parts of the systems that the researchers proposed were found in this study, arranged in a table, and categorised using a methodology that demonstrated the ability of deep learning technology to recognise attacks in Internet of Things devices.

Shakeel, P. Mohamed, *et al* [23] suggested using the blockchain-assisted shared audit framework (BSAF) to examine IoT platform digital forensic data. In order to identify the origin or source of data scavenging attacks in virtualised

resources (VR), a recommended methodology was created. Blockchain technology is used in the suggested architecture to manage access logs and controls. Using cross-validation and logistic regression (LR) machine learning, adversary event detection consistency is examined in access log data. Thapaliya, Suman, and Pawan Kumar Sharma [24] A model that takes feature fusion into account is described for identifying cyberattacks. The Fractional Gravitational Search Algorithm (FGSA) is used to route data towards Base Station (BS). Cybercrime detection is carried out at BS, where data is divided using enhanced fuzzy c-means clustering (FCM) while taking the MapReduce model into consideration. While the reduction handles cybercrime detection, the mapper uses mutual information and the Deep Quantum Neural Network (DQNN) to fuse features. The Deep Belief Network (DBN) based on Fractional Mayfly Shepherd Optimisation (FrMSO) is designed to describe the digital examination to detect and track the behaviours of attacks in the Internet of Things. The suggested FrMSO algorithm, which was created by combining the Shuffled Shepherd Optimisation Algorithm (SSOA), the Mayfly Optimisation Algorithm (MA), and the Fractional Calculus (FC), trains the DBN in this instance.

Nazar, Nidhin, *et al* [25] Massive volumes of information are frequently available in the field of cyber forensics, perhaps more than in other forensics specialities. The difficulties and innovations associated with applying deep learning to cyber forensics are essentially the same as in any other field where artificial intelligence is utilised to address problems that are vital to an individual or, more often than not, an organisation. Initially, in order to combine Deep Learning with Cyber Forensics—that is, after an incident—it must first be taught in Cyber Security—more precisely, Cyber Defense—that is, before an incident. This concept makes a lot of sense. In this work, deep learning models are compared to the human brain, which is the most complex structure in the known universe. These models are, after all, founded on and inspired by the human brain. This study suggests ways that Deep Learning models could benefit the field of Cyber Security, particularly for the IR teams, and looks for current solutions on how to apply a Deep Learning model in the domains of Cyber Forensics. Barik, Kousik, *et al* [26] The study intends to examine numerous problems that arise during the course of the investigation as well as the various stages of digital forensic techniques. The study also focusses on the careful examination of several digital forensic instrument types. The process entails constructing, defending any scene, conducting a thorough examination, communicating effectively, and identifying. It also entails identifying all of the regulations for regulating proof as well as the prospects for digital inquiry. This article discusses the methods and resources that can be used to look into digital crime. Among the topics covered are desktop forensic tools, live forensic tools, operating system forensic tools, and email forensic tools.

Ahmad, Ayaz, *et al.* [27] provided research that might be utilised to develop plans for developing standards, guidelines, and technological research to minimise problems that can't be resolved by using the tools and techniques available today. This chapter covers a number of subjects, including cloud computing, cybercrimes, digital forensics, and cloud forensics. The fundamentals and overview of cloud computing, digital forensics, cybercrimes, difficulties, and prospects in the field of cloud forensics are also explored. A review of the literature on related work to digital forensics techniques in the cloud computing environment is included, along with the state of the art in the cloud forensic area. Rajeev, Aishwarya, and P. Raviraj [28] explored a wide range of forensic analysis disciplines, including as audio, video, and network forensics. Many methods are employed in this study to accomplish various forms of forensic analysis, including Random Forest, Multilayer Perceptron (MLP), and Convolutional Recurrent Neural Networks (CRNN). Additionally, image fusion is employed, which can extract features from the source photos and provide more information than a single image. With an accuracy of 98.02 percent, this study concluded that the random forest offers the best outcomes for network forensic investigation. The paper attempts to give a comprehensive overview of the substantial amount of work that has been done in the subject of video source authentication in recent years through a review of existing techniques and machine learning algorithms.

Ramesh, S., *et al* [29] Deep Learning (DL) models offer automated malware classification, spam, phishing, and intrusion detection as well as the extraction of optimal values from network data. By making judgements based on evidential weights, the DL-based cyber forensic investigation engine makes it easier to preserve, analyse, and understand evidence. The purpose of this chapter is to highlight the developments and breakthroughs in deep

learning for digital and cyber forensics Arshad, M. Zeeshan, et al[30] This paper's primary goal is to create a framework that security can use to conduct forensic investigation on IoT devices with limited resources. In this study, we have suggested a system that uses a node to node (N2N) architecture to automatically do forensic analysis and detect the many types of assaults carried out on the endpoint (IoT device). In order to identify various attack types, this suggested solution also combines a variety of forensic tools with machine learning techniques. It addresses the issue of recovering evidence from the compromised endpoint by using a third-party log server. We have used the security onion (forensic server) to analyse the logs in order to ascertain the type and scope of the assault. Furthermore, this framework is capable of employing various machine learning methods to automatically identify assaults.

Research Gaps

Despite its importance, cloud forensics faces numerous challenges:

Complexity of Cloud Architectures: Cloud environments are often highly complex, comprising various service models (IaaS, PaaS, SaaS) and deployment models (public, private, hybrid). Investigators must navigate this complexity to locate and analyze relevant evidence effectively.

Multi-tenancy Issues: In cloud environments, multiple clients often share the same infrastructure, which raises concerns about data isolation and privacy. Investigators must ensure that they do not inadvertently access data belonging to other clients, which could lead to legal and ethical issues.

Dynamic and Ephemeral Data: Cloud environments can generate vast amounts of dynamic data, such as logs and temporary files, that may be deleted or overwritten quickly. This impermanence complicates the data collection process, as investigators must act swiftly to capture evidence before it is lost.

Limited Access to CSP Infrastructure: Investigators often have limited access to the underlying infrastructure of CSPs, making it challenging to perform in-depth forensic analysis. Collaboration with CSPs is essential to obtain necessary data, but legal and operational hurdles may impede timely access.

Legal and Regulatory Compliance: The legal landscape surrounding cloud forensics is complex, with varying regulations across jurisdictions. Investigators must remain compliant with local laws and international regulations regarding data privacy and security.

Volume and Variety of Data: The sheer volume of data generated by modern digital devices and systems presents a substantial challenge. Digital forensics experts must sift through terabytes or even petabytes of data to locate relevant evidence. The variety of data formats and storage systems also complicates the process.

Encryption and Privacy Issues: Encryption technologies, while essential for securing personal and corporate data, can impede forensic investigations. Decrypting encrypted files often requires specialized tools and expertise, and in some cases, may be impossible without access to encryption keys.

Future Research Direction

As digital technologies continue to evolve, so too does the field of digital forensics. One of the most significant trends in recent years is the growing use of artificial intelligence (AI) and machine learning (ML) in forensic investigations. These technologies offer the potential to automate certain aspects of the forensic process, such as the identification of anomalies or the classification of evidence. Additionally, the increasing use of blockchain technologies in data storage and transactions has introduced new opportunities and challenges for digital forensics, particularly in the areas of fraud detection and secure record-keeping. Furthermore, as cloud computing and IoT devices continue to expand, forensic investigators will need to adapt to the distributed and decentralized nature of these systems. New tools and

methodologies will be required to effectively investigate incidents in environments where data is stored across multiple platforms and geographies.

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RESEARCH ARTICLE

Enhancing Quality of Service in Cloud Computing: A Comprehensive Review of Techniques and Challenges

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ABSTRACT

The rapid growth of cloud computing has revolutionized data storage, application hosting, and resource management, making it a cornerstone of modern digital infrastructure. However, the adoption of cloud services introduces critical challenges related to performance optimization, Quality of Service (QoS), and security. This literature review aims to explore various strategies that have been proposed to improve cloud computing performance while maintaining high QoS standards and robust security measures. The review delves into techniques such as dynamic resource allocation, virtualization, load balancing, and traffic management to enhance system efficiency and scalability. It also examines encryption protocols, authentication mechanisms, and intrusion detection systems aimed at fortifying cloud security. By analyzing current research, this review highlights the trade-offs between performance and security, offering insights into how emerging technologies such as machine learning, blockchain, and edge computing are being integrated to strike a balance. The findings provide a comprehensive understanding of the existing frameworks and future directions for optimizing cloud performance without compromising on QoS and security requirements.

Keywords: Cloud Security, Quality of Service, Security

INTRODUCTION

Cloud computing has become an integral part of modern information technology infrastructures, enabling organizations and individuals to access and manage data, applications, and services over the internet. Its promise of on-demand resource availability, scalability, cost efficiency, and flexibility has driven widespread adoption across various industries, including healthcare, finance, education, and entertainment. However, as reliance on cloud computing increases, so do the challenges related to ensuring high levels of performance, Quality of Service (QoS), and security. Performance in cloud computing refers to the ability of cloud systems to provide users with fast, efficient, and reliable access to resources while handling large-scale workloads. This aspect is crucial in cloud environments where unpredictable spikes in demand can strain resources. To mitigate these issues, cloud service providers (CSPs) deploy performance enhancement techniques such as dynamic resource allocation, load balancing, and virtualization, which aim to maximize resource utilization and maintain optimal system throughput. However, maintaining high performance often comes at the expense of other critical factors, such as QoS and security [1] [2].

Quality of Service (QoS) represents the overall service quality experienced by end-users, encompassing elements such as availability, latency, bandwidth, and error rates. It is essential in maintaining user satisfaction and ensuring seamless operation for businesses relying on cloud services. The dynamic and distributed nature of cloud environments complicates QoS management, requiring sophisticated algorithms for resource allocation, traffic management, and real-time monitoring. Ensuring consistent QoS across geographically dispersed data centers, varying network conditions, and diverse workloads remains a complex challenge for CSPs [3]. At the same time, security in cloud computing is paramount, given the sensitivity of the data and applications hosted in these environments. Organizations entrust CSPs with confidential data, making cloud infrastructures attractive targets for cyberattacks. Cloud security encompasses a wide range of concerns, including data protection, user authentication, network security, and compliance with privacy regulations. Techniques such as encryption, intrusion detection, access control, and multi-factor authentication are employed to safeguard cloud environments. However, achieving high levels of security often involves overhead that can negatively impact performance, creating a trade-off between security measures and the efficiency of cloud operations [4] [5].

In this context, the interplay between performance, QoS, and security becomes a critical area of concern for researchers and practitioners alike. Improving performance while maintaining a robust QoS and ensuring high security levels presents a unique set of challenges. For instance, adding security measures such as encryption can lead to increased computational load, thus reducing performance. Similarly, prioritizing performance optimization might lead to gaps in security or compromise on QoS aspects like latency or service availability. This literature review seeks to explore the existing body of research that addresses these interconnected challenges in cloud computing. By examining state-of-the-art methodologies and technologies, including machine learning-based optimization techniques, blockchain for decentralized security, and edge computing for distributed workloads, the review will highlight approaches aimed at enhancing cloud performance without compromising QoS or security. It will also identify key trends and future directions in the field, particularly the integration of emerging technologies to balance performance, QoS, and security requirements in cloud environments.

Background Study of Cloud Security

Cloud computing has become a cornerstone of modern digital infrastructure, enabling organizations to deploy, store, and process data with unprecedented scalability, flexibility, and cost efficiency. However, as cloud adoption grows, so does the complexity of ensuring the security of these vast, distributed systems. Cloud security encompasses a broad range of technologies, protocols, and policies designed to protect data, applications, and infrastructure from a wide array of threats. The unique characteristics of cloud environments—such as multi-tenancy, on-demand resource provisioning, and remote access—create significant challenges for securing data integrity, confidentiality, and availability.

The Evolution of Cloud Security

Cloud security evolved alongside the development of cloud computing technologies. Initially, concerns about security were among the biggest barriers to cloud adoption, with enterprises hesitant to entrust sensitive data to third-party service providers. Over time, cloud providers invested heavily in developing security mechanisms that address both traditional IT security concerns and the novel risks introduced by cloud infrastructures [6] [7]. Traditional data centers operated within a single organizational boundary, where physical and network access controls could be tightly managed. In contrast, cloud environments are shared, decentralized, and accessible over the internet, raising new challenges in protecting against insider threats, external attacks, and accidental data leaks. To mitigate these risks, cloud service providers (CSPs) have implemented a range of security measures, such as encryption, identity management, access controls, and auditing tools. However, securing cloud environments is not solely the responsibility of CSPs; it requires a collaborative effort between providers and users, each responsible for different layers of the security model.

Shared Responsibility Model

One of the foundational concepts in cloud security is the Shared Responsibility Model. In this model, cloud service providers and customers share the responsibility of securing data and infrastructure, though the scope of responsibility varies based on the cloud service model used—Infrastructure as a Service (IaaS), Platform as a Service (PaaS), or Software as a Service (SaaS). IaaS: In an IaaS model, the cloud provider manages the physical data center, servers, and network, while the customer is responsible for securing the operating system, applications, and data. This model provides the greatest control for the user but also demands the most comprehensive security management from the customer's side.

PaaS: In PaaS, the provider also manages the underlying infrastructure and platform (such as operating systems and middleware), leaving customers responsible mainly for securing their applications and data. Security responsibilities here are somewhat reduced for customers but still involve considerable attention to data protection and application security. SaaS: In a SaaS model, the cloud provider handles nearly everything—network, servers, applications, and data storage—while the customer is generally responsible for securing their access credentials and managing user permissions. SaaS users are at the mercy of the provider's security measures, making it critical for customers to carefully evaluate their provider's security practices.

Key Cloud Security Threats

As cloud adoption grows, so does the landscape of threats targeting cloud environments. Some of the most prominent security threats include:

Data Breaches: Data breaches remain one of the most significant threats to cloud security. Multi-tenant cloud environments, where data from multiple customers resides on shared infrastructure, increase the risk of unauthorized access. Breaches can occur due to poor configuration, weak access controls, or vulnerabilities in cloud services. High-profile data breaches, such as the Capital One incident in 2019, underscore the risks posed by misconfigurations in cloud infrastructure [8].

Data Loss: Data loss can occur for a variety of reasons, including accidental deletion, hardware failures, software bugs, and malicious attacks (such as ransomware). In a cloud context, ensuring data redundancy and backup procedures are critical for minimizing the risk of permanent data loss. While replication across multiple data centers can help mitigate this risk, it also requires careful management to ensure consistency and data integrity.

Insider Threats: Cloud environments are particularly vulnerable to insider threats due to the vast number of users with varying levels of access. Employees or administrators of cloud providers, as well as users within an organization, may intentionally or unintentionally misuse their access, leading to data breaches or service disruptions. Insider threats can be mitigated by strong access controls, logging, and continuous monitoring.

Denial of Service (DoS) Attacks: Distributed Denial of Service (DDoS) attacks, which aim to overwhelm cloud services with traffic, can render services unavailable to legitimate users. Cloud providers offer DDoS mitigation tools, such as traffic filtering and load balancing, but large-scale attacks can still cause significant disruptions, especially for smaller providers [9].

Insecure APIs: Application Programming Interfaces (APIs) are widely used in cloud environments to enable integration and automation. However, insecure APIs—those lacking proper authentication, encryption, or access controls—can expose cloud systems to cyberattacks. Ensuring the security of APIs is a critical aspect of cloud security, requiring regular auditing and testing for vulnerabilities.

Account Hijacking: Weak or stolen credentials remain a common attack vector in cloud security. Once attackers gain access to cloud accounts, they can manipulate data, steal sensitive information, or perform malicious activities under the guise of legitimate users. Multifactor authentication (MFA), encryption, and strict access controls are essential defenses against account hijacking.

Background Study of the Data Replication Methodologies

Cloud computing offers numerous advantages such as scalability, flexibility, and cost efficiency. However, ensuring **Quality of Service (QoS)** in a cloud computing environment remains one of the most significant challenges faced by both Cloud Service Providers (CSPs) and users. QoS in cloud computing refers to the overall performance of the cloud system, which includes metrics such as **availability**, **reliability**, **latency**, **bandwidth**, and **error rates**. A high QoS guarantees that users can access services consistently and reliably, without interruptions or delays. Achieving and maintaining this quality is complex due to the dynamic, distributed, and resource-shared nature of cloud environments[10]. This background study explores the major concepts, existing challenges, and solutions in improving QoS in cloud systems.

QoS Metrics in Cloud Computing

To better understand how QoS can be improved, it is essential to identify the key performance indicators (KPIs) or metrics that define the quality of service in cloud computing environments:

Availability: The percentage of time a cloud service is accessible and operational. High availability ensures that services are always accessible to users.

Latency: The time taken to respond to a user request. Lower latency is crucial in performance-sensitive applications such as real-time data processing.

Reliability: The ability of a system to function without failure over a specific time period. High reliability is critical for long-running processes and transactions.

Throughput: The rate at which data is processed and transferred. Ensuring high throughput is necessary for data-intensive applications.

Scalability: The ability to handle increasing workloads by allocating more resources. A scalable system adapts efficiently to demand fluctuations.

Security and Privacy: Although security and privacy are often separate domains, their management affects QoS. Any breaches in security can degrade service quality and customer trust.

LITERATURE REVIEW

Wang, Jinjiang, *et al*[11] proposed strategy, termed LBVMP, seeks to establish a novel framework comprising a balanced flat surface of a physical machine (PM) regarding CPU, RAM, and bandwidth (BW), alongside another proportional flat surface representing the remaining resource capacity of the targeted PM divided by the requested resources (CPU, RAM, and BW) of a virtual machine (VM). Subsequently, LBVMP computes the distance between two plots to assess VM allocation solutions. Xu, Heyang, *et al*. [12] Examined the issue of fault tolerance-aware VM scheduling and articulated it as a multi-objective optimisation model incorporating various QoS constraints. The proposed model aims to minimise customers' overall spending while simultaneously maximising the successful execution rate of their enterprises. A greedy-based best fit decreasing (GBFD) algorithm is then designed to resolve the proposed optimisation model. The GBFD method employs a cost efficiency factor defined by the characteristics of CNs to select an appropriate CN for each VM request. Comprehensive experiments are performed to validate the practicality of the suggested models and algorithms using both real-world CDC cluster datasets and simulated data. Tamilarasu, P., and G. Singaravel [13] An Improved Coati Optimisation Algorithm-based Task Scheduling (ICOATS) is proposed to mitigate prolonged scheduling durations, excessive costs, and increased stress on Virtual Machines (VMs) in cloud computing environments. This suggested ICOATS constructs a model for work distribution and scheduling based on the variables of virtual machines, cost, and time. It also incorporated a multi-objective fitness function aimed for minimising makespan while simultaneously maximising resource utilisation efficiency. It established a potential strategy for each coati about the task scheduling process, which assists in identifying the appropriate assignment of incoming work to virtual machines (VMs). The proposal addresses premature convergence by integrating an exploitation method that enhances local search potential through a well-balanced trade-off between exploration and exploitation.

Rajak, Ranjit, *et al* [14] Task scheduling, characterised by dependencies between activities, is executed by resource allocation via Directed Acyclic Graph (DAG) scheduling. DAG is a crucial scheduling method because to its extensive applicability in various domains, including environmental technology, resource management, and energy optimisation. NP-completeness is a prominent issue, prompting the proposal of numerous models in the literature to address it. Nonetheless, the emergence of Quality of Service (QoS)-aware services in the CCE platform has become a significant and prevalent method for delivering computing resources, presenting a fresh essential challenge. The primary objective of this work is to formulate an innovative Directed Acyclic Graph (DAG) scheduling model to enhance the Quality of Service (QoS) parameters in the CCE platform, which can be validated using comprehensive simulation techniques.

Sharma, Minakshi, Rajneesh Kumar, and Anurag Jain [15] The proposed approach is an expansion of the previously suggested quality of service (QoS)-enabled join minimum loaded queue (JMLQ). The suggested methodology has been evaluated using the CloudSim simulator, and the findings indicate that it outperforms QoS-enabled JMLQ and its variants within the cloud context. Monika, and Om Prakash Sangwan [16] Utilised an innovative backpropagation-based Adaptive Dynamic Programming parameter tuning strategy, incorporating two fundamental prediction methods, to create a self-adaptive intelligent system that offers automatic parameter tuning capabilities for both techniques. To assess the suggested methodology, we conducted a simulation using a real QoS dataset, and the experimental findings indicate superior prediction accuracy relative to conventional methods.

Pakhrudin, Nor Syazwani Mohd, Murizah Kassim, and Azlina Idris [17] The aim of this research is to enhance the efficacy of the existing RR approach for action scheduling in the cloud by reducing the average waiting, turnaround, and response times. The CloudAnalyst tool was employed to refine the RR approach by adjusting parameter values to optimise for high accuracy and cheap cost. The results indicate that the total minimum and maximum response times achieved are 36.69 ms and 650.30 ms, respectively, for a duration of 300 minutes of RR. The expense for the virtual machines (VMs) ranges from $0.50 to $3.00. The duration of usage correlates positively with the expense of data transfer. This research is crucial for enhancing communication and the quality of interactions among groups.

Malla, Parvaz Ahmad, and Sophiya Sheikh [18] Cloud computing systems are recognised as significant consumers of energy resources globally. Moreover, power consumption has emerged as a critical factor since the majority of cloud computing systems rely on conventional nonrenewable energy sources. To render data centres environmentally sustainable, it is essential to implement optimal strategies to minimise energy usage and their detrimental impact on the environment. The primary purpose of this research is to examine several ways for constructing and sustaining an energy-efficient cloud. The paper will thoroughly examine several energy-efficient resource provisioning techniques and present a graphical comparison analysis of Quality of Service (QoS) metrics in cloud computing. Furthermore, the current study delineates the domains requiring enhancement to augment the energy efficiency of cloud computing systems.

Katkar, Alok, *et al* [19] This abstract provides an overview of current achievements in the automated assessment of quality of service in cloud computing systems. Cloud computing architectures provide substantial flexibility and scalability to clients. The total performance of a cloud platform is significantly affected by the quality of service. The quality of service is generally determined by outstanding criteria, including response time, availability, throughput, security, and others. Intelligent approaches have gained increased prominence for enhancing the quality of service monitoring and measuring. These tactics employ Artificial Intelligence (AI) and machine learning (ML) technologies to detect anomalies. Automated measures are implemented to guarantee the maintenance of superior service quality. Tabassum, Nazia, and C. R. K. Reddyy [20] VANET and Cloud Computing will significantly contribute to the advancement of efficient technology for autonomous driving, vehicle control, and intelligent systems in the near future. Cloud computing is a centralised paradigm that fails to adequately manage numerous Quality of Service (QoS) parameters, such as latency, throughput, and bandwidth optimisation. Fog Computing (FC) is established in VANETs to address the constraints of Cloud Computing (CC). The IoV-CC must tackle issues related to security and privacy. Consequently, the security protocols employed in conventional VANET and CC must be revised for IoV-CC, necessitating the development of a new secure algorithm to ensure secure communication between FOG and cloud nodes. Innovating QoS in VANET for IoV-CC faces considerable challenges related to data dissemination and security. This project aims to investigate the data distribution and security acceptability of the Internet of Vehicles (IoV) in relation to centralised and decentralised computer systems.

Arunkumar, J. R. [21] The computer resources of cloud service providers are reassigned dynamically based on demand, with their infrastructure, platform, software, and other resources shared among various corporate and private clients. The continuous rise of cloud computing subscribers utilising shared resources has heightened concerns regarding cloud security. This review article delineates present cloud security challenges and practices, while proposing several creative solutions aimed at enhancing cloud computing security in future domains. Agarwal, Rajesh, and Sanjay Dhingra [22] This research aims to identify the determinants of cloud service quality and evaluate the influence of service quality on customer satisfaction and loyalty. A study with 419 cloud experts/users was executed in India utilising a structured questionnaire based on the Likert scale. The participants were cloud professionals and users utilising the services of the five leading cloud service providers in India. Research hypotheses were evaluated by partial least squares structural equation modelling. The research indicated that agility, service assurance, dependability, scalability, security, service responsiveness, and usability all positively and significantly influence total cloud service quality. The study demonstrated a partly mediating impact of customer satisfaction between service quality and customer loyalty. Service quality exhibits a favourable and strong correlation with customer loyalty and customer satisfaction.

Pawar, Ankush Balaram, Shashikant U. Ghumbre, and Rashmi M. Jogdand [23] This work aims to create and construct a paradigm for authentication and data security in cloud computing. This technique comprises six distinct units: cloud server, data owner, cloud user, inspection authority, attribute authority, and central certified authority. The devised privacy preservation system has multiple stages: setup phase, key creation phase, authentication phase, and data exchange phase. The setup step is initially conducted by the owner, who provides the security attributes, while the key creation stage produces the system master key and the public parameter. Subsequently, the authentication process is conducted to ascertain the security measures of the information system. The data is

ultimately decrypted at the data sharing phase to facilitate data exchange and ensure privacy for confidential information. Furthermore, dynamic splicing is employed, alongside security mechanisms including hashing, Elliptic Curve Cryptography (ECC), Data Encryption Standard-3 (3DES), interpolation, polynomial kernel, and XOR, to safeguard sensitive data. Kirubakaran, S. Stewart, *et al* [24] Formulated a Privacy-Preserved Data Security Approach (PP-DSA) to provide data security and integrity for outsourced data in a Cloud Environment. This work ensures privacy preservation through the Efficient Authentication Technique (EAT), which use the Group Signature method in conjunction with a Third-Party Auditor (TPA). The auditor's responsibility is to safeguard data and ensure the integrity of shared information. Furthermore, the Cloud Service Provider (CSP) and Data User (DU) may also act as the perpetrators that must be addressed by the EAT. The primary aim of this effort is to improve cloud security and thus boost Quality of Service (QoS).

Sindjoung, Miguel Landry Foko, Mthulisi Velempini, and Clémentin Tayou Djamegni [25] Mobile Edge Computing (MEC) relocates computing and storage resources from cloud data centres to edge data centres, positioning them nearer to end-user devices to minimise end-to-end latency in request processing. Nonetheless, MEC is susceptible to security, data privacy, and authentication issues that impact the end-user Quality of Experience (QoE). It is essential to address these difficulties to prevent a subpar user experience resulting from inadequate security or data privacy. This research proposes a hybrid cryptographic system that integrates symmetric and asymmetric cryptographic methods to enhance data security, privacy, and user authentication in a MEC-based network. Guo, Zixuan, and Xuejun Yu [26] utilised the QoS (Quality of Service) of cloud services as the foundational data, derive the subjective weights of these services through AHP hierarchical analysis, ascertain the objective weights via the entropy weighting method, and calculate the recommendation degree for each service through weighting. Concurrently, they evaluate the trustworthiness of cloud services using the TOPSIS decision method, ultimately proposing the development of a cloud service trustworthiness metric model. This methodology mitigates the impact of user evaluation subjectivity on the trustworthiness assessment of cloud services by offering an objective and efficient trustworthiness metric. This study examines the processing of QoS data, the classification of metrics, and the application of the entropy weight approach to get the objective weights of the relevant metrics for cloud services.

Kaliyanandi, Maharajan, *et al* [27] developed a comprehensive strategy for load balancing in cloud computing that incorporates security measures. The Quantum-Based Security Framework has been developed, and the load is equilibrated by fuzzy logic. The primary security policies are effectively evaluated, and service is provided according to the user's specified requirements.The Security Framework devised a technique for cloud data storage by generating check bits in lieu of keys, enabling users to access their data upon verification of the check bits. Only the user may utilise the services and load balancing if the check bits produced by the user and the cloud service provider are same. Mirrored copies are created to mitigate the risk of data loss from failures or outages. This security technique enables us to achieve a high level of security. Liu, Xiaofei [28] The proposed methodology introduces a novel blended technique known as the Integrated Aquila Optimiser (IAO), which combines the traditional Aquila Optimiser (AO) with the Particle Swarm Optimisation (PSO) algorithm. The primary aim of this hybridisation is to address the deficiencies encountered by both AO and PSO algorithms. These algorithms are prone to becoming ensnared in local optima and exhibit restricted solution diversity. The suggested method introduces an innovative transition mechanism that enables appropriate changes between the search operators, assuring ongoing enhancements in the solutions. The transition method enables the algorithm to alternate between AO and PSO when either becomes stagnant or when solution variety diminishes. This adaptability improves the overall performance and efficacy of the hybrid method. The suggested IAO approach undergoes comprehensive testing via experiments done on the Cloudsim simulation platform.

Materwala, H., L. Ismail, and H. S. Hassanein [29] Introduced an innovative Artificial Intelligence QoS-SLA-aware adaptive genetic algorithm (QoS-SLA-AGA) to enhance application execution time for multi-request offloading in a heterogeneous edge-cloud computing environment, accounting for the effects of overlapping multi-request processing and variable vehicle speed. The suggested genetic algorithm incorporates an adjustable penalty function to accommodate the SLA constraints related to latency, processing time, deadlines, CPU, and memory needs.

Numerical investigations and analyses juxtapose our QoS-SLA-AGA with baseline genetic-based, meta-heuristic Particle Swarm Optimisation (PSO), random offloading, All Edge Computing (AEC), and All Cloud Computing (ACC) methodologies. Ali, Munwar, *et al* [30] Proposed a viable method to tackle these concerns with a novel service paradigm termed Confidentiality-based Classification-as-a-Service (C2aaS), which executes data processing by dynamically categorising data depending on its security level in anticipation of cloud storage. Our suggested service model demonstrates superior security for confidential data and effectively mitigates cloud system overloading compared to existing ways.

Research Gap

There are several inherent challenges in ensuring a high QoS in cloud environments due to their architecture and operational nature:

Dynamic Resource Allocation: Cloud environments operate on shared infrastructure, and resource contention can degrade QoS. As users' demands fluctuate, CSPs must allocate computing, storage, and network resources dynamically to ensure consistent performance. Poor resource allocation algorithms can lead to underutilization or resource overloading, both of which negatively affect QoS.

Geographically Distributed Data Centers: Cloud data centers are often distributed across different regions to minimize latency and ensure redundancy. However, geographic distribution introduces the complexity of managing network latency, data replication, and consistency across diverse locations. Ensuring uniform QoS in such scenarios is challenging, especially for global users.

Fault Tolerance and Failover: Faults in hardware, software, or network components can lead to service outages or reduced performance. High fault tolerance mechanisms are required to maintain QoS during failures. Failover strategies must be seamless and fast, ensuring no degradation in service during resource or network failures.

Multi-Tenancy and Resource Sharing: In a cloud environment, resources are shared among multiple tenants (users). While this leads to efficient resource utilization, it also introduces the risk of "noisy neighbors," where the actions of one tenant can negatively affect the performance of others. For example, a tenant running a heavy workload may consume more bandwidth or CPU resources, causing delays for other tenants.

Future Research Direction

Given these challenges, researchers and cloud service providers have proposed various strategies to improve QoS in cloud computing environments.

Dynamic Resource Allocation and Auto-Scaling: Dynamic resource allocation is one of the most effective strategies to ensure QoS. Cloud systems use **auto-scaling** mechanisms that dynamically allocate or deallocate resources based on real-time demand. By leveraging machine learning and predictive analytics, CSPs can forecast usage patterns and allocate resources more efficiently, preventing both resource underutilization and overloading.

Load Balancing Techniques: Load balancing is crucial for distributing workloads evenly across cloud servers. This helps in avoiding overloading specific servers, reducing response times, and maintaining high availability. Different algorithms are used to implement load balancing in cloud environments:

Round Robin: Distributes requests to all servers in a circular fashion.
Least Connections: Sends requests to the server with the fewest active connections, thereby preventing overload.
Dynamic Load Balancing: Uses real-time performance metrics to allocate resources based on current loads.

Service Level Agreements (SLAs):Service Level Agreements (SLAs) are contracts between CSPs and customers, outlining the expected QoS levels, including availability, response time, and performance guarantees. SLAs serve as a

framework for managing user expectations and hold CSPs accountable for performance and QoS failures. CSPs use SLAs to define specific thresholds, penalties, and compensations for non-compliance, incentivizing the maintenance of QoS.

Traffic Management and Network Optimization: Managing network traffic efficiently is essential to improving QoS in cloud systems. Network congestion or inefficient routing can lead to higher latencies and reduced throughput, negatively impacting performance. Advanced traffic management techniques, including Software-Defined Networking (SDN) and Network Function Virtualization (NFV), allow CSPs to dynamically manage network resources, optimize routing, and reduce latency.

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RESEARCH ARTICLE

Machine Learning Classifications for Automatic Sentiment Analysis on Twitter

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ABSTRACT

The number of algorithms that can decipher the tone of social media posts has skyrocketed in the past several years. Regarding the airing of views and opinions in virtual and social media arenas, common thinking is antiquated. These expressions can describe a lot of different feelings and moods. Emotion and sentiment analysis encompass a wide range of methodologies. In favour of studying the positivity or negativity of these utterances, most research disregard the feelings they represent. To find out what these utterances really mean, this study goes beyond sentiment analysis. This work demonstrates that a hybrid rule-based technique may be used to produce an entirely annotated dataset for five emotions: angry, afraid, pleased, sorrowful, and devastated. The proposed approach used all 45,000 of our English-language tweets that had the keywords "COVID-19 and India" in this study's dataset. Support Vector Machine, Stochastic Gradient Boosting, Naive Bayes, Logistic Regression, Random Forest, and Logistic Regression were some of the machine learning classifiers used for sentiment and emotion classification. It has been found that the Support Vector Machine outperformed the other classification methods when we compared them.

Keywords: "COVID-19, Random Forest, machine learning, technique, dataset.

INTRODUCTION

The rise of microblogging in the last several years has greatly increased the accessibility of text that contains emotions. Microblogs' limited character limit has inspired new emotions and prompted people to communicate their ordinary thoughts in real-time. These are not the only textual sources; there are also blogs, social media, emails, and product reviews. In today's Internet-driven society, social media sites are the ideal places to air your grievances. People use several forms of media, including text, images, audio, and video, to express themselves. A vast volume of unstructured and unshaped content is posted on the Internet every second as a result of the overwhelming nature of text communication through social media. In order to comprehend human psychology, it is necessary to quickly examine newly generated data; sentiment analysis, which detects textual polarity, can assist. It processes the data and generates an opinion, be it positive, negative, or neutral, on anything (a person, a brand, a movie, an event, etc.). Sentiment analysis refers to the act of classifying the emotions conveyed in the source material.

In the case of a pandemic, social media sites like Facebook, Twitter, YouTube, etc., play an essential role. Fast and easy, millions of individuals all around the globe can share their thoughts on any number of issues using Twitter. Due to the public nature of this data, Twitter has become a major subject of research. Anyone can view a user's profile and reply to their tweets. Tweets provide a wealth of sentiment data on people's views on a variety of topics. Consequently, we developed an autonomous machine learning sentiment analysis model to determine customer sentiment. Because sentiment analysis isn't always accurate, we need emotion analysis, which can dependably determine how someone is feeling. For the most part, earlier studies on text classification concentrated on sentiment analysis, which assigns positive or negative labels to data, and the vast majority of these datasets were in English. Although neutral sentiments were included in certain studies, analyzing emotions rather than sentiments provides a better understanding of the data. Although there can be no more than two dimensions to a sentiment classification, we use the word "multi-dimensional" to further characterize emotions in this research. English has been the principal target language for the majority of models and tools. Even people for whom English is not a first language often write in English for publications.

Even among academics for whom English is not a first language, the majority use it for both study and writing purposes. Using English and data related to "COVID-19 and India" as our primary examples, we focus on annotation projection as a simple way to generate high-quality English datasets. All things considered, 45,000 English-language tweets concerning "COVID-19 and India" were utilized in order to investigate these mixed rules. This article goes into detail on text classification analysis, sentiment and emotion identification using machine learning, and more. Findings from applicable previous studies on emotion and sentiment analysis are compiled in Section 2 of this work. The methods proposed for assessing the mood and emotion in tweets are discussed in Section 3. Classifiers for machine learning, metrics for performance, techniques for extracting features, annotations for data, text preprocessing, and dataset collection are all components. Section 4 gives the results of the study on feelings and sentiments, and Section 5 concludes the whole endeavor.

REVIEW LITERATURE

Presented the six primary emotion types: sad, angry, disgusted, afraid, and happy. He laid out his major argument in regard to the suggested fundamental emotions. It was proposed a method for generic emotional responses based on psychological observations. With the inclusion of "anticipation" and "trust" in his list of basic emotion categories, Ekman increased the number of his categories from six to eight. Analyzed and rated existing text sentiment analytics and sentiment detection techniques. Also discussed were the problems that arose during the processes. A supervised machine learning system for emotion classification was developed and evaluated. Online and offline classification were the two primary functions it combined. In order to categorize emotions while working offline, a model-generating system named "Emotex" was created. Creating a two-stage framework named "EmotexStream" to categorize the emotion tracking of real-time tweets was necessary for the challenge. Over 90% of the emotions in the

text messages were accurately categorized by the created algorithms, according to their tests. Classified Twitter user sentiment using both supervised and unsupervised algorithms. Making and using a vocabulary was essential for the classification process.

The model's score was determined by use of a Google search engine. Various datasets were subjected to sentiment identification using ML algorithms. Classification at the sentence level based on POS and unigram presence was shown to be the most accurate when additional variables were considered. Examined tweets for tone and emotional content. We collected all the tweets and responses that were subject-specific. Aside from user information, sentiments, emotions, etc., the collection also included text from Twitter. Sentiment and emotion detection in tweets were accomplished using the dataset. A number of user- and tweet-centric attributes formed the basis for the predicted user replies and influence scores. Finally, the latter data was utilized to provide suggestions for users, both generic and personalized, based on their behavior on Twitter. Gather tweets that displayed at least one of the seven main emotions. The 42,000 tweets that comprised the collection fairly reflected all of the human emotions. A vocabulary of over 40,000 words was built from this dataset; each phrase was linked to a weighted vector that represented a particular mood. After cleaning the tweets, we put different sentiment detection systems to the test.

Both lexically-centered and supervised ML-centered categorization were utilized in these methods. An ensemble technique, which utilized several multi-class classifiers trained using the unigram features of the lexicon, was used to finish the evaluation. After comparing the ensemble technique to other methods on both existing datasets and the one created for this study, the results showed that it performed the best. Ensemble classifier uses decision trees, k-nearest neighbors, and '1500' multilayer perceptron. Regardless of the text's regularity or irregularity, it could steadily and properly differentiate between different moods. The basic classifier's parameters were fine-tuned using Tree-structured Parzen Estimator. The 'three' datasets utilized to train the method were ISEAR, OANC, and CrowdFlower, and they involved both regular and irregular phrases. With a detection accuracy of 88.59% for irregular sentences and 99.49% for regular ones, the ensemble classifier proved to be the most effective. The normalizing function introduces a new way to determine tone. Their approach was more precise than the standard sum and mean function. Using the BERT model to analyze the tenor of Twitter data. Tweet locations and mentions of India are the two main pieces of information gathered. During the height of the pandemic, when fear seized people all across the globe, the tweets were compiled. An enormous quantity of anti-COVID-19 sentiment is seen in the sample.

A fully annotated dataset was constructed using eight commonly experienced emotions. In order to determine the intended tone of the text, they developed an algorithm that took the emoji into account. Discovered more about the COVID-19 pandemic's impact on people's physiological well-being through an analysis of worldwide Twitter data. Based on the emojis employed in the expressions, the study identified eight distinct emotional states. Familiarize yourself with the literature on textual emotion recognition, focusing on studies that analyze both overt and covert displays of emotion. The most effective methods are those that combine learning with hybridization and make use of conventional text representation, as demonstrated by the outcomes. Factors that impacted the efficiency of the proposed systems were also highlighted in the poll, including natural language processing tasks, part-of-speech tagging, and parsing. We created a system that can predict and identify emotions in text. Machine learning techniques that were considered for the classification included Decision Tree, k-Nearest Neighbor, Multinomial Naïve Bayes, and Vector support machine. At its core, the paradigm was based on the six core emotions.

METHODOLOGY

Every single tweet in this study is part of a Twitter corpus that we have annotated with fundamental emotions like angry, sad, joyous, and devastated. The corpus was annotated using a combined rule-based method that made use of Natural Language Processing tools. The suggested method will train an artificial classifier to identify attitudes and emotions expressed in tweets. Logistic Regression, Stochastic Gradient Boosting, Naïve Bayes, Support Vector

Machine, Forest Random, and Logistic Regression were among the machine learning classifiers used to categorize the tweets based on the proposed emotions. We used distinctness, evoke, f1-score, and exactness as metrics to assess the classifiers on this corpus. The process of using machine learning classifiers to analyze sentiment and emotion on Twitter is illustrated in Figure 1. The steps of the process are these:

- Twitter Information Gathering
- Data Preprocessing
- Emotion and Sentiment Data Annotation
- Annotating Data for Emotions and Sentiment
- Evaluating Public Opinion
- Analyzing Emotions
- Assessment of Work Performance

Tweets Data Collection

With the help of Academic Research Access, we created a Twitter developer account to collect the required data. A Python-coded application might be registered with this account. The script is written in Python and the Tweepy module, which implements the Twitter API V2, is used to download data. If you want your data collected from Twitter, make sure all the tweets with the phrase "COVID-19 and India" are in English and don't have any retweets. We reduced the dataset by deleting tweets that contained responses, quotations, or retweets so that we could obtain an accurate prediction. The application retrieves the tweets in "JSON" object format, which includes the columns "id," "created_at," "author_id," "lang," and "text" for possible subsequent processing.Gathering Information, the vast majority of datasets found in the real world contain some combination of unclear, noisy, or missing data. Results from data mining operations performed on such disorderly and unexpected data would be inadequate. Data preparation is the only way to get good data. Accordingly, the "Noise" from the Tweets can be eliminated by modifying the raw data according to the preprocessing processes outlined below. The preprocessing entails the following steps:

- Each and every one of the tweets' words were lowercased.
- Removed all digits and punctuation.
- Deleted any and all links, HTML, and URLs from the text.
- Deleted every single emoji from the given text data.
- Edited the text to remove all hashtags.
- A greater variety of abbreviations, acronyms, and shortened words were used.
- A list of stop words provided by NLTK was used to tidy up the text.
- Added fewer gaps to ensure accurate sentence processing.
- Tokenization, which divides a larger piece of text into smaller pieces called tokens, was employed.
- Words were removed from the phrase word for word.
- To simplify the tweet, the procedure of lemmatization is applied to each word.
- The panda library is used to save the pre-processed dataset in a separate dataset, protecting the original downloaded dataset from any potential damage.

Annotating Data on Emotions and Sentiment

Annotation includes analysis of the collected tweets using the NLTK toolkit. The Python software adds sentiment and emotion annotations to tweets. The script assigns a "Positive" or "Negative" attitude to the tweet based on its tone and subjective content. Following the completion of pre-processing, the algorithm employs lemmatization to ascertain the sentiment associated with each word in the tweet. Anger, fear, joy, grief, and broken heart are all examples of such emotions. The two datasets are now ready for further processing.

Annotated Dataset Feature Extraction

Feature extraction refers to the process of converting data into characteristics that can be used in a machine learning model. Numbers are the most common input for machine learning algorithms. Since ML models can't comprehend human language, NLP relies on vectorization. Tokenization, or vectorization, is the process of transforming a list of

messages or tweets into a matrix of vectors. The Bag of Words tool now maps the text or word into numerical vectors. Count Vectorizer and FT-FID can be used to extract these features. Count vectorizer is an easy way to get features out of a document by just counting how many times a word or token appears. A method for assigning relative importance to words or phrases inside a text or corpus is known as Frequency Term-Frequency Inverse text (FT-FID). In this study, we employ FT-FID as a feature extraction method; FT stands for the number of times a phrase or word appears in a tweet, and FID is the weight of the words calculated from their frequency. Due to the fact that the length of each tweet varies, it is possible for a term to occur many times in the dataset. Thus, the following is the formula for FT-FID:

FT=frequency of a word's occurrence in a text

word count of the paper

FID = word count of the paper

The quantity of papers that include the phrase

FTFID=FT∗FID

Sentiment Analysis

Sentiment analysis is a subfield of Natural Language Processing that allows for the extraction of feelings, opinions, reviews, and thoughts from text, audio, video, and social media data. The tweets are categorized as favorable or negative based on sentiment analysis. The sentiment of tweets from our downloaded dataset is examined in this research using Frequency Term-Frequency Inverse Document (FT-FID) and five machine learning classifiers. Then, we evaluate these classifiers' performance using metrics like exactness, evoke, f1-score, and distinctness. We have created sentiment analysis that takes the tweets as input and uses them to measure the subjectivity and polarity of each message. Making use of the Python Textblob package—a wrapper for implementing thewe ran sentiment analysis on the Twitter corpus. Textblob is a great resource for learning the ropes of Natural Language Processing. Each tweet is assigned a subjective and polarity rating using Textblob. The sentiment subjectivity scale encompassed the whole spectrum, from 0 (no sentiment) to 1 (strong negative sentiment). A score between -1 and 1 was used to determine the polarity of each tweet based on its terms. Feelings of negativity are indicated by numbers between -1 and 0, while positive emotions are indicated by scores between 0 and 1.

Classification of Emotions

The process of organizing sentences or documents into a predefined structure is called classification. Separate from one another, rule-based and machine learning-based classification methods are available. Here, we classify tweets according to the emotions they convey using five ML classifiers: angry, scared, happy, sad, and devastated.

Support Vector Machine Classifier

In order to find the best separating hyper-plane with the widest margin to both sides, vector support machine—the most successful binary classifierprimarily searches. The objective is to find a hypothesis that ensures the lowest conceivable true error. An exhaustive description of the operation of the SVM classifier is given in Figure 2 below. It is possible to define the decision boundary, also known as the hyperplane, using the SVM method. Figure 2 shows support vectors, which are the blue and green points, and the margin, which is the distance between the hyperplanes and the support vectors. The optimum hyperplane is the one that maximizes the margin, which is the purpose of SVM.

Bayes Naïve

Naïve Bayes is a fundamental machine learning classification approach that is based on Bayes' Theorem. The Naïve Bayes classifier is a fast, accurate, and dependable method that achieves high accuracy on large datasets. Historically, Naive Bayes classifiers have mostly been used for text classification and analysis. The Naïve Bayes can be described by two words: "Naïve" and "Bayes ". Consequently, Bayes' theorem is applicable:

$P(X|Y)=\frac{P(X|Y)P(X)}{P(Y)}$

the posterior probability of hypothesis X, given the observed event Y, is denoted as P (X|Y). If a hypothesis is correct, then the likelihood probability, denoted as P (Y|X), is high. The prior probability, P(X), is the likelihood of the hypothesis before looking at the evidence, and the marginal probability, P(Y), is the likelihood of the evidence after looking at it. Rational Regression When it comes to supervised machine learning algorithms, logistic regression is among the most popular and user-friendly options. We use logistic regression when our target variable is clear. Logistic Regression is a kind of predictive analysis that uses the idea of probability to make predictions about the future, such as whether the output value will be true or false, zero or one, etc. There are three ways to classify LR: binomial, multinomial, and ordinal. The function of X is predicted by a logistic regression model as P(Y=1). Classification challenges involving LR include cancer cell identification, diabetes prediction, cancer detection, and many more.

Forest unstructured Among the many machine learning algorithms used to solve classification and regression problems, forest random is by far the most effective. The classifier Forest Random uses a random collection of training data to construct a set of decision trees called the Forest Random. The test object's ultimate class will be determined by the majority voting of various decision trees. The combination of several decision trees lowers the noise and improves the accuracy of the outputs. The forest random approach for machine learning is illustrated in picture 4 below. How profitable is a random improvement? The Stochastic Gradient Boosting method has proved successful in solving numerous sparse ML issues. Natural language processing and text classification are just two examples. Stochastic Gradient Descent offers many advantages, including being efficient and easy to utilize. A linear SVM -like SGD Classifier's decision boundary is shown in Figure 5. The SGD classifier uses two arrays, X and Y, just like its forerunners. X contains training samples with n features and n samples. The form of Y is n_samples, and it contains the goal values for the training samples. In each iteration, SGD finds the gradient of the function for a single instance instead of the gradient of the cost function overall.

Evaluation of Results We have calculated the success rate of the classifiers using the f1 score, exactness, distinctness, and evoke as indicators of information retrieval. Provides a rough approximation of the distinctness:

Distinctness=$\frac{TP}{(TP+FP)}$

Where TP is the total number of sentences correctly classified to a category, and FP is the total number of sentences incorrectly classified to a category.

evoke=$\frac{TP}{(TP+FN)}$

Where FN is the number of sentences that were not classified at all and TN is the numbers of sentences marked as being in a particular category and were not.

F1-score= $\frac{\text{Distinctness} \times \text{evoke} \times 2}{(\text{Distinctness} + \text{evoke})}$

The exactness is evaluated as in :

Exactness=$\frac{TP+TN}{(TP+TN+FN+FP)}$

RESULTS

Results for sentiment and emotion categorization using Twitter data using the proposed machine learning model are showcased. For this analysis, we put the proposed model through its paces in Python using our Twitter dataset. A number of classification metrics were employed to evaluate the proposed model, including evoke, distinctness, f1-score, and exactness. The research shows that while some tweets on "COVID-19 and India" are hostile, the vast majority are positive. Table 1 details the results of the performance measures used by the sentiment-based classifiers. When comparing the two methods, the SVM algorithm yields the weighting scheme's highest exactness value and the NB technique the lowest. Tables 2-6 provide the classifiers' results for bitterness, Afraid, delight, sorrow, and heartbroken, along with their exactness, distinctness, evoke, and f1-scores. According to the results, out of all the

expressed emotions, "bitterness" was the most accurately captured. The proposed Machine Learning Model was able to validate more precise emotion classification in the Twitter data when used with the FT-FID weighting method.

CONCLUSION

This study aimed to examine the participants' emotional and mental experiences during the COVID-19 pandemic in India. This project builds a dataset that can show people's thinking for a specific domain so that Twitter data can be used for emotional prediction. In the proposed model, we analyzed the feelings and emotions using a variety of machine learning approaches. Classifiers trained with the proposed term weighting scheme (FT-FID) achieve accuracy levels greater than 85% when it comes to sentiment analysis. When it came to emotional analysis, the SVM classifier got the best results for the proposed emotions, with an approximate accuracy of 95%. In light of the current COVID-19 pandemic, it is more important than ever to monitor and control people's emotional and physical well-being. We grounded our model on worldwide tweets on "COVID-19 and India" since that's where the majority of individuals expressed their anger throughout the pandemic. How resistant are humans to the coronavirus can be uncovered by examining these facts. One way to make this work better is to use ML architectures that can detect and analyze sentiment and emotional classification in text data automatically.

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Table1: The precision with which a machine learning classifier can identify tweet tone

CLASSIFIER	METRICS				
	Sentiment	Exactness	Distinctness	evoke	F1-Score
VSM	P+	0.87	0.97	0.98	0.99
	N-		0.83	0.84	0.85
NB	P+	0.97	0.77	0.78	0.79
	N-		0.99	0.98	0.97
RF	P+	0.92	0.93	0.95	0.96
	N-		0.88	0.89	0.9
LR	P+	0.91	0.94	0.95	0.96
	N-		0.87	0.88	0.89
SGB	P+	0.81	0.91	0.93	0.95
	N-		0.89	0.91	0.92

Table 2 Results of naïve bayes classifier for emotions

Emotions	Exactness	Distinctness	evoke	F1Score
Joyfulness	0.97	0.98	0.92	0.97
Bitterness	0.98	0.98	0.93	0.94
Astonished	0.98	0.98	0.94	0.98
Heartbroken	0.96	0.96	0.94	0.98
Afraid	0.96	0.94	0.95	0.96

Table 3 A vector-support machine classifier's results for emotion classification

Emotions	Exactness	Distinctness	evoke	F1Score
joyfulness	0.95	0	0	0
Bitterness	0.88	0	0	0
Astonished	0.63	0.1	0.1	0
Heartbroken	0.63	0.1	0.1	0.1
Afraid	0.69	0.71	2	0.87

Table 4 - Results from a logistic regression classifier that takes emotions into account

Emotions	Exactness	Distinctness	evoke	F1Score
Joyfulness	0.95	0.98	0.74	0.83
Bitterness	0.96	0.8	0.68	0.77
Astonished	0.95	0.97	0.86	0.94
Heartbroken	0.92	0.98	0.88	0.86
Afraid	0.89	0.87	0.98	0.84

Table 5 - Forest random results for emotions

Emotions	Exactness	Distinctness	evoke	F1Score
Joyfulness	0.78	0	0	0
Bitterness	0.86	0	0	0
Astonished	0.59	0	0	0
Heartbroken	0.59	0	0	0
Afraid	0.67	0.69	2	0.85

Table 6- A boost gradient classifier's emotional outcome

Emotions	Exactness	Distinctness	evoke	F1Score
Joyfulness	0.76	0	0	0
Bitterness	0.86	0	0	0
Astonished	0.79	0	0	0
Heartbroken	0.89	0	0	0
Afraid	0.63	0.65	1	0.85

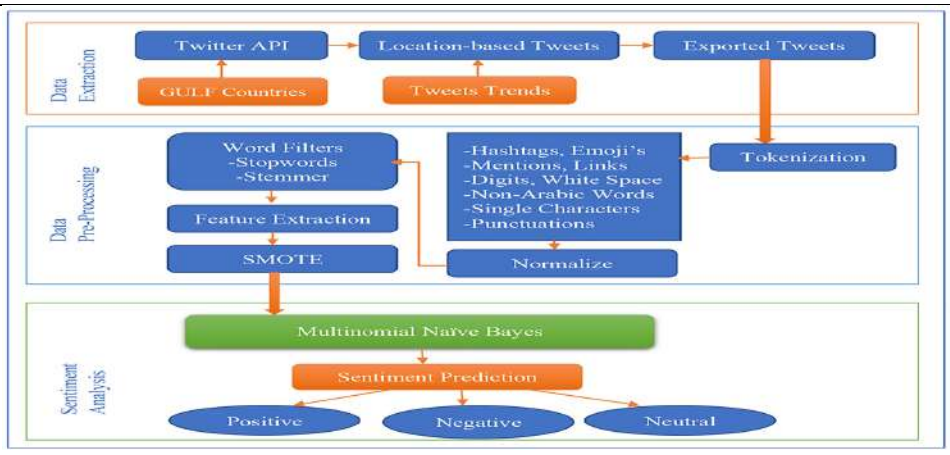


Figure 1:A look at how sentiment and emotion analysis on Twitter work

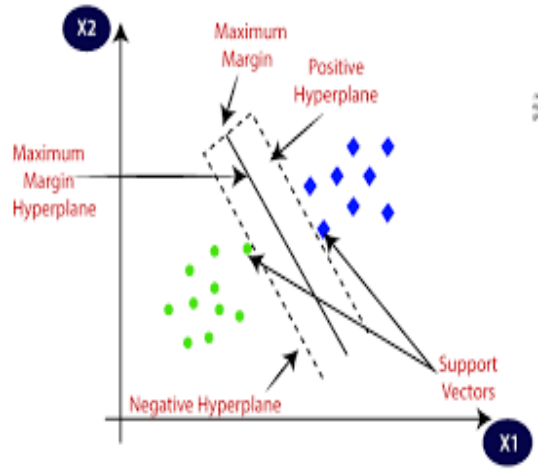


Figure 2: Algorithm for machine learning with vector assistance

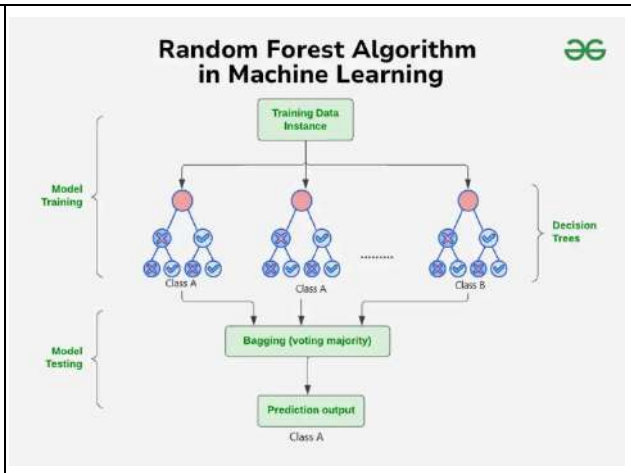


Figure 3: Mathematical Foundations of the Forest Random Algorithm

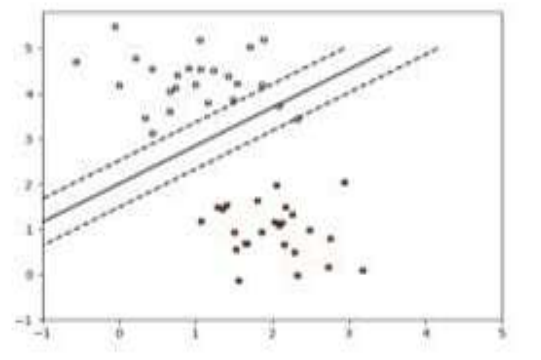


Figure 4 The machine learning algorithm known as Stochastic Boost gradient



Figure 5: Assessment of several emotion analysis classifiers according to their accuracy

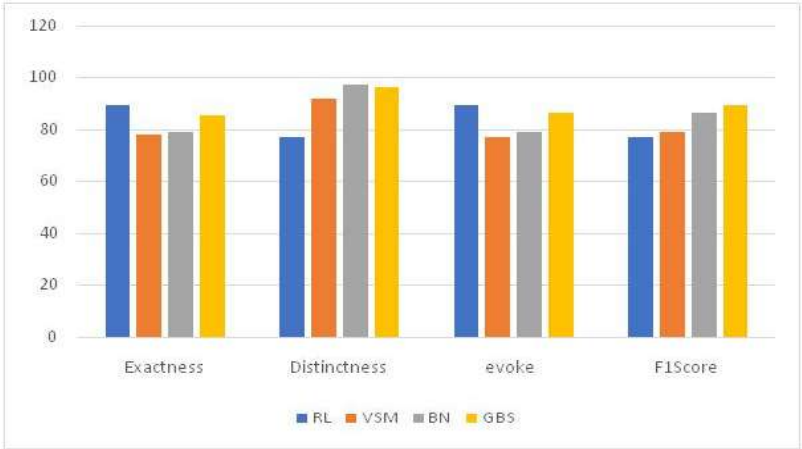


Figure 6 Assessment of several emotion analysis classifiers according to their accuracy

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REVIEW ARTICLE

The Evolution of Massive Open Online Courses (MOOCs): A Comprehensive Literature Review on Their Impact and Effectiveness in Higher Education

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ABSTRACT

This literature review examines the impact of awareness and perception of Massive Open Online Courses (MOOCs) on the e-learning processes among autonomous engineering colleges in Tamil Nadu. As the landscape of higher education increasingly embraces digital platforms, understanding how students perceive and engage with MOOCs is crucial for optimizing educational outcomes. The review synthesizes existing research on various aspects of MOOC utilization, including factors influencing student awareness, the perceived effectiveness of MOOCs in enhancing learning experiences, and the challenges faced by students in accessing these resources. It highlights the role of institutional support, technological infrastructure, and student attitudes towards online learning in shaping perceptions of MOOCs. Additionally, the review explores the correlation between awareness of MOOCs and student engagement levels, academic performance, and overall satisfaction with the e-learning process. By identifying gaps in the current literature and suggesting directions for future research, this study aims to provide insights that can inform policymakers, educators, and institutions in effectively integrating MOOCs into their educational frameworks, thereby enhancing the learning experience for engineering students in Tamil Nadu.

Keywords: Massive Open Online Courses (MOOCs), Autonomous Colleges, Chi-Square Test, Correlation Analysis

INTRODUCTION

The advent of technology has revolutionized the educational landscape, with Massive Open Online Courses (MOOCs) emerging as a significant mode of e-learning. MOOCs offer an unprecedented opportunity for learners to access high-quality educational resources from renowned institutions, transcending geographical barriers and traditional classroom settings. In recent years, particularly within the context of autonomous engineering colleges in Tamil Nadu, there has been a growing interest in understanding the awareness and perception of MOOCs among students and educators alike [1] [2]. Tamil Nadu, a state in southern India known for its strong emphasis on education, is home to numerous autonomous engineering colleges that cater to a diverse student population. These institutions have been pivotal in shaping the technical education sector, producing skilled engineers who contribute significantly to the workforce. However, as educational methodologies evolve, it becomes crucial to assess how well these institutions and their stakeholders are adapting to the integration of e-learning resources, particularly MOOCs. This study aims to fill this gap by investigating the awareness levels and perceptions of MOOC e-learning resources among students and faculty in these colleges[3].

Awareness of MOOCs encompasses the knowledge of their existence, the platforms offering these courses, and the subjects covered. Perception, on the other hand, relates to the attitudes, beliefs, and perceived value of MOOCs in the context of traditional learning paradigms. Understanding these factors is essential for several reasons. Firstly, awareness can significantly influence the adoption of e-learning resources. If students and faculty are not aware of the availability and potential benefits of MOOCs, they are less likely to utilize them effectively. Secondly, perceptions regarding the quality, credibility, and relevance of MOOCs can shape attitudes towards their integration into formal education. Positive perceptions may lead to greater acceptance and usage, while negative perceptions could hinder their implementation [4] [5]. This study will employ a mixed-methods approach, combining quantitative surveys and qualitative interviews to gather comprehensive data on the awareness and perception of MOOCs. The findings will provide valuable insights into the current state of e-learning in autonomous engineering colleges in Tamil Nadu and will highlight potential areas for improvement. Additionally, the study aims to contribute to the broader discourse on the effectiveness of MOOCs as an educational tool and their role in enhancing learning outcomes in higher education. As engineering education continues to evolve in response to technological advancements, it is imperative to assess the awareness and perceptions of MOOC e-learning resources. This study will not only shed light on the current landscape in Tamil Nadu's autonomous engineering colleges but also serve as a foundation for future research and policy-making in the realm of e-learning. By understanding the perspectives of both students and faculty, stakeholders can make informed decisions that will enhance the quality and accessibility of education in this rapidly changing environment.

MASSIVE OPEN ONLINE COURSES (MOOCs)

The concept of Massive Open Online Courses (MOOCs) emerged in the early 2000s, propelled by advancements in technology and the growing demand for accessible, high-quality education. MOOCs are characterized by their ability to accommodate an unlimited number of participants, providing learners worldwide with the opportunity to access educational resources online, often for free or at a minimal cost [6]. The rise of MOOCs has transformed the educational landscape, offering new avenues for learning and challenging traditional educational paradigms.

Origin and Development

The term "MOOC" was first coined in 2008 by Dave Cormier, referring to a course titled "Connectivism and Connective Knowledge," which was designed by George Siemens and Stephen Downes. This course attracted over 2,000 participants, demonstrating the potential of online learning environments to reach large audiences. The initial success of this model prompted the development of other MOOCs, particularly by prominent universities, which sought to leverage their expertise and resources to a global audience [7]. By 2012, MOOCs gained significant traction with the launch of platforms such as Coursera, edX, and Udacity, which partnered with prestigious institutions like Stanford, Harvard, and MIT. These platforms expanded the reach of MOOCs, allowing universities to offer courses

across various disciplines, from computer science and engineering to humanities and social sciences. This period marked a paradigm shift in higher education, where the boundaries of traditional classroom settings were blurred, enabling learners to participate in courses from anywhere in the world.

Characteristics of MOOCs

MOOCs typically feature a range of elements that distinguish them from conventional educational models [8]:

Open Access: MOOCs are designed to be accessible to anyone with an internet connection, removing barriers related to enrollment and tuition fees. This inclusivity promotes lifelong learning and democratizes education.

Massive Scale: MOOCs can accommodate thousands, if not millions, of participants simultaneously. This scalability is facilitated by online platforms that host course materials, discussion forums, and assessments.

Diverse Learning Materials: MOOCs utilize various instructional methods, including video lectures, interactive quizzes, reading materials, and discussion forums. This multimedia approach caters to different learning styles and preferences.

Peer Interaction: Many MOOCs incorporate social learning elements, allowing participants to interact with one another through forums, group projects, and peer assessments. This collaborative environment fosters knowledge exchange and enhances the learning experience.

Self-Paced Learning: MOOCs often allow learners to progress through courses at their own pace, accommodating diverse schedules and learning speeds. This flexibility empowers learners to take ownership of their education.

Impact on Education

The introduction of MOOCs has had profound implications for the education sector. They have expanded access to quality education, particularly for individuals in remote or underserved areas. Moreover, MOOCs have prompted educational institutions to reconsider their teaching methods, curricular offerings, and assessment strategies. The integration of online learning resources into traditional classrooms has encouraged blended learning models, combining face-to-face instruction with online components [9]. However, the rapid proliferation of MOOCs has also raised concerns about their effectiveness, quality, and sustainability. Critics argue that while MOOCs provide access, they may not always deliver the same educational value as traditional classroom experiences. Issues related to course completion rates, learner engagement, and credential recognition have been subjects of ongoing research.

Importance of MOOCs In Engineering Colleges

The integration of Massive Open Online Courses (MOOCs) in engineering colleges represents a significant evolution in the field of technical education. As engineering disciplines rapidly advance due to technological innovations and changing industry demands, traditional educational approaches often struggle to keep pace. MOOCs have emerged as a viable solution, providing flexible, accessible, and diverse learning resources that can enhance the educational experience for engineering students [10].

Addressing Educational Gaps

Engineering colleges face numerous challenges, including the need to keep curricula current and relevant. Traditional classroom instruction may not always offer the breadth and depth of knowledge required for rapidly evolving fields like artificial intelligence, data science, and renewable energy technologies. MOOCs address this gap by providing access to up-to-date content created by experts from leading institutions and organizations. This enables students to explore emerging topics and technologies that may not be fully covered in their formal education. Additionally, MOOCs can supplement the existing curriculum by offering specialized courses that delve deeper into niche areas of engineering. For instance, a student studying mechanical engineering may benefit from a MOOC on

advanced robotics or materials science. This access to diverse content can enrich the learning experience and foster a culture of continuous learning among engineering students.

Enhancing Practical Skills

In engineering education, practical skills are critical for students' success in the workforce. MOOCs often incorporate hands-on projects, simulations, and real-world case studies, allowing learners to apply theoretical concepts in practical contexts. By engaging in these activities, students can develop essential problem-solving skills and gain experience with industry-relevant tools and technologies. This experiential learning is particularly valuable in fields where technical proficiency is crucial, such as software engineering, civil engineering, and electrical engineering. Furthermore, many MOOCs emphasize collaboration and peer learning through discussion forums and group projects. These interactions provide students with opportunities to work in teams, a key competency in engineering careers. Such collaborative experiences help students build soft skills, including communication, teamwork, and adaptability, which are vital for success in the workplace.

Promoting Lifelong Learning

The dynamic nature of the engineering field necessitates a commitment to lifelong learning. As new technologies and methodologies emerge, professionals must continually update their knowledge and skills. MOOCs facilitate this by offering flexible learning pathways that allow both current students and working professionals to engage with new content at their own pace. This adaptability supports the development of a growth mindset, encouraging engineers to seek out new knowledge and skills throughout their careers. Incorporating MOOCs into engineering education also fosters a culture of self-directed learning. Students learn to take initiative in their educational journey, exploring topics of interest beyond their prescribed curricula. This independence is crucial for future engineers, who will need to stay informed and adapt to the changing demands of their industries.

Bridging the Gap Between Academia and Industry

Another significant advantage of MOOCs in engineering colleges is their potential to bridge the gap between academic learning and industry needs. Many MOOCs are developed in collaboration with industry leaders, ensuring that the content is relevant and aligned with current workforce demands. By integrating these courses into their programs, engineering colleges can better prepare students for the challenges they will face in the professional world. Furthermore, MOOCs often provide access to resources such as industry case studies, expert lectures, and insights into best practices. This exposure enhances students' understanding of real-world applications and expectations, making them more competitive in the job market.

LITERATURE REVIEW ON MOOCs

Voudoukis, Nikolaos, and Gerasimos Pagiatakis [11] This study aims to elucidate the concept of Massive Online Open Courses (MOOCs), along with the associated practices, trends, and issues faced by higher education institutions. Despite their brief history, MOOCs experienced significant growth in 2012 when MIT and Harvard established “edX,” former Stanford professors launched “Coursera,” a corporate entity introduced “Udacity,” and the UK’s Open University initiated “Future Learn.” Currently, most academic institutions in the US and Europe provide MOOCs to their students, presenting a diverse array of online courses across various areas, with the option to get a course certificate if desired. The emergence of MOOCs has significantly impacted global higher education, as learners now possess enhanced access and increased options for their education, compelling higher education institutions to reassess their pedagogical strategies and align with contemporary educational trends. Numerous factors motivate students to engage in a MOOC. Zubkov, Artyom [12] This study investigates the challenges associated with utilising massive open online courses to arrange language instruction in foreign languages for aspiring economists enrolled in undergraduate programs at Transport University. The demands of the contemporary labour market and global circumstances necessitate the implementation of novel approaches in the professional training process, and transportation university's foreign language program is no exception. The author examines

massive open online courses in foreign languages as a creative approach to teaching a foreign language to Economics students at Transport University. We looked at the top internet platforms to see if they were relevant to the study question. Massive Open Online Courses (MOOCs) that satisfy state and federal educational standards, STU curriculum, and the disciplines applied at the "English Language" department were chosen.

Laaser, Wolfram [13] The discussion around "massive open online courses" (MOOCs), which first surfaced in 2008 and have since spread like a "Tsunami" among European educators and universities, is summarised in this paper. However, the definition of MOOCs, often known as "disruptive educational innovation," is not very clear, which has caused some annoyance and scepticism. As a result, the concepts that MOOCs are built upon will be discussed, and the pedagogical and technological context will be clarified through in-depth accounts of real-world cases. After laying out the background, the elements that contributed to the initial excitement surrounding MOOCs will be examined, along with the criticism that will soon be levelled at the claims made by those who support them. The ups and downs in expectations surrounding the introduction of educational breakthroughs are well-illustrated by the Gartner hype cycle model. A quick retrospective on earlier advancements in remote learning will be included to enhance the conversation. Agasisti, Tommaso, Giovanni Azzone, and Mara Soncin [14] The purpose of the current study is to evaluate the impact of Massive Open Online Courses (MOOCs) specifically for the purpose of remedial education. The information relates to Politecnico di Milano, the flagship institution of Italy, where a MOOC platform was introduced in accordance with the "MOOCs to bridge the gaps" approach. Thus, the study's objective is to evaluate how finishing a MOOC that served as a physics foundation course affected the students' performance on the ensuing on-campus physics exam (N = 2,830). Propensity Score Matching (PSM) was employed in the study, with the propensity scores being based on the students' academic and personal data.

De Moura, Valéria Feitosa, Cesar Alexandre de Souza, and Adriana Backx Noronha Viana [15] The purpose of this research is to better understand how blended learning can incorporate MOOCs. In order to achieve this, an exploratory case study in the field of Fundamentals of Administration at a Brazilian university was conducted in order to assess three factors: (1) the pedagogical approach and rationale; (2) the pedagogical and instructional design for incorporating the MOOC into the course; and (3) the students' perceptions of the MOOC's quality and value. The findings demonstrate that the MOOC was implemented as a blended learning technique in an introductory course, taking the place of some of the in-person class hours. This allowed for an increase in the number of students per teacher while also increasing student interest in the field. Akhmetshin, Elvir, *et al.* [16] In order to serve the interests of all parties involved in the educational process and national innovation (educational) strategy, this study aims to determine the prerequisites, including pedagogical ones, for the successful development and operation of MOOCs. The current work is grounded in the traditional scientific research methodology, which encompasses a range of scientific techniques like logical analysis of past events, dialectical observation of the environment, conceptual analysis of concepts in relation to their contradictory aspects, determining the causes and relationships between phenomena, abstracting and defining findings, and multiple-thematic comparative research. Sociological surveys are the method used in this study to gather empirical data. Moreover, it makes use of statistical and graphical data processing techniques. Additional techniques used are the examination of pertinent contemporary scientific literature and the synthesis of innovative ideas that show promise for the advancement of universities utilising digital learning technology. In order to interview teachers and students about the proposed research topic, pertinent questionnaires were created. Students' attitudes towards MOOCs and digital instructional technology are generally good.

Arkorful, Valentina, Kwaku Anhwere Barfi, and Nyinaku Odoi Baffour [17] The study looked at how students' perceived knowledge of Massive Open Online Courses (MOOCs) affects their utilisation of them. The study looks at what influences students' utilisation of MOOCs in Ghanaian universities using the Innovation Diffusion Theory and the Technology Acceptance Model. The Statistical Package for the Social Sciences was used to analyse the data. Structural Equation Modelling was used to analyse the data (SEM-Amos). The results demonstrated that students' use of MOOC systems is positively impacted by their perceptions of the systems' perceived usefulness, perceived simplicity of use, compatibility, and observability. However, students' use of MOOCs systems is adversely affected by their perception of the systems' complexity. Guerrero, Maribel, Sohvi Heaton, and David Urbano [18] Over the

past few years, massive open online courses, or MOOCs, have drawn a lot of attention. While the educational and technological components of MOOCs have been extensively discussed in the literature, there is a dearth of actual data supporting MOOCs' impact on university outcomes. To close this gap, this study will examine the relationships between three key areas: (a) ordinary capabilities required to accomplish the university's core strategies (i.e., teaching quality, research quality, and administrative quality); (b) intrapreneurial capabilities required to accomplish the university's entrepreneurial strategy (i.e., MOOC orientation by taking on risks, sensing opportunities, and changing routines to become more innovative and proactive); and (c) the expected outcomes from these strategies (i.e., prestige in teaching/research, drawing in local and international students, and income structure diversification). Results from an analysis of 145 universities worldwide demonstrate that MOOC-based intrapreneurial capabilities both directly and indirectly contribute to the achievement of university outcomes. They do this by mediating the favourable impact of the university's ordinary capabilities on the outcomes of the university.

Li, Yong. [19] 175 students enrolled in the School of Marxism's massive open online courses (MOOCs) at a university in the province of Henan were chosen as responders for this study. Using SPSS22.0, a hierarchical clustering analysis was performed, and k-means clustering was used to categorise learners' learning preferences. Data envelopment analysis (DEA) was used to evaluate the learners' learning efficiency, and a variance test was used to examine the variations in learners' learning styles in learning inputs and learning outputs. The findings showed that four classes could be formed from the learning behavioural markers of MOOC learners using hierarchical clustering analysis. Learning styles can be categorised into four groups based on the outcomes of k-means clustering: high-input-high-output, high-input-low-output, low-input-high-output, and low-input-low-output. Asten, Tamara, and Ekaterina Egorova [20] In order to utilise mass open online courses as an extra educational resource for university students studying foreign languages, this study aims to compile an analytical review of the technologies of these courses, including their goals, objectives, pedagogical features, and technical aspects of the organisation. The study aims to perform a content analysis, categorisation, and generalisation of the findings concerning the pedagogical conditions and attributes of the most exemplary mass open online course examples in the Russian and global educational Internet resource segments. The competence-based and personality-oriented approaches to foreign language instruction at the university form the foundation of the study methodology. In order to achieve this, the study looked at the methodological and organisational aspects of the language courses offered by Universarium, Stepik, Lectorium, edX, Coursera, and Udemy, among other open education platforms. Systematising, condensing, and presenting the primary methodological and organisational features of educational platforms in terms of training structure and language course material was made feasible by the analysis.

Khalid, Asra, *et al*. [21] Information overload is a result of the exponential growth in the availability of online learning resources. Recommender systems that can suggest educational materials to users based on their interests have been presented as a solution to this issue. A massive amount of data is available in MOOCs, and this number grows as more students sign up. Poor quality recommendations are the outcome of traditional recommendation systems' scalability, sparsity, and cold start issues. Moreover, they are inappropriate for the dynamic environment of MOOCs since they are unable to handle the model's gradual updating upon the introduction of new data. Based on this line of inquiry, the authors suggest a unique online recommender system, called NoR-MOOCs, that solves a number of previously documented issues with recommender systems while also being accurate and scaling well with the data. Pampouri, A., *et al* [22] examined the tenets that underpin MOOC development and design, their philosophy and features, the learning theories that underpin them, and the essential components of a successful MOOC. The term MOOCs was coined in 2008 by Stephen Downes and George Siemens, and they can be broadly classified into two groups: cMOOCs, which prioritise participant contributions and social networking, and xMOOCs, which adhere to the behavioural model of learning approach. In summary, MOOCs promote lifelong learning and collaborative approaches, offer free, open, equitable, high-quality training, and may be used for either professional or personal growth, depending on the needs of the individual.

Longhini, Jessica, *et al*. [23] Distance learning has been heavily incorporated into healthcare sciences curricula in response to the recent challenges posed by the Coronavirus 2019 outbreak. Universities have also been urged to

collaborate on learning opportunities in order to maintain educational continuity and the timely integration of newly graduated students into the healthcare system. Decisions on its introduction, however, ought to be backed by current data that can give a summary of the body of knowledge. To map the current status of research on massive open online courses (MOOCs) in undergraduate and graduate health sciences education, as well as the tools and assessment techniques used to quantify learning outcomes, and the elements that have been shown to increase MOOCs' effectiveness. Syahid, Adi, Khairol Anwar Kamri, and Siti Norbaya Azizan [24] carried out to assess MOOC-Open Learning's usefulness according to undergraduate students' opinions. A survey was distributed online to students enrolled in several undergraduate programs at Universiti Tun Hussein Onn Malaysia (UTHM), a public university in Malaysia, using the quantitative approach. According to the study's findings, respondents had generally moderately good evaluations of MOOC-OpenLearning's usability—that is, its utility, ease of use, ease of learning, and satisfaction—as support for their learning process. The results of this study suggest that respondents have serious doubts about MOOC-OpenLearning's usability, and that more research may be necessary to address the new issues that arise with its use.

Tao, Da, *et al*. [25] Within the context of the Technology Acceptance Model (TAM), this study aims to explore important aspects of user acceptance from interface design (i.e., usability), content quality (i.e., perceived quality), and emotional arousal (i.e., perceived enjoyment) of MOOCs. A self-reported questionnaire measuring TAM components and three hypothesised factors derived from MOOC features was distributed to 658 college students. Every path coefficient was found to be statistically significant based on the path analysis findings. Students' behavioural intention to use MOOCs was highly influenced by their perceptions of the courses' ease of use, utility, and enjoyment. Perceived effectiveness of MOOC use was significantly influenced by both behavioural intention and perceived usefulness. Bokova, Tatiana Nikolaevna, and Olga Aleksandrovna Kabanova [26] Using a comparative analysis and a review of the literature, this study tracks the growth of MOOCs and identifies some widely recognised blended learning models for higher education. This essay also makes an effort to illustrate the drawbacks and benefits of incorporating MOOCs into in-person instruction. The results focus on how Russian institutions may employ massively open online courses effectively.

Li, Yao [27] examined, from the standpoint of higher education, how globalisation of MOOCs affects equality in higher education and the growth pattern of MOOCs in higher education in Mainland China. Wong, Billy Tak-ming [28] studied the educational elements of language MOOCs, or massively open online courses, for language acquisition. Providing quick movies and reading materials for independent study, along with machine-graded quizzes for self-evaluation and discussion boards primarily for peer-to-peer communication on course material, is the standard MOOC methodology. The pedagogical aspects of pertinent MOOCs have not yet been thoroughly examined in relation to language acquisition, which has traditionally been viewed as skill development. Shrivastava, Archana, and Ashish Shrivastava [29] sought to ascertain which aspects of the online program are taken into account and calculate how significant a role each plays in the choice to buy. In order to help online education organisations create their product design strategy and draw in clients with the most appealing offering, this study tries to determine the most profitable bundling of these features and their respective levels. The goal of this study paper is to pinpoint the qualities of online learning that consumers take into account when choosing a product. The main characteristics of online education programs were determined using exploratory factor analysis and confirmatory factor analysis.

Zhou, Xinyu, *et al*. [30] The purpose of this research is to investigate the state of AI education in massively open online courses (MOOCs). To better understand the content and delivery strategies of AI education on MOOC platforms, we coded data on course overviews, content outlines, suggested materials, and teaching methodologies after screening 128 sample MOOC courses from ten learning platforms. The findings indicate that: (1) Companies and universities make up the majority of the organisations delivering MOOCs; (2) Coursera and Edx platforms offer the greatest number of ESD-related courses; and (3) the number of courses connected to AI education that have been offered since 2012 has been rising annually. AI courses are currently very popular, with an average enrolment of over 120,000 students; (2) the main content of AI education consists of topics related to typical applications and core

algorithms; (3) the most popular pedagogical methods used in MOOCs at this time are online procedural teaching, task-driven teaching, and online collaborative learning.

Research Gaps

Despite the numerous benefits of MOOCs, their integration into engineering colleges is not without challenges. Issues such as course completion rates, learner engagement, and the recognition of MOOC credentials can affect their perceived value. Engineering colleges must address these concerns by implementing strategies that encourage participation, support learners, and ensure that MOOCs complement traditional educational approaches effectively.
Awareness and Accessibility: While MOOCs offer extensive resources, there is limited research on the level of awareness among students and faculty in Tamil Nadu's engineering colleges. Understanding the extent to which stakeholders are aware of available MOOCs, their features, and how to access them is crucial for promoting their adoption.

Perceptions and Attitudes: Research on the perceptions and attitudes of engineering students and faculty towards MOOCs in Tamil Nadu is scarce. Understanding how learners view the quality, credibility, and relevance of MOOCs compared to traditional classroom learning is vital. This includes exploring any biases or misconceptions that may exist and how they influence the acceptance and use of MOOCs in engineering education.

Impact on Learning Outcomes: While several studies have examined the effectiveness of MOOCs in various educational contexts, there is a need for specific research focused on engineering colleges in Tamil Nadu. Investigating the impact of MOOCs on students' academic performance, retention rates, and skill acquisition can provide valuable insights into their effectiveness as a supplementary educational resource. Additionally, comparative studies between MOOC participants and non-participants could shed light on the tangible benefits of MOOCs in engineering education.

Curriculum Integration: The integration of MOOCs into existing engineering curricula presents challenges and opportunities that require further exploration. Research is needed to identify best practices for incorporating MOOCs into traditional teaching methods, ensuring alignment with academic standards, and addressing potential curricular gaps. Additionally, studies could focus on the development of hybrid learning models that effectively combine MOOCs with face-to-face instruction.

Student Engagement and Completion Rates: Student engagement and course completion rates are critical factors influencing the success of MOOCs. However, there is a lack of research focusing on the specific engagement strategies that can be employed in engineering colleges in Tamil Nadu to enhance participation and motivation among students. Investigating factors that contribute to high dropout rates, such as course design, content relevance, and support mechanisms, is essential for improving completion rates.

Future Research Direction

As MOOCs continue to evolve, various trends are shaping their future. The integration of artificial intelligence and personalized learning technologies is enhancing the adaptability of MOOCs, allowing for tailored learning experiences. Additionally, the development of micro-credentials and stackable courses is creating new pathways for learners to gain recognized qualifications in specific fields. In summary, MOOCs represent a significant development in the educational landscape, offering unprecedented access to learning resources and fostering new ways of knowledge acquisition. As they continue to evolve, ongoing research and assessment of their impact, effectiveness, and potential will be crucial in shaping the future of education. Understanding the dynamics of MOOCs is essential for stakeholders, including educators, policymakers, and learners, as they navigate this transformative era in education.

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RESEARCH ARTICLE

An Ensemble Framework Approach to Crop Type Prediction Using Feature Selection and Multiclass Classification

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ABSTRACT

Crop type classification plays a crucial role in modern agriculture, aiding in yield prediction, resource management, and land-use planning. This paper presents a comprehensive framework for crop type classification utilizing a combination of feature selection techniques, robust classification Algorithm, and a Support Vector Machine (SVM)-based multiclass classification approach. The proposed framework begins with a novel feature selection process that identifies the most relevant attributes from the Agricultural Data and Rainfall data. This feature selection step is essential for reducing data dimensionality, enhancing classification accuracy, and improving model interpretability. Following feature selection, a state-of-the-art multiclass classification strategy based on Support Vector Machines is employed. SVMs are known for their capability to handle high-dimensional data and have demonstrated superior performance in various classification tasks. In this framework, SVMs are adapted to handle multiclass crop type classification efficiently. The model is trained on the selected features and optimized using hyper parameter tuning techniques to ensure robust performance.

Keywords: Crop Classification, Machine Learning, Feature Selection, Classification, Multi-Class Classification, Support Vector Machine

INTRODUCTION

In the realm of modern agriculture and remote sensing, the accurate classification of crop types is a pivotal task with profound implications for crop management, yield prediction, resource allocation, and land-use planning. Accurate identification and mapping of crop types from satellite and aerial imagery have the potential to revolutionize precision agriculture and aid in optimizing farming practices [1] [2]. To achieve this, researchers and practitioners have turned to advanced data-driven techniques, leveraging feature selection, classification algorithms, and multiclass classification strategies. Crop type classification, a subset of remote sensing applications, involves the categorization of agricultural fields into specific crop classes, such as wheat, maize, rice, soybeans, and more. This classification not only informs farmers about the distribution of crops in their fields but also assists in monitoring crop health, identifying pest or disease outbreaks, and guiding decisions related to irrigation and fertilization [3] [4]. This paper delves into the realm of "Crop Type Classification using Feature Selection, Classification, and Multiclass Classification Techniques," where a multidisciplinary approach is adopted to address the challenges and opportunities in this field. We explore the fusion of three fundamental components:

Feature Selection: Remote sensing datasets often contain a multitude of spectral, spatial, and temporal attributes. Feature selection techniques play a vital role in extracting the most informative and discriminative features from this wealth of data. By identifying key features, we can not only reduce dimensionality but also enhance the efficiency and effectiveness of subsequent classification algorithms. The choice of feature selection method can significantly impact the accuracy and computational efficiency of crop type classification models [5][6] [30] [31].

Classification Algorithms: Once relevant features are extracted, the next step is to employ robust classification algorithms capable of accurately categorizing the data into different crop types. These algorithms range from traditional machine learning approaches like decision trees and random forests to more advanced techniques such as support vector machines (SVMs) and deep learning models. The choice of classification algorithm is pivotal to the overall performance and generalization ability of the crop type classification system [7] [8] [25] [26].

Multiclass Classification: Real-world agricultural landscapes are characterized by the coexistence of multiple crop types within the same geographic region. Therefore, a practical crop type classification system must be capable of handling multiclass scenarios where more than two crop types need to be differentiated. Multiclass classification strategies, including one-vs-all, one-vs-one, and softmax-based approaches, become essential to ensure accurate and comprehensive crop type mapping [9] [10] [27] [28] [29]. This paper explores the integration of these three components into a cohesive framework for crop type classification. Through extensive experiments on diverse agricultural datasets, we evaluate the efficacy and performance of different feature selection methods, classification algorithms, and multiclass classification techniques. Ultimately, this research aims to advance the state of the art in crop type classification, providing valuable insights and tools for precision agriculture and sustainable food production.

Related Works

Kalimuthu, M., P. Vaishnavi, and M. Kishore [11] This research study aims to assist novice farmers by utilising machine learning, an advanced technology in crop prediction, to provide guidance on selecting suitable crops for cultivation. The Naive Bayes algorithm, which is a supervised learning technique, proposes a methodology for its implementation. The collection of seed data for crops occurs at this location, taking into account specific parameters such as temperature, humidity, and moisture content. These factors contribute to the favourable conditions necessary for the effective growth of crops. Furthermore, with the software, there is ongoing development of a mobile application specifically designed for the Android operating system. Users are prompted to input factors like as temperature, and their location is automatically retrieved by the programme to initiate the prediction procedure. Nischitha, K., *et al* [12] The system was developed utilising machine learning algorithms with the objective of

enhancing the agricultural practises for the benefit of farmers. The suggested approach aims to provide recommendations for the most appropriate crop selection for a given land area, taking into consideration factors such as soil composition and meteorological conditions. Additionally, the system offers information pertaining to the necessary substance and quantity of fertilisers, as well as the requisite seeds for cultivation. Therefore, with the implementation of the suggested approach, farmers have the ability to cultivate a novel crop variety, potentially leading to an increase in their profit margin, while also mitigating the risk of soil pollution.

Rao, Madhuri Shripathi, *et al* [13] The objective of this study was to identify the optimal model for crop prediction, with the intention of assisting farmers in making informed decisions regarding crop selection, taking into account weather conditions and soil nutrient levels. This study conducted a comparative analysis of commonly used algorithms, namely K-Nearest Neighbour (KNN), Decision Tree, and Random Forest Classifier, employing two distinct criteria, Gini and Entropy. Gupta, Archana, *et al*. [14] Agriculture plays a crucial role in driving economic growth. The maintenance of a healthy biosphere is contingent upon this factor. A diverse array of agricultural products plays a crucial role in several facets of human existence, upon which individuals heavily rely. Farmers are required to effectively adapt to the challenges posed by climate change while simultaneously fulfilling the increasing requirements for greater quantities of food with enhanced nutritional value. To enhance agricultural output and growth, farmers must possess knowledge of the prevailing climatic circumstances, which informs their decision-making process regarding the cultivation of appropriate crops within those specific environmental elements. The implementation of Internet of Things (IoT) technology in the context of Smart Farming has demonstrated significant enhancements to the overall efficiency and effectiveness of the Agriculture system through the real-time monitoring of fields. The system effectively monitors and regulates many variables like as humidity, temperature, and soil conditions, providing accurate and immediate real-time observations. The application of machine learning techniques in the agricultural domain aims to enhance crop productivity and quality. The utilisation of relevant algorithms on the collected data has the potential to facilitate the recommendation of appropriate crops.

Kumar, Y. Jeevan Nagendra, *et al*. [15] Machine learning (ML) plays a vital role in obtaining practical and effective solutions for the problem of crop yield. Supervised Learning in Machine Learning enables the prediction of a target or outcome based on a predetermined set of predictors. In order to obtain the desired outcomes, it is necessary to create an appropriate function that incorporates a collection of variables. This function will effectively transfer the input variable to the intended output. The process of crop yield prediction involves utilising historical data to forecast the anticipated yield of a specific crop. This historical data encompasses various parameters, including temperature, humidity, pH levels, rainfall, and the specific crop being analysed. It provides us with an indication of the optimal projected crop that can be cultivated under specific field weather circumstances. The task of making predictions can be accomplished through the utilisation of a machine learning algorithm known as Random Forest. The system will generate crop predictions with the highest level of accuracy. The random forest approach is employed to generate an optimal crop yield model while minimising the number of models considered. Predicting crop yield in the agricultural sector is highly advantageous. Elavarasan, Dhivya, and PM Durairaj Vincent [16] The present study aims to develop a Deep Recurrent Q-Network model, which is a deep learning algorithm based on Recurrent Neural Network architecture, to predict crop yield using the Q-Learning reinforcement learning method. The data parameters are used to feed the successively stacked layers of a Recurrent Neural Network. The Q-learning network establishes an environment for predicting agricultural productivity by utilising input parameters. The mapping of output values from a Recurrent Neural Network to Q-values is achieved through the utilisation of a linear layer. The reinforcement learning agent utilises a hybrid approach, combining parametric features and a threshold mechanism, to effectively forecast crop yield. Ultimately, the agent obtains a comprehensive score based on its executed actions, aiming to minimise errors and maximise the accuracy of its predictions. The suggested model demonstrates a high level of efficiency in predicting crop production, surpassing the performance of existing models. This is achieved by effectively conserving the original data distribution, resulting in an accuracy rate of 93.7%.

Reddy, D. Jayanarayana, and M. Rudra Kumar [17] I conducted a systematic review that involved the extraction and synthesis of features utilised for the prediction of crop yield, specifically focusing on the cytochrome P450 enzyme

system (CYP). Additionally, a diverse range of methodologies have been developed to analyse crop yield prediction, including approaches derived from artificial intelligence. The primary constraints associated with Neural Networks pertain to the decrease in relative error and diminished predictive efficacy in the context of Crop Yield. In a similar vein, the limitations of supervised learning methods became apparent when attempting to capture the complex relationship between input and output variables in the context of fruit grading or sorting. Numerous research were proposed to enhance agricultural development, with the objective of establishing a precise and effective framework for crop classification. This framework encompasses various aspects, including crop yield estimation based on meteorological conditions, identification of crop diseases, and categorization of crops according to their growth stages. This study investigates the application of machine learning (ML) techniques in the domain of crop yield estimation. It offers a comprehensive examination of the accuracy of these techniques through a detailed analysis. Pant, Janmejay, *et al* [18] This work employs machine learning techniques to forecast the yields of four commonly farmed crops across several regions in India. Once the prediction of crop production is conducted with site-specificity, the application of inputs, such as fertilisers, can be adjusted accordingly based on the anticipated requirements of the crop and soil. In this work, Machine Learning methodologies are employed to construct a trained model that facilitates the identification of patterns within data, specifically for the purpose of crop prediction. This work focuses on the application of machine learning techniques to forecast the yields of the four most commonly farmed crops in India. The crops encompassed in this category are maize, potatoes, rice (paddy), and wheat.

Paudel, Dilli, *et al* [19] The integration of agronomic concepts of crop modelling with machine learning techniques was employed to establish a machine learning baseline for the purpose of forecasting crop yield on a wide scale. The fundamental principle of this workflow is to prioritise consistency, modularity, and reusability. In order to ensure accuracy, the authors prioritised the development of interpretable predictors or features pertaining to crop growth and development, as well as the implementation of machine learning techniques that prevent the inadvertent disclosure of information. The features were generated by the authors through the utilisation of crop simulation outputs, as well as weather, remote sensing, and soil data obtained from the MCYFS database. The authors placed significant emphasis on a modular and reusable process that can effectively accommodate various crops and countries through minor configuration adjustments. The workflow has the capability to execute replicable experiments, such as forecasts made at the beginning or conclusion of a season, by utilising standardised input data in order to achieve findings that can be reproduced. The findings provide a foundation for future enhancements. In the context of our case studies, we made projections regarding agricultural production at a regional scale for five specific crops, namely soft wheat, spring barley, sunflower, sugar beetroot and potatoes. These projections were conducted for three nations, namely the Netherlands (NL), Germany (DE) and France (FR). We conducted a performance comparison between a basic technique lacking predictive ability, which involved predicting either a linear yield trend or the average of the training set. Nishant, Potnuru Sai, *et al*. [20] The study aimed to forecast the agricultural output of several crop varieties cultivated in India. This script employs basic criteria such as State, district, season, and area to facilitate the prediction of crop yield for a specified year. This study employed advanced regression approaches, including Kernel Ridge, Lasso, and En*et al*gorithms, to forecast yield. Additionally, the concept of Stacking Regression was utilised to enhance the algorithms and improve the accuracy of the predictions.

Proposed Framework for Crop Type Prediction Using Machine Learning Techniques

Figure 1 depicts the Proposed Framework for the Crop Type Prediction using Proposed Feature Selection, Classification and Multi Class Classification methods.

Proposed Gain Ratio Differential Evolution Feature Selection (GRDEFS) Method

Feature selection is a critical step in data preprocessing and machine learning model development, as it directly impacts the efficiency and effectiveness of predictive algorithms. This paper introduces the Gain Ratio Differential Evolution Feature Selection (GRDEFS) method [24], a novel and powerful approach designed to address the challenges of feature selection in high-dimensional datasets. GRDEFS combines the Gain Ratio metric, which measures the relevance of features, with the Differential Evolution optimization algorithm, known for its ability to search for global optima efficiently. The GRDEFS method begins by calculating the Gain Ratio for each feature,

providing a quantitative measure of the feature's contribution to the classification task. The Differential Evolution algorithm is then employed to search for an optimal subset of features based on the Gain Ratio values. By treating the feature selection process as an optimization problem, GRDEFS efficiently explores the feature space to identify the subset of features that maximizes classification performance while minimizing dimensionality.

Proposed Optimized Artificial Neural Network (OANN) Classification Method

Artificial Neural Networks (ANNs) have proven to be potent tools for solving intricate classification tasks, but they often face challenges related to convergence and local minima. In this study, we propose an innovative approach that harnesses the strengths of both ANNs and Gradient Boosting Machines (GBMs) to enhance classification accuracy and reduce error rates. The novel method begins by initializing ANN architecture with appropriate hyper parameters. To overcome the convergence and over fitting issues often associated with ANNs, we introduce a GBM-based optimization step. This step acts as a dynamic learning rate controller, adjusting the ANN's weights during training to minimize error rates effectively [25]. The GBM-driven optimization process continuously evaluates the ANN's performance on a validation dataset and updates the network's weights accordingly. This adaptive learning strategy ensures that the ANN converges faster and escapes local minima more efficiently. Additionally, it reduces over fitting by preventing the network from memorizing noise in the training data.

Proposed Enhanced Support Vector Machine based Multi Class Classification Method

Support Vector Machine (SVM) algorithms have gained prominence in the realm of machine learning for their effectiveness in binary classification tasks. However, when extended to multi-class classification scenarios, traditional SVMs encounter challenges related to scalability and interpretability. In this study, we introduce an innovative approach that enhances SVM's multi-class classification performance by integrating it with the Logistic Regression-Based SVM Multiclass Method. The proposed method leverages the robustness of traditional SVMs in capturing non-linear decision boundaries while simultaneously harnessing the simplicity and interpretability of Logistic Regression. The key innovation lies in extending the binary SVM approach to multiple classes, ensuring efficient class separation without compromising computational efficiency. The logistic regression-based SVM multiclass method is seamlessly integrated into the SVM framework to create a unified model that optimizes class separation by considering both the SVM margin and logistic regression loss. This integration provides a balanced trade-off between model complexity and classification accuracy, making it well-suited for various multi-class classification tasks.

RESULT AND DISCUSSION

Performance Metrics

Table 1 depicts the Performance Metrics used in this research work.

Description of the Dataset

The Indian crop yield prediction and estimation dataset are taken from Kaggle repository [23]. The dataset is composed of 7 features. Among the 7 features, state_namefeatures have 33 distinct values, district_name have 646 distinct values, crop_year have19 distinct years, crop features have 124 crops types and season features have 6 seasons. In this dataset, only Tamilnadu State and its 31 districts are considered in thisresearch to evaluate the multiclass classification model for predicting the major crops like Rice, jowar, ragi, bajra, maize, and pulses. For training the model, crop cultivated year of 1997 to 2013 and only three seasons (Kharif, Rabi and Whole Year) are considered since the above-mentioned crops are cultivated during this seasons. Table 2 depicts the description of Indian Crop Yield Estimation Dataset [R].

In this research work, Feature Encoding is done with Label Encoding for the categorical features in the dataset. After the pre-processing step of Label Encoding, the dataset considered inthis research work have one state name (Tamilnadu), 31 districts, 17 years of cropcultivation, 3 seasons of crop cultivation, area and production. So, totally, 54 are obtained after the Feature Encoding. In the feature selection step, Proposed Gain Ratio Differential Evolution

Feature Selection (GRDEFS) method [] is used. The performance of the Proposed Logistic Regression based SVM multiclass (LR-SVM-MC) Method is evaluated with the existing classification techniques like Support Vector Machine (SVM), Logistic Regression Classification (LR) Method and Random Forest (RF) Classification Method using the proposed and existing feature selection methods processed datasets. Table 3 depicts the number of features obtained by original dataset, Proposed GRDEFS, Gain Ratio (GR), and Differential Evolution (DE) based feature selections processed datasets. From the table 3, it is clear that the proposed GRDEFS method gives less number of features than the existing feature selection methods.

Table 4 depicts the Classification Accuracy (in %) obtained by the Proposed LR-SVM-MC, SVM and RF classification methods using feature selection processed datasets. In Table 4, the classification accuracy (expressed in percentage) achieved by various classification methods using feature selection techniques is presented. The methods compared are the Proposed LR-SVM-MC, SVM, LR, and RF. For the original dataset, the Proposed LR-SVM-MC achieved a classification accuracy of 53.76%, while SVM, LR, and RF achieved lower accuracies of 48.23%, 45.67%, and 40.32% respectively. Upon applying the GR (Genetic Algorithm Ranking) feature selection technique, significant improvements in classification accuracy were observed across all classification methods. The Proposed LR-SVM-MC exhibited the highest accuracy of 79.43%, followed by SVM with 67.49%, LR with 66.17%, and RF with 63.52%. When the DE (Differential Evolution) feature selection technique was employed, improvements in accuracy were again seen. The Proposed LR-SVM-MC achieved an accuracy of 60.42%, while SVM, LR, and RF achieved accuracies of 58.39%, 57.42%, and 54.71% respectively.

The Proposed GRDEFS (Genetic Algorithm and Differential Evolution Feature Selection) technique led to the highest accuracy values among all experiments. The Proposed LR-SVM-MC achieved an impressive accuracy of 95.66%, followed by SVM with 83.67%, LR with 89.45%, and RF with 79.22%. Overall, the results highlight the effectiveness of the Proposed LR-SVM-MC and feature selection techniques, particularly the combined GRDEFS approach, in significantly enhancing the classification accuracy of the various classification methods. Table 5 depicts the Recall (in %) obtained by the Proposed LR-SVM-MC, SVM and RF classification methods using feature selection processed datasets.

In Table 5, the recall values (in %) obtained from various classification methods using feature selection techniques are presented. The compared methods are the Proposed LR-SVM-MC, SVM, LR, and RF. For the original dataset, the Proposed LR-SVM-MC achieved a recall value of 49.81%, while SVM, LR, and RF achieved lower recall values of 45.85%, 42.26%, and 40.85% respectively. Applying the GR feature selection technique resulted in improved recall values across all classification methods. The Proposed LR-SVM-MC achieved the highest recall of 73.46%, followed by SVM with 61.30%, LR with 60.62%, and RF with 57.22%. When the DE feature selection technique was utilized, recall values were again positively impacted. The Proposed LR-SVM-MC achieved a recall of 74.39%, while SVM, LR, and RF had recalls of 52.53%, 51.84%, and 48.81% respectively. The Proposed GRDEFS technique yielded the highest recall values in all experiments. The Proposed LR-SVM-MC achieved a substantial recall of 95.32%, followed by SVM with 80.48%, LR with 79.73%, and RF with 75.21%. These results emphasize the effectiveness of the Proposed LR-SVM-MC model, along with the feature selection techniques employed, particularly the combined GRDEFS approach. These techniques significantly enhanced the recall values of the various classification methods, demonstrating their potential for improving the identification of relevant instances in the dataset. Table 6 gives the False Positive Rate (in %) obtained by the Proposed LR-SVM-MC, SVM and RF classification methods using feature selection processed datasets.

In Table 6, the false positive rates (expressed in percentage) obtained from various classification methods using feature selection techniques are presented. The methods compared are the Proposed LR-SVM-MC, SVM, LR, and RF. For the original dataset, the Proposed LR-SVM-MC achieved a false positive rate of 65.51%, while SVM, LR, and RF achieved higher false positive rates of 68.78%, 70.35%, and 72.44% respectively. Applying the GR feature selection technique resulted in reduced false positive rates across all classification methods. The Proposed LR-SVM-MC achieved the lowest false positive rate of 34.81%, followed by SVM with 46.22%, LR with 54.64%, and RF with

59.21%. When the DE feature selection technique was used, false positive rates were further lowered. The Proposed LR-SVM-MC achieved a false positive rate of 34.59%, while SVM, LR, and RF had false positive rates of 41.15%, 52.73%, and 55.87% respectively. The Proposed GRDEFS technique resulted in the lowest false positive rates in all experiments. The Proposed LR-SVM-MC achieved a remarkable false positive rate of 12.58%, followed by SVM with 20.43%, LR with 22.58%, and RF with 35.63%. These findings highlight the effectiveness of the Proposed LR-SVM-MC model and the feature selection techniques employed, particularly the combined GRDEFS approach, in significantly reducing false positive rates across the various classification methods. Table 7 gives the Precision (in %) obtained by the Proposed LR-SVM-MC, SVM and RF classification methods using feature selection processed datasets.

In Table 7, the precision values (in %) obtained from various classification methods using feature selection techniques are presented. The compared methods are the Proposed LR-SVM-MC, SVM, LR, and RF. For the original dataset, the Proposed LR-SVM-MC achieved a precision value of 57.85%, while SVM, LR, and RF achieved lower precision values of 50.53%, 48.77%, and 45.81% respectively. Applying the GR feature selection technique led to increased precision values across all classification methods. The Proposed LR-SVM-MC achieved the highest precision of 88.8%, followed by SVM with 81.73%, LR with 79.26%, and RF with 69.31%. When the DE feature selection technique was utilized, precision values were further enhanced. The Proposed LR-SVM-MC achieved a precision of 83.68%, while SVM, LR, and RF had precisions of 79.47%, 71.13%, and 67.41% respectively. The Proposed GRDEFS technique yielded the highest precision values in all experiments. The Proposed LR-SVM-MC achieved an exceptional precision of 95.72%, followed by SVM with 85.42%, LR with 82.57%, and RF with 78.52%. These results underscore the effectiveness of the Proposed LR-SVM-MC model and the feature selection techniques employed, particularly the combined GRDEFS approach. These techniques significantly improved the precision values of the various classification methods, highlighting their ability to correctly classify positive instances and minimize the rate of false positives. Table 8 gives the Specificity (in %) obtained by the Proposed LR-SVM-MC, SVM and RF classification methods using feature selection processed datasets.

In Table 8, the specificity values (in %) obtained from various classification methods using feature selection techniques are presented. The compared methods are the Proposed LR-SVM-MC, SVM, LR, and RF. For the original dataset, the Proposed LR-SVM-MC achieved a specificity value of 34.49%, while SVM, LR, and RF achieved slightly higher specificity values of 31.22%, 29.65%, and 27.56% respectively. Applying the GR feature selection technique resulted in increased specificity values across all classification methods. The Proposed LR-SVM-MC achieved the highest specificity of 65.19%, followed by SVM with 53.78%, LR with 45.36%, and RF with 40.79%. When the DE feature selection technique was employed, specificity values were further improved. The Proposed LR-SVM-MC achieved a specificity of 65.41%, while SVM, LR, and RF had specificities of 58.85%, 47.27%, and 44.13% respectively. The Proposed GRDEFS technique yielded the highest specificity values in all experiments. The Proposed LR-SVM-MC achieved a notable specificity of 87.42%, followed by SVM with 79.57%, LR with 77.42%, and RF with 64.37%. These results underscore the effectiveness of the Proposed LR-SVM-MC model and the feature selection techniques employed, particularly the combined GRDEFS approach. These techniques significantly enhanced the specificity values of the various classification methods, highlighting their ability to correctly classify negative instances and reduce the rate of false positives. Table 9 depicts the Miss Rate (in %) obtained by the Proposed LR-SVM-MC, SVM and RF classification methods using feature selection processed datasets.

Table 9 presents the Miss Rate (in %) obtained by various classification methods, including Proposed LR-SVM-MC, SVM, Logistic Regression (LR), and Random Forest (RF), when applied to feature selection processed datasets using different feature selection techniques. Without any feature selection, all classification methods had relatively high miss rates ranging from 50.19% to 59.15%. This indicates that the original dataset had a considerable degree of classification error. Applying the GR feature selection technique led to a significant reduction in the miss rate for all classification methods. The miss rates dropped to a range of 26.54% to 42.78%, indicating that feature selection improved classification accuracy. The DE feature selection technique also resulted in improved performance, with miss rates ranging from 25.61% to 51.19%. Similar to GR, DE helped reduce classification errors for all methods. The Proposed GRDEFS feature selection technique produced the lowest miss rates across all classification methods,

ranging from 4.68% to 24.79%. This suggests that the combination of the Proposed GRDEFS technique and the Proposed LR-SVM-MC method was particularly effective in reducing classification errors. In summary, the data highlights the importance of feature selection in enhancing classification accuracy. Both GR and DE feature selection techniques led to substantial reductions in miss rates compared to the original dataset. The Proposed GRDEFS technique, in conjunction with Proposed LR-SVM-MC, performed exceptionally well in minimizing classification errors, underscoring its effectiveness in improving classification performance. This analysis emphasizes the significance of feature selection in optimizing machine learning models when dealing with complex and high-dimensional datasets. Table 10 gives the False Discovery Rate (in %) obtained by the Proposed LR-SVM-MC, SVM and RF classification methods using feature selection processed datasets.

Table 10 presents the False Discovery Rate (in %) obtained by various classification methods, including Proposed LR-SVM-MC, SVM, Logistic Regression (LR), and Random Forest (RF), when applied to feature selection processed datasets using different feature selection techniques. Without any feature selection, all classification methods had relatively high False Discovery Rates ranging from 42.15% to 54.19%. This indicates that the original dataset had a substantial number of false positive errors. Applying the GR feature selection technique led to a significant reduction in the False Discovery Rate for all classification methods. The False Discovery Rates dropped to a range of 11.2% to 30.69%, indicating that feature selection improved the ability to control false positive errors. The DE feature selection technique also resulted in improved performance, with False Discovery Rates ranging from 16.32% to 32.59%. Similar to GR, DE helped reduce false positive errors for all methods. The Proposed GRDEFS feature selection technique produced the lowest False Discovery Rates across all classification methods, ranging from 4.28% to 21.48%. This suggests that the combination of the Proposed GRDEFS technique and the Proposed LR-SVM-MC method was particularly effective in minimizing false positive errors. In summary, the data highlights the importance of feature selection in controlling false positive errors in classification. Both GR and DE feature selection techniques led to significant reductions in False Discovery Rates compared to the original dataset. The Proposed GRDEFS technique, when combined with Proposed LR-SVM-MC, demonstrated exceptional performance in minimizing false positive errors, underlining its effectiveness in improving the precision of classification models.

CONCLUSION

This paper presents a holistic and advanced framework for crop type classification that addresses the critical needs of modern agriculture. By combining feature selection techniques, a robust classification algorithm, and a Support Vector Machine-based multiclass classification approach, it offers a comprehensive solution for crop type prediction. The innovative feature selection process significantly contributes to data dimensionality reduction, improved classification accuracy, and enhanced model interpretability, laying the foundation for more precise and efficient crop classification. Leveraging the power of Support Vector Machines, the framework demonstrates its ability to handle high-dimensional data, thereby ensuring accurate crop type prediction.

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Table 1: Performance Metrics

Metrics	Equation
Accuracy	$\frac{TP + TN}{TP + TN + FP + FN}$
True Positive Rate (TPR) (Sensitivity or Recall)	$\frac{TP}{TP + FN}$
False Positive Rate	$\frac{FP}{FP + TN}$
Precision	$\frac{TP}{FP + TP}$
True Negative Rate (Specificity)	1- False Positive Rate
Miss Rate	1- True Positive Rate
False Discovery Rate	1-Precision

Table 2: Description of Indian Crop Yield Estimation Dataset

Sl.No	Feature Name	Description
1	State_Name	Depicts the state name of the crop obtained (TotalState Count: 33)
2	District_Name	Depicts the district name of the crops obtained(Total District Count: 646)
3	Crop_Year	Gives the crop cultivation year (Number of Years:19)
4	Season	Describes the various seasons that the crop hasbeen cultivated (Total number of Seasons: 6)
5	Crop	Describes the type of crops has been cultivated(Total Number of crop type: 124)
6	Area	Describes the area in sq.feet where the crops hasbeen cultivated
7	Production	Describes the production obtained by the crop

Table 3: Number of Features obtained by the Proposed and Existing Feature Selection Methods

Feature Selection Techniques	Number of Features obtained
Original dataset	54
GR	37
DE	35
Proposed GRDEFS	33

Table 4: Classification Accuracy (in %) obtained by the Proposed LR-SVM-MC, SVM and RF classification methods using feature selection processed datasets

Feature Selection Techniques	Classification Accuracy (in %) by Classification Methods			
	Proposed LR-SVM-MC	SVM	LR	RF
Original dataset	53.76	48.23	45.67	40.32
GR	79.43	67.49	66.17	63.52

DE	71.42	58.39	57.42	54.71
Proposed GRDEFS	95.66	83.67	89.45	79.22

Table 5: Recall (in %) obtained by the Proposed LR-SVM-MC, SVM and RF classification methods using feature selection processed datasets

Feature Selection Techniques	Recall(in %) by Classification Methods			
	Proposed LR-SVM-MC	SVM	LR	RF
Original dataset	49.81	45.85	42.26	40.85
GR	73.46	61.30	60.62	57.22
DE	74.39	52.53	51.84	48.81
Proposed GRDEFS	95.32	80.48	79.73	75.21

Table 6: False Positive Rate (in %) obtained by the Proposed LR-SVM-MC, SVM and RF classification methods using feature selection processed datasets

Feature Selection Techniques	False Positive Rate(in %) by Classification Methods			
	Proposed LR-SVM-MC	SVM	LR	RF
Original dataset	65.51	68.78	70.35	72.44
GR	34.81	46.22	54.64	59.21
DE	34.59	41.15	52.73	55.87
Proposed GRDEFS	12.58	20.43	22.58	35.63

Table 7: Precision (in %) obtained by the Proposed LR-SVM-MC, SVM and RF classification methods using feature selection processed datasets

Feature Selection Techniques	Precision (in %) by Classification Methods			
	Proposed LR-SVM-MC	SVM	LR	RF
Original dataset	57.85	50.53	48.77	45.81
GR	88.8	81.73	79.26	69.31
DE	83.68	79.47	71.13	67.41
Proposed GRDEFS	95.72	85.42	82.57	78.52

Table 8: Specificity (in %) obtained by the Proposed LR-SVM-MC, SVM and RF classification methods using feature selection processed datasets

Feature Selection Techniques	Specificity(in %) by Classification Methods			
	Proposed LR-SVM-MC	SVM	LR	RF
Original dataset	34.49	31.22	29.65	27.56
GR	65.19	53.78	45.36	40.79
DE	65.41	58.85	47.27	44.13
Proposed GRDEFS	87.42	79.57	77.42	64.37

Table 9: Miss Rate (in %) obtained by the Proposed LR-SVM-MC, SVM and RF classification methods using feature selection processed datasets

Feature Selection Techniques	Miss Rate(in %) by Classification Methods			
	Proposed LR-SVM-MC	SVM	LR	RF
Original dataset	50.19	54.15	57.74	59.15
GR	26.54	38.7	39.38	42.78
DE	25.61	47.47	48.16	51.19
Proposed GRDEFS	4.68	19.52	20.27	24.79

Table 10: False Discovery Rate (in %) obtained by the Proposed LR-SVM-MC, SVM and RF classification methods using feature selection processed datasets

Feature Selection Techniques	False Discovery Rate (in %) by Classification Methods			
	Proposed LR-SVM-MC	SVM	LR	RF
Original dataset	42.15	49.47	51.23	54.19
GR	11.2	18.27	20.74	30.69
DE	16.32	20.53	28.87	32.59
Proposed GRDEFS	4.28	14.58	17.43	21.48

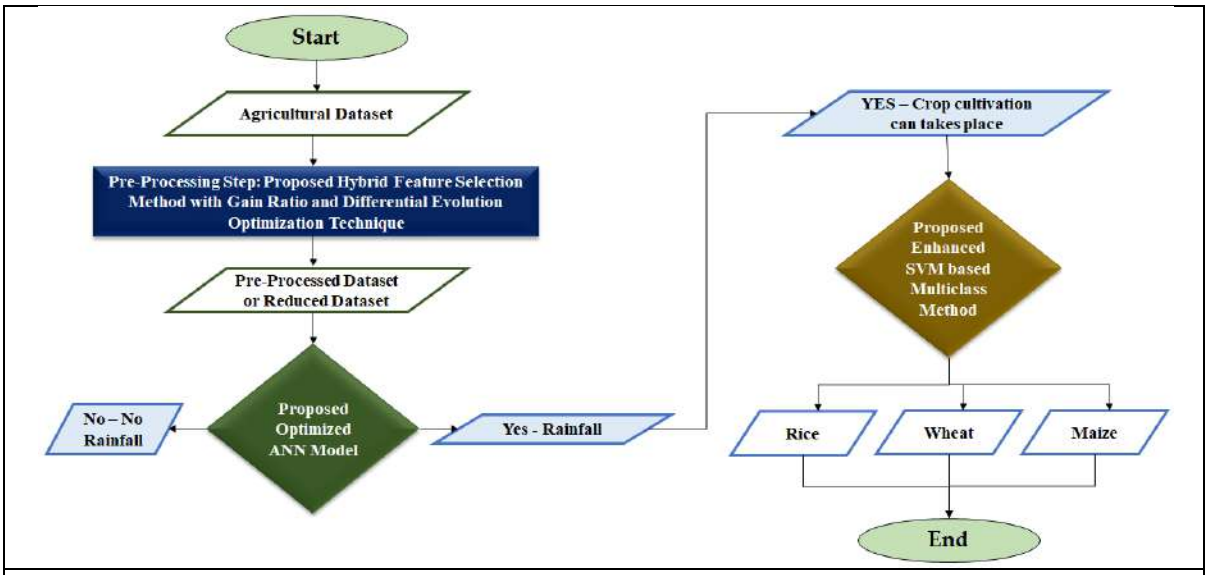


Figure 1: Proposed Framework for the Crop Type Prediction using Machine Learning Methods

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RESEARCH ARTICLE

Early Diagnosis of Type II Diabetes Prediction on Real Time Data Using Machine Learning Algorithm

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ABSTRACT

From a global health perspective, Type II Diabetes is emerging as an ever increasing challenge: it has almost reached epidemic proportions and its complications constitute one of the important causes of mortality for deaths in European countries. An early diagnosis is very important for a better management of the problem and to prevent further complications in health. The research demonstrated in this paper deals with early detection of Type II Diabetes, [sic] using real time data and classification algorithm (namely Random Forest). We use Random Forest a robust and accurate algorithm, to predict the high-risk of an individual by biomedical markers as well lifestyle factors. The model is thoroughly tested with k-fold cross-validation to make an unbiased and better generalizer by dividing the dataset into various subsets. The study uses a large real-time dataset that covers numerous variables like blood glucose, body mass index (BMI), age, high/low blood pressure and family history of diabetes. The Random Forest algorithm takes the approach of ensemble learning in which it forms multiple decision trees and compile their predictions to increase accuracy with a decrease over fitting. Running a k-fold cross-validation helps even more in making our model reliable by taking averages of multiple evaluation metrics after training the model on various splits, thereby ensuring an unbiased evaluation of how good or bad your algorithm will generalize. The results indicate that the Random Forest classifier performs a good prediction on real time data for predicting Type II Diabetes with F1, Sensitivity and Specificity up to almost 90% in each case. The model was found to be adequately reliable for early detection of LD (Table), based on its

performance indicators, which include precision and recall as well mean area under receiver operating characteristic curve.

Keywords: Machine Learning, Random Forest, Diabetes, Health care, K-fold, BMI.

INTRODUCTION

Type II Diabetes Mellitus is diagnosed as an impaired tissue sensitivity/insulin resistance to insulin and the lack of ability by B cells in secreting more insulin sufficient enough for preventing hyperglycemia. Factors such as aging populations, unhealthy diets combined with a rise in obesity and physical inactivity have ensured that globally the incidence of Type II diabetes is going up. This has made it a major public health issue, now with serious consequences such as cardiovascular disease; kidney failure neuropathies and retinopathies. Early diagnosis and intervention in these cases is essential to prevent these complications, improve patient outcomes and reduce the burden on healthcare systems metrics. Traditional way for diagnosing Type II Diabetes are clinical examination in addition to blood tests followed by which the disease is usually caught at a stage when it has come long-way into progression. Yet as we continue to improve the utility of prediction models within data science and machine learning; there are increasing efforts for modeling patient populations that have not yet displayed clinically-significant symptoms from developing Type II Diabetes. In turn, models like this could greatly assist in the transformation of preventative care by allowing early intervention and individualized medicine.

This research work is intended to build a real time data based predictive model for early identification of Type II Diabetes using Random Forest classification technique.... Given this large and high-dimensional dataset, the ensemble method Random Forest can be a good choice as well because of its robustness to overfitting (large amount features) yet still able to capture complex interactions between variables. Aggregating and analyzing data from real-time sources including biomedical markers, contextual lifestyle factors and demographic information to uncover patterns that correlate with increased risk of developing Type II Diabetes. Using k-fold cross-validation is a primary evaluation technique in the study to ensure that the predictive model not only can be applied on an unseen set of data, but also perform better than random guess. K-fold cross-validation splits the dataset in K subsets and trains on k-1 of these subsets while evaluating the model other remaining one. This is done k times and each fold will be used as a test once, the results are then averaged to give an accurate estimate of how well the model will perform on unseen samples. This way the model not only is less prone to overfitting, it also ensures that its predictive accuracy remains more or less consistent across different subsets of data. This paper covers the application of Random Forest classification for predicting onset of Type II diabetes in real-time and concentrate on early identification among at-risk patients. The intent of the study is to strengthen approaches for more accurate, sensitive and timely diagnostic tools in diagnosis management of Type II Diabetes by coupling contemporary machine learning methods with robust ade quant evaluation.

These results contribute significantly to predictive analytics in health care, specifically for early detection of Type II Diabetes:

- This work outlines an approach to design a new predictive model for the early diagnosis of Type II Diabetes based on real-time information and Random Forest classification technique. The model integrates broadly-based biomedical, lifestyle and demographic variables to provide a full systems analysis capable of identifying at-risk individuals prior to the onset of clinical symptom.
- The study demonstrates that the Random Forest algorithm is suitable for high-dimensional data, and can pick up non-linear interactions between variables.
- The effectiveness of the model is evaluated using k-fold cross-validation which ensures that it perform robustly on any set new unseen samples.

- The predictive model with real-time data contributes most eminently, by providing a more interactive and dynamic risk evaluation.
- The research however also is of relevance to the wider field of preventive healthcare, in as much as it supplies a method for both experts and (potentially) patients themselves to identify those at high risk before Type II Diabetes appears with all its very obvious symptoms.

LITERATURE SURVEY

An especially important research focus has been on the early detection of Type II Diabetes with many data sources and predictive models investigated to improve the accuracy and timeliness of diagnosis. This literature review follows the progression of work in this area, taking into account both machine learning methodologies (Random Forest classification), and incorporating real time data into predictor models. Numerous machine learning techniques have been used for predicting the onset of type 2 diabetes from various related input variables, these include classifiers such as support vector machines (SVM), decision trees and neural networks amongst others alongside ensemble-based models like Random Forest. Research by Xing *et al.* (2019) which compared various classifiers and concluded that Random Forest is superior e.g., in terms of accuracy, but also robustness for large or at least more complex data. Pima Indian Diabetes Dataset (PIDD) is widely employed in many studies as a benchmark which observed Random Forest exceeding desirable metric of Precision and Recall i.e. Efficiency to predict diabetes.

Introduced by Breiman (2001), the Random Forest algorithm is an ensemble learning method that constructs a collection of decision trees during training and outputs the mode or mean prediction of the individual trees. Studies such as Zhang *et al*. Random Forest's appropriateness with respect to medical data and its capability for higher-dimensional feature spaces other than the ability of capturing interactions has specifically been pointed out by Chen *et al*. (2020). Research by López *et al*. Recently McKinzie *et al*., (2021) confirmed that feature selection techniques also improves the performance of Random Forest in diabetes prediction, and they improve its false positive rate by reducing model complexity. Efforts have also been made to incorporate real-time data into the prediction models for Type II Diabetes to help increase accuracy of predictions in assessing research misconception by health services and policy researchers. Mujumdar and Vaidehi (2017) contributed to the development of diabetes prediction models by using real-time electronic health records (EHRs) although their main focus remained static data sources. Studies, such as Choi *et al* (2008)., have also used RMT technology like continuous glucose monitoring (CGM), and practical sensors to offer a more accurate prediction of diabetes in real-time.

K-fold cross-validation has been widely used for the evaluation of predictive models, to ensure robustness in performance metrics. Kohavi [8] emphasized that using k- fold cross-validation to evaluate machine learning models is a general practice, which diminishes bias and variance introduced by the data in model estimation. Patel *et al*. (2019), in the domain of diabetes prediction also validated their Random Forest model using 10-fold cross-validation, which allowed them to reproduce and generalize the results across different data partitions. The method has been very successful in sparse data situations where the risk of over-fitting is important. Random Forest also ranked well in comparison with other machine learning methods for predicting diabetes from clinical data. For example, Alghamdi *et al*. In an empirical comparison, Krompaß and Weidlich (2020) evaluated the performance of Random Forest to Logistic Regression, SVMs/SVCs, GBMs : Gradient Boosting Machines for this scenario indicating that Random Forest is a robust trade-off among interpretable model. Hyperparameter tuning and feature engineering, as well are found to improve the performance of Random Forests immensely, a fact experimentally proven by study conducted by Rahman *et al*. (2021) in which the number of trees and the depth were optimizing to increased model accuracy. Even though the Random Forest method and real-time data integration has been successful in our diabetes prediction, many challenges still persist. Such challenges include inadequate broad data to thrive on population-wide variation and uncertainty, a classic hallmark of studies in personalized medicine; together with difficulties regarding even the more restricted genomic datatypes encompassing subjective lifestyle measures. The possible future research

as suggested by Zhou *et al*. (2022), should develop more intelligible models for not only forecasting time-to-diabetes but also underlying risk factors to guide demographic specific prevention strategies,

Proposed Work

By developing a novel approach to the problem of early diagnosis with real-time data and using Random Forest classifier classifies tests results for Type II Diabetes, validated by k-fold cross-validation this work provides several important contributions to healthcare analytics. Here we present a fresh idea for diabetes prediction by using the real-time data, which is up to-date biomedical and life-style information. In contrast to traditional models that require static datasets, this research shows how real-time data can enhance the accuracy and timeliness of predictions in a continuously changing environment. Machine learning based framework is proposed and developed to predict T-IIDM with the help of lifestyle indicators. The procedural flow from data acquisition to experimental results is depicted in the framework presented by Figure 1.

We employ an ensemble learning framework to provide better predictions of T2DM based on the lifestyle indicators. Sequentially steps which were performed for the development of framework Canvas:

- Initially we imported Type 2 diabetes mellitus dataset from database into Jupyter Notebook using Python programming.
- We have applied the preprocessing techniques to verify the missing values, outliers, corrupted and inconsistent data samples if any.
- The data is being split into training and testing datasets in the ratio of 75% of dataset to train different EL models, while other 25% was used for validation.
- We have used 10-fold cross validation to validate the accuracy of all classifiers.
- This paper compares a number of statistical measurements such as, accuracy, precision, recall and F1-score etc to identify the optimal EL model for T2DM prediction.

Pre-Processing

Data pre-processing is an essential step in any machine learning model development where the raw data gets transformed into a more appropriate format which can be used by different algorithms. This phase guarantees that the data is consistent, tidy and suitable for analysis.

Data Cleaning

Data cleaning Dealing with missing values, outliers and data inconsistency

Handling Missing Values

Missing data may be addressed by either imputing the missing values or removing them. Imputation methods use mathematical approaches to approximate and complete missing data.

Mean Imputation

If a feature x_j has missing values, they may be substituted with the average of the available values.

$$x'_{i,j} = \frac{1}{N_j}\sum_{i=1}^{N_j} x_{i,j} \;\forall\; i \; where \; x_{i,j} \; is \; missing \quad (1)$$

N_j is the count of observations that are not missing for feature j.

Outlier Detection

Outliers are exceptional data points that have the potential to skew analytical results.

Z-Score method

To standardize data and detect outliers, we might consider values that deviate from the mean μ by a specific number of standard deviations σ.

$z_{i,j} = \frac{x_{i,j-\mu_j}}{\sigma_j}$ (2)

An outlier is typically defined as $|z_{i,j}| > 3$.

Interquartile Range (IQR) Method

An outlier is defined as a number that falls beyond the range determined by the first quartile Q_1 and the third quartile Q_3.

$IQR = Q_3 - Q_1$ (3)

Outliers are values outside $[Q_1 - 1.5\,X\,IQR, Q_3 + 1.5XIQR]$

Feature Extraction and Selection

In this paper, we make an attempt to build effective and accurate Type II Diabetes prediction model that can predict using real-time data by feature extraction and selection. Such techniques can reduce dimensionality, help the model learn better and make sure we use only those features that are most important for a prediction. Central to these routines is the construction of a predictive model, and as such mathematical algorithms like PCA (Principal Component Analysis), mutual information, RFE based feature selection or Lasso must be performed prior this task so that it results in a performant & interpretable predictive model.

Filter Methods

Filter approaches use statistical metrics to rank attributes and then choose the most significant ones.

Mutual Information

Mutual information quantifies the level of interdependence between two variables. Feature X_j and target are defined as follows:

$I(X_j, Y) = \sum_{x_j \in X_j} \sum_{y \epsilon\, Y} p(x_i, y) log \frac{p(x_j,y)}{p(x_j)p(y)}$ (4)

Variables with more mutual information have a stronger predictive power for the target variable.

Chi-Square Test

The chi-square test may be used to evaluate the independence between category characteristics and the target variable.

$\boldsymbol{X^2} = \frac{(O_i - E_i)^2}{E_i}$ (5)

$O_i$and E_i represent the observed and predicted frequencies, respectively.

Feature Selection

Recursive Feature Elimination (RFE)

RFE (Recursive Feature Elimination) is a method that iteratively eliminates the least significant features by considering the coefficients of the model. The RFE algorithm proceeds as follows for a model $f(x)$ with features $X = \{X_1, X_{2,\ldots\ldots\ldots} X_p\}$,:

- Train the model using all the features in the dataset.
- Assign relevance ratings to the features based on their coefficients in linear models and rank them accordingly.
- Eliminate the aspect of least significance.
- Iteratively retrain the model and continue this process until the required number of features is achieved.

Random Forest Feature Importance

Random Forest, an ensemble of decision trees, can compute the importance of each feature based on how much each feature decreases the impurity (Gini index or entropy) in the trees.

For each feature X_j, the importance score $I(X_j)$ is:

$I(X_j) = \sum_{t=1}^{T}[I(G_{before}) - I(G_{after})]$ (6)

Where G_{before} and G_{after} are the Gini indices before and after the split on feature X_j in tree t.

Classification

Various tools and techniques were applied for the implementation of proposed framework, to design the EL models in case on predicting T2DM. An open source software toolkit of Anaconda 2020 and Experimental language is python(3.9.1) along with it IDE used Jupyter Notebook for computation.

Random Forest is a versatile and simple ensemble learning method for classification and regression class methods. It constructs several decision trees and then combines them in order to provide a better prediction than a single tree. Concept of Random Forest Random Forest is Ensemble method and it used multiple Decision Trees to Improve Classification Accuracy. Each tree in the forest is constructed based on a random sample from both data and features, final predictions are an average of all trees (in case of regression) or majority vote for each class (classification task).

Algorithm 1: Early prediction of T-IIDM using RF

Input: Data Collected from people

Output: Prediction of T-II DM

Step 1: Calculate Boot Strap Sampling

Generate m bootstrap samples, $D_1, D_2, \ldots . D_m$, from the original dataset D containing n samples. Each bootstrap sample is created by randomly selecting instances from D with replacement.

Step 2: Select Feature Subset Selection

Randomly choose a subset of k features from the whole collection of p features for each decision tree. This stochasticity aids in decorrelating the trees.

At each node, choose k features from the total p features $\{X_1, X_2, \ldots . X_p\}$ in a random manner.

This extract may be designated as:

Feature subset at node j: $F_j \subseteq \{X_1, X_2, \ldots . X_p\}$, with $|F_j| = k$ (7)

Step 3: Construct the decision tree

For every bootstrap sample D_i and its matching feature subset, construct a decision tree T_i until it reaches its maximum depth (or until a halting requirement is satisfied). The optimal split at each node is found by evaluating a criteria such as Gini impurity or entropy.

Step 4: Calculate the Gini impuriy

At each node t calculate the Gini impurity $G(t)$ for a binary classification task:

$G(t) = 1 - \sum_{i=1}^{C} p_i^2$ (8)

Let p_i represent the percentage of examples belonging to class i at node t, and let C be the total number of classes. The split that is selected is the one that minimizes the weighted average Gini impurity across the child nodes.

$\Delta G = G(t) - \frac{n_L}{n} G(t_L) + \frac{n_R}{n} G(t_R)$ (9)

Let t_L and t_R represent the left and right child nodes, respectively, and n_L and n_R denote the number of occurrences in each child node.

Step 4: Calculate Entropy (Information Gain)

Entropy at a node t is defined as:

$H(t) = -\sum_{i=1}^{C} p_i \log_2(p_i)$ (10)

Information gain for a split is:

$\Delta H = H(t) - \frac{n_L}{n} H(t_L) + \frac{n_R}{n} H(t_R)$ (11)

Step 4: Voting

In classification tasks, each tree within the forest contributes to a class vote, and the ultimate prediction is determined by the majority vote. In regression tasks, the predictions are computed by taking the average.

In the classification process, each tree $T_i$generates a prediction y_i' for a given input x. The ultimate forecast $y_i$is acquired via a process of majority vote.

$y' = mode(y_1', y_2' \ldots\ldots\ldots y_m')$ (12)

RESULT AND DISCUSSION

Data set Collection

Survey and Google-form based data bases collected from Kishtwar district-Rajouri geographical belt of Jammu & Kashmir, India. Experts like Diabetologists, Endocrinologists for Disease wise selection of parameters have been different; so are the professionals: Dieticians/Nutritionist etc. The dataset has 1978 (987 — non-diabetic and 991– diabetic) instances with a total of T2DM 11 features based on lifestyle properties aiming to maintain health, treat or avoid problems. Table 1List of the biological features with their Description, Class and Data Type. The data in this study was personal medical history and results from the population of each group. Dataset primary goal The main aim of the dataset used for this study is to be able predict whether a patient will suffer from diabetes or not, based on some lifestyle indicators with machine learning. Based on the Asides the selected features provided in the dataset, it predict as well that are possible patients and how positive they might be of having this disease. Also dataset which have used is good composition of the patients includes people from different location, male female ratio patents in class (Urban and Ruler) all age groups including adults. The dataset were collected with survey and google forms prepared in csv file to perform the prediction of T-II DM through different models forest model for this. The dataset description is used to compute several descriptive statistical measures of the dataset. The describe() function of a Data Frame [160] is used to provide a comprehensive summary of the dataset's parameters. Table 2 displays the calculation of statistical metrics such as count, mean, standard deviation, minimum, percentile, maximum, and other numerical values for the Data Frame.

Performance Analysis

When assessing the performance of a Classification task, many metrics may be used based on the unique objectives and kinds of tasks, such as classification, segmentation, and object identification. Below are some of the parameters utilized for performance metrics:

Accuracy: The accuracy is defined as the proportion of properly identified photos to the total number of images.

$\boldsymbol{Accuracy} = \frac{\boldsymbol{True\ positives + True\ Negatives}}{\boldsymbol{Total\ samples}}$ (13)

Precision: The precision is defined as the number of true positive predictions divided by the total number of positive predictions.

$\boldsymbol{Precision} = \frac{\boldsymbol{True\ positives}}{\boldsymbol{True\ Posiives + False\ Positives}}$ (14)

Recall: The accuracy is defined as the proportion of accurately predicted positive observations to the total number of observations in the actual class.

$\boldsymbol{Recall} = \frac{\boldsymbol{True\ positives}}{\boldsymbol{True\ Posiives + False\ Negatives}}$ (15)

F-1 score: The harmonic mean of Precision and Recall is calculated by taking the reciprocal of the arithmetic mean of their reciprocals.

$$F1 - Score = 2X\frac{Precison\ X\ Recall}{Preciosn+Recall} \quad (16)$$

Histogram Plot for data in Table 2:

Histogram is an instrument for visualization used in case the data comes from some groups. Continuous/discrete variable distribution in an interval of time. Data is plotted and kept contained in sections called bins; this is done using a histogram. Histograms can be used to display the underlying distribution of frequency such as normal distributions, skewness and outliers etc. Figure 3: Histogram contains all the attributes with their distribution.

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Performance analysis of the proposed work, simply displayed in figure 4. Based on the confusion matrix, it can be said that the model has successfully predicted 900 non diabetic patients (True Negative) and predict Diabetic of 800 patient, True positive also shows very good overall performance. But it incorrectly also classified 100 non-diabetic as diabetic (False Positives) which may give rise to unnecessary anxiety and interventions. Worse yet, 178 confirmed diabetic cases (False Negatives) were overlooked as 'healthy', potentially postponing life-saving treatment for many individuals. Although the model provides a good prediction for majority of cases, A large number of false negative represents that there is much room to improvement in order not to leave any diabetic patients untreated from becoming late converters.

The accuracy curve for a Random Forest classifier with 85.7% of the accuracy is shown in Figure 5. This is depicted as the red dashed line threshold of 85.7%, there we can see that the accuracy curve level off so it would be some kind of saturation point in which adding more features decrease, rather than improve model performance. This visualization is very important as it assists you to understand when during your classifier's performance reaches and maintains this level of accuracy. Table 3 presents a comparison of the performance measures (Precision, Recall, F1-Score, Accuracy) between the proposed RF classifier and three other models such as K-SVM, K-NN, and DT. A bar plot comparing these metrics across the 4 model can be visualized as shown in figure 6. Figure 6 Performance metrics (Precision, Recall, F1-Score vs Accuracy) comparison of proposed Random Forest classifier with K-SVM,K-NN and Decision Tree models Overall, the Random Forest model performs better than other models on most metrics including Recall (87.2%), and Accuracy (85.7%). Figure 8 K-SVM, as close to performance with a precision of 81.0% and Accuracy:(83.5%). K-NN and Decision Tree have lower performances across all metrics, with K-NN performing worst of all. Random Forest — A high Recall-Precision balance contributes to an impressive F1-Score of 85.2% reflecting the ability when identifying diabetic cases while limiting false positives and negatives This is what makes it a better performer than the compared models in this scenario of classification task.

CONCLUSION

We carried the research for comparing our proposed Random Forest classifier with three available models: K-SVM, K-NN and Decision Tree in terms of varied performance metrics including Precision, Recall, F1 Score and Accuracy. The results show that for most cases, The Random Forest model outperforms all the classifiers with an outstanding 87.2% Recall and a good 85.7% Accuracy which are both essential in positively identifying individuals as potential early-onset T2D positive persons Of these, K-SVM exhibited the most competitive performance but only slightly under-performed in terms of Precision (81.0%) and Accuracy (83.5%). K-NN and Decision Tree models, however are not the best as they showed worst performance in all metrics with K- K being found unsuitable. Random Forest yielded the highest F1-Score (85.2%) and a good balance of Precision & Recall indicating it can better identify diabetic cases without much losing positive or negatives due to its imbalance in class distribution Procedure, compared to rest models, as illustrated by high specificity score. This balance is crucial in a healthcare setting, where accurate and early diagnosis can have major effects on patient lives. Consequently, according to the results of this study Random Forest classifier appears as more efficient predictor for such classification task providing accurate predictions useful for prevention and management of Type 2 diabetes at early stages.

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Table 1: Features taken for survey

S.No	Parameter	Description	Values	Type
1	Age	Age of the subject in years.	Between 5 to 83	numeric
2	Sex	Gender of the subject	Male 1, Female 0	categorical
3	Family History	Whether any family member of the subject is/was suffereing from diabetes	No-0, Yes-1	categorical
4	Smoking	Whether the subject is a smoker or not.	No-0, Yes-1	categorical
5	Drinking	Whether the subject is liquor or non-liquor.	No-0, Yes-1	categorical
6	Thirst	The number of times the subjects drink water in a day/night.	Min-1, Max-15	numeric
7	Urinaion	How many times the subject passes urine in a day/night.	Min-2, Max-15	numeric
8	Height	Height of the subject in centimeter (cm)	Between 61-766	numeric
9	Weight	Weight of the subject in kilogram (Kg).	Min-15, Max-96	numeric
10	Fatigue	If the subject feels fatigued or not.	No-0, Yes-1	categorical
11	Outcome	If the subject is diabetic or not	Non Diabetic-0, Diabetic-1	categorical

Table 2: Description of Dataset

Parameters	count	mean	std	Min	Max
Age	1978	53.429	15.835	5	83
Sex	1978	0.531	0.499	0	1
Family History	1978	0.362	0.445	0	1
Smoking	1978	0.157	0.354	0	1
Drinking	1978	0.466	0.38	0	1
Thirst	1978	8.125	2.434	1	15
Urinaion	1978	8.325	3.461	2	15
Height	1978	214.87	33.14	61	185
Weight	1978	87.43	11.481	15	96
Fatigue	1978	0.257	0.461	0	1
Outcome	1978	0.673	0.5	0	1

Table 3: Performance Comparison of Proposed Vs Existing model

Model	Precision	Recall	F1-Score	Accuracy
Random Forest	83.4	87.2	85.2	85.7
K-SVM	81	85	82.9	83.5
K-NN	78.5	82.3	80.3	82
Decision Tree	79.7	84.1	81.8	83

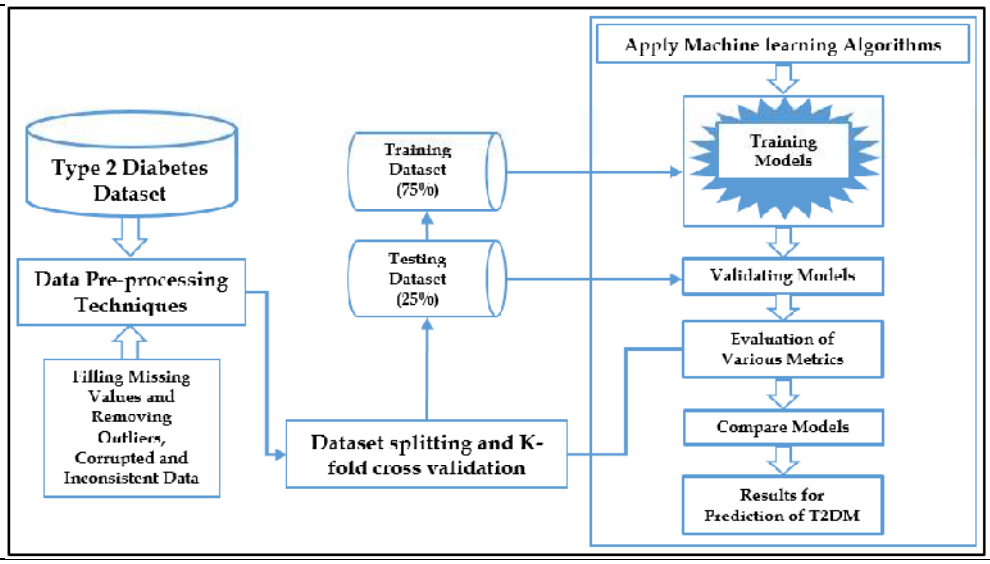


Figure 1: Framework for T-II DM Prediction

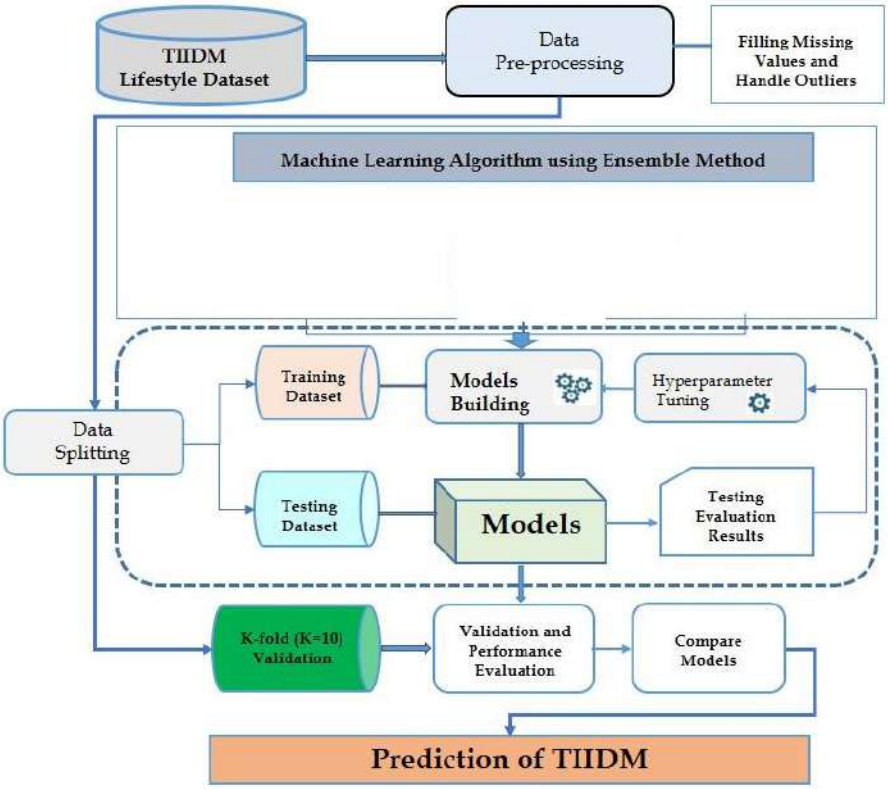


Figure 2: Proposed Frame work for early identification of TII DM

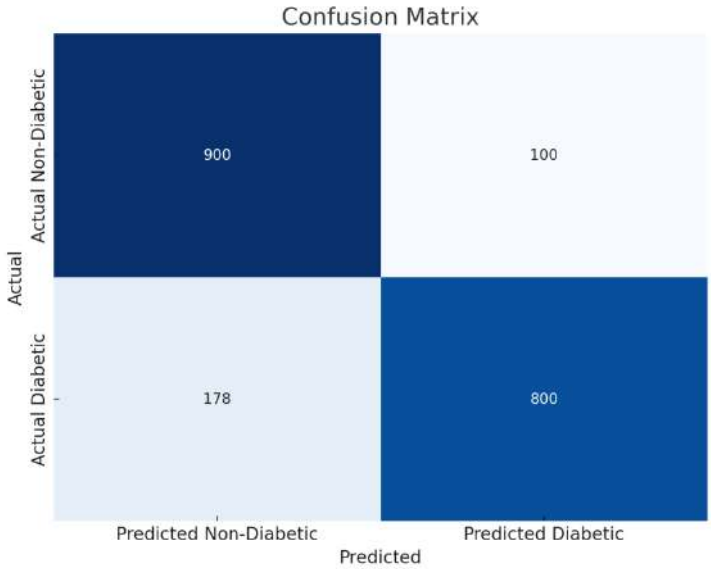


Figure 4: Confusion matrix of proposed work

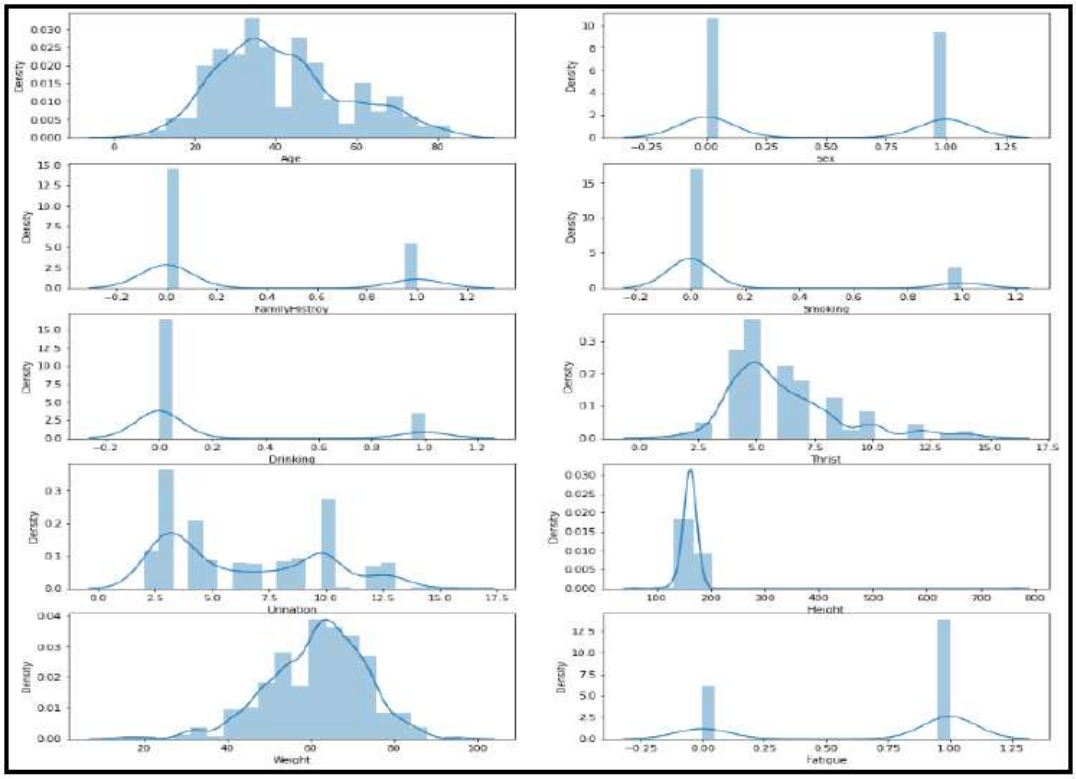


Figure 3: histogram equalization for dataset

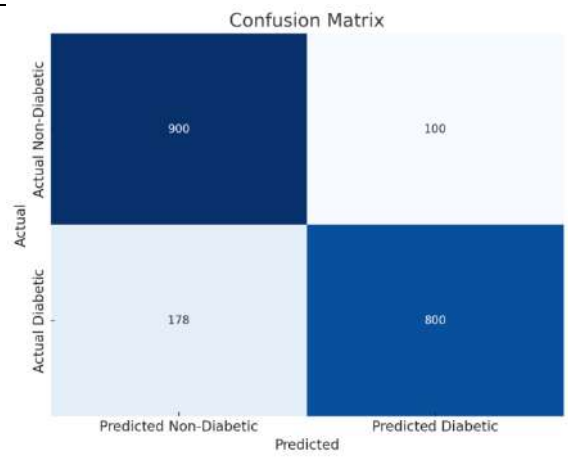


Figure 4: Confusion matrix of proposed work

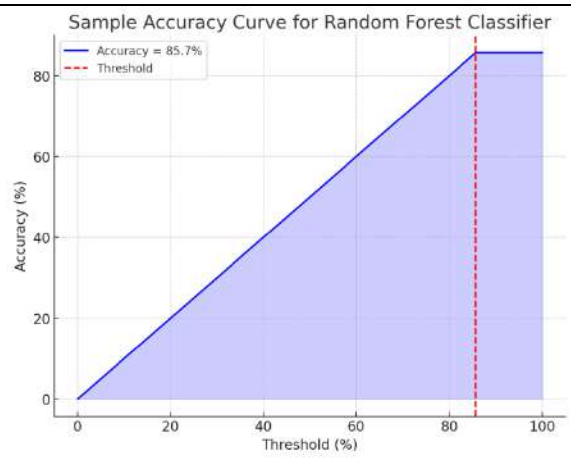


Figure 5: Accuracy Curve for Proposed Model

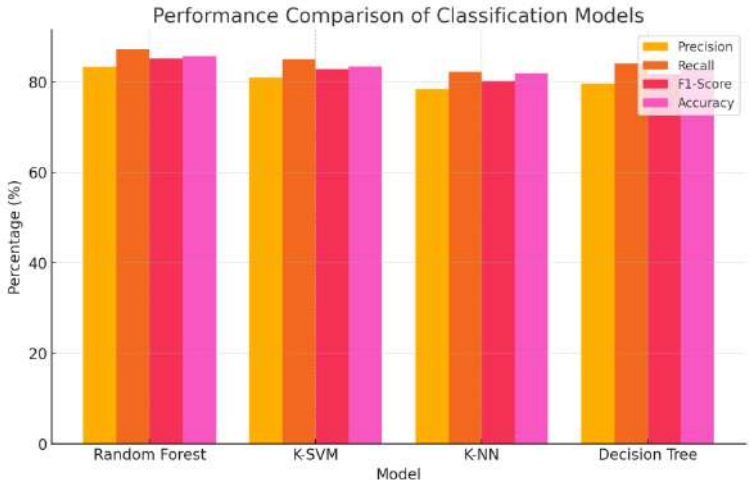


Figure 6: Performance Comparison of proposed work Vs Existing work

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RESEARCH ARTICLE

Hellinger Divergencive Theil–Sen Regression-Based Deep Multilayer Perceptive Feed Forward Network for Predictive Analytics with Big Data

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ABSTRACT

Predictive analytics was the technique with an advanced research approach to find future events, especially in the agriculture field. Agriculture of precision is the leading part within the development of the financial system. Climate as well as soil quality conditions changes have become the most important risk in the prediction of crop yield in agriculture field. But, an accurate prediction faces high complexity. Hellinger divergence matching pursuit Jaspen's correlative regression-based deep multilayer perceptive feed-forward Network (HDMPJCR-DMPFFN) is introduced for increasing accuracy by lesser complexity. Deep feed forward Network includes several layers for processing the given input data. Deep multilayer perceptive network has input layer that collects a large volume of data. Next, input was transformed of deep neural network where the feature selection was performed by Hellinger divergence target matching pursuit. By applying Hellinger divergence, the significant target features related to the prediction are selected. The feature selection helps to reduce complexity time as well as space complexity. Next, selected features were given to subsequent thidden layer to classify the information based on the Multivariate Jaspen's correlative Theil–Sen regression. The regression function detects training features as well as testing features by Multivariate Jaspen's correlation to classify the data for accurate prediction with higher accuracy. Experimental evaluation of HDMPJCR-DMPFFN has various parameters like prediction accuracy, false-positive rate, prediction time, and space complexity. HDMPJCR-DMPFFN enhances accuracy of prediction and decreases the time consumption and space complexity of prediction methods.

Keywords: predictive analytics, big data, Deep feed forward Network, Steepest Hellinger divergence target matching pursuit, Multivariate Jaspen's correlative Theil–Sen regression

INTRODUCTION

Predictive analyzing has large volume of information for extracting helpful patterns and applicable data that provide future results. Recently, several applications are interested in big data such as Agriculture, healthcare, weather forecasting, and so on. Therefore, big data analytics provides better results in agriculture forecasting for timely and reliable yield prediction. Since the crop yield prediction has soil moisture and weather conditions. In order to achieve this goal, several big data techniques and technologies have been developed to handle and analyze the large volume of data from different resources. An integrated ConvLSTM layer by 3-Dimensional CNN (3DCNN) to crop yield prediction method called 'DeepYield' was introduced in [1] based on correct as well as consistent spatiotemporal feature extraction. But accuracy level of prediction and minimum time consumption was not obtained. An Adaptive Domain Adversarial Neural Network (ADANN) was developed in [2] for accurate prediction. But, designed method was failed for designing feature extractor using more advanced architectures to the well-handled large volume of data. Different machine learning methods were introduced in [3] for forecasting soil moisture. But the key features as well as machine learning scheme was not applied for improving accurate soil moisture prediction. Fuzzy Enumeration Crop Prediction Algorithm (FECPA) was developed in [4] for an efficient crop yield prediction. The designed algorithm decreases the time complexity but the space consumption for accurate crop yield is not performed.

Artificial neural network is developed in [5] to the prediction and improving the performance of Big data analysis and conduct huge quantity of information generated to obtain higher agricultural yield. But, it was unsuccessful failed for focusing better prediction results. Machine learning techniques were introduced in [6] for agriculture by using Big Data. But the processing speed of the data is not increased. Similarity of four machine learning techniques is implemented in [7] for computing the monthly soil temperatures at different intensities. But the techniques failed to work with more data. A deep learning approach was introduced in [8] for crop yield using genotype with climate conditions. An approach failed to perform crop management with the soil data. A deep reinforcement learning technique was developed in [9] for smart agriculture IoT systems. However, the designed technique failed to apply for multitask learning and deep computation for smart agriculture. A crop recommendation system was introduced in [10] that employ Map Reduce with K-means clustering for the prediction of crop yield. However, deep learning scheme is not applied to precise prediction.

Major contributions

The major contribution of HDMPJCR-DMPFFN was described by,

1. A novel technique called HDMPJCR-DMPFFN is developed for big data Prediction with the help of two major processes namely feature selection and classification incorporated into the deep multilayer perceptive feed-forward Network.
2. To decrease the prediction time and space complexity, HDMPJCR-DMPFFN uses the Hellinger divergensive target matching pursuit for detecting the significant features for classification process. The matching pursuit projects the relevant features based on divergence estimation. This helps to minimize the memory consumption.
3. To increase the prediction accuracy, Multivariate Jaspen's correlative Theil–Sen regression is applied to the hidden layer of Multivariate Jaspen's correlative Theil–Sen regression. The regression function analyzes the training features and testing features using Multivariate Jaspen's correlation. Based on the correlation, prediction is performed with higher accuracy.
4. Finally, comprehensive experiments are used for estimating quantitative analysis of HDMPJCR-DMPFFN by conventional deep learning on different parameters.

Organization of Paper

The paper was organized by: section 2 provides related works within prediction of big data. Section 3 explains the HDMPJCR-DMPFFN by neat diagram. Section 4 illustrates experimental setup by dataset description. Section 5 gives simulation outcome of dissimilar parameters. Section 6 concludes paper.

Related works

Hybrid method termed as crop modeling with machine learning is designed in [11] to provide predictions as well as find a feature over crop modeling. But the time consumption for accurate prediction is not reduced. Machine learning algorithms are introduced in [12] to predict maize yield. The algorithms failed to obtain an accurate prediction. A radar echo prediction scheme was developed in [13] to accurately forecast outline of weather radar echo. However, it failed to perform the long-term forecast to obtain detailed information. Integration of machine learning as well as deep learning was introduced in [14] for forecasting crop yield. But, accuracy estimation remained unaddressed. Machine learning-based random forest (RF) is developed in [15] for predicting cotton yield on different period. But, algorithm failed to use efficient device for forecasting crop yield quicker as well as accurate way. The rainfall prediction scheme was introduced in [16] for prediction on spatial-temporal outline. But, method failed to obtain an accurate prediction with minimum time consumption. Machine-learning techniques were developed in [17] to compute the soil moisture in wheat fields. However, it failed to consider evaluation technique for soil moisture prediction. Multi-temporal deep learning were developed in [18] for accurate performance of large-scale crop mapping. But the important feature selection was not performed. Spatial resolution on quality of crop yield prediction was performed in [19] for site-specific crop management. However, it failed to apply machine learning or deep learning for accurate quality of crop yield. Deep learning regression network (DNNR) was introduced in [20] with big data for a soil moisture prediction. It enhances accuracy but time complexity analysis is not performed.

METHODOLOGY

Big Data prediction is the process of analyzing and extracting valuable data from huge number of structured, semi-structured, as well as unstructured data. Big Data needs tools as well as techniques for identifying with extract patterns over huge-scale data. The increasing nature of Big Data requires enhanced data storage capabilities, higher time, as well as memory consumption. Therefore, feature selection is a dimensionality reduction technique to select the important features for providing accurate predictive results. But, the existing methods failed for increasing performance of accuracy as well as time during prediction process with big data. Deep learning techniques are introduced for enhancing accuracy as well as minimize time. Based on motivation a novel deep learning technique called HDMPJCR-DMPFFN is introduced in this paper. It increases prediction accuracy and time by feature selection and classification. Figure 1 portrays different processes of predictive analytics using HDMPJCR-DMPFFN. The number of features is collected from the dataset. In the first stage, the feature selection process is performed using Hellinger divergensive target matching pursuit to minimize the complexity of prediction. Secondly, the classification process is said to be performed using Multivariate Jaspen's correlative Theil–Sen regression. A detailed explanation of the proposed is provided in the following sections.

Deep multilayer perceptive feed-forward Network

The proposed HDMPJCR-DMPFFN technique uses a deep multilayer perceptive feed-forward Network for accurate big data prediction. A deep multilayer perceptive feed-forward network has set of weights for forecast of future. Multilayer feed-forward neural network includes multiple layers. From figure 3,deep multilayer perceptive feed-forward Network was explained. Figure 2 depicts the deep multilayer perceptive feed-forward Network. The structure comprises multiple layers and the neurons like the nodes. Input layer and weighted are transferred concurrently towards the second layer, called a hidden layer. Hidden layer units are given to input to another hidden layer. A hidden layer is chosen based on processes of technique. Weighted outputs of final hidden layer were given to input of the output layer produces the output. Therefore, output of one layer was completely linked to the subsequent forward layer. Hence it is called as feed-forward neural network. Neuron input is generally created as a linear combination of its incoming input values.

$$I_i(l) = \sum_i \alpha_i^l x_i^l + \varphi_i^l \quad (1)$$

Where, the neuron input '$I_i(l)$' is generally constructed as a linear combination of its incoming input values 'x_i^l' and corresponding to the weight of the connection 'α_i^l' at layer 'l', φ_i^l denotes bias that stored the value is '1'. Input was transmitted within initial hidden layer.

Hellinger divergensive target matching pursuit

Big data has the demanding task of machine learning and data mining because the dataset comprises a large volume of data. Feature selection was defined as procedure of attaining the subset over original feature to specific measure by removing the redundant and irrelevant features. Therefore a feature selection process improves the learning accuracy and decreases the time complexity. Based on motivation, the proposed technique introduces a Hellinger divergensive target matching pursuit is a dimensionality reduction technique that helps to find the best matching features from high dimensional to low dimensional space. The target matching pursuit uses the Hellinger divergence for identifying the efficient features.

Figure 3 depicts the block diagram of Hellinger divergencive target matching pursuit for relevant features taken from the dataset the given dataset is $k_1, k_2, k_3, \ldots . k_n$ is distributed in the given dimensional space. By applying the Hellinger divergence, the distance is measured between the features.

$$H_D = \frac{1}{\sqrt{2}} \| k_i - k_j \| \quad (2)$$

From the (2), H_D denotes a Hellinger divergence of two features 'k_i, k_j'. Then the threshold function was employed for identifying minimum divergence among features. Therefore, the projection is formulated as given below,

$$Y = \begin{cases} H_D > T \,; irrelevant\ features \\ H_D < T \,; relevant\ features \end{cases} \quad (3)$$

Where, Y denotes an output function, H_D denotes a Hellinger divergence, T denotes a threshold. The more divergent features are said to be irrelevant. Otherwise, the feature is said to be a relevant feature. In other words, the divergence is lesser than the threshold said to be relevant. Otherwise, the feature is said to be irrelevant. Followed by this, two distinct categories are generated by employing the threshold function for Hellinger divergence. This is owing to the reason that redundant features associated with other features have to be eliminated. The minimum divergence is selected as a relevant feature. Otherwise, the feature is said to be irrelevant. The relevant features are selected for prediction as well as eliminate irrelevant features. Relevant features were projected over high-dimensional space into low-dimensional space.

$$\boldsymbol{\varphi} : k_R\,(h) \rightarrow \delta_s \quad (4)$$

Where, $\boldsymbol{\varphi}$ indicates a projection function to project the relevant features from the high dimensional space'($k_R\,(h)$) 'into the subset 'δ_s'in low dimensional space. With this computationally efficient and relevant features were chosen to prediction for minimizing time complexity and maximize accuracy.

Multivariate Jaspen's correlative Theil–Sen regression

After the feature selection, the prediction is performed in the second hidden layer of the deep multilayer perceptive feed-forward Network. HDMPJCR-DMPFFN employs Theil–Sen regression function to detect training as well as testing information on Multivariate Jaspen's correlation function. Here the multivariate represents the correlation is measured based on the number of testing and training features. The Theil-Sen regression is a machine learning technique for estimating the relationships between one or more variables (called 'features'). The main aim of regression analysis is used to predict similar types of data with a specific mathematical criterion. The mathematical criterion is performed using Jaspen's correlation function.

Figure 4 demonstrates the block diagram of the Multivariate Jaspen's correlative Theil–Sen regression to analyze the given input training and testing data based on the correlation. The input training data $D_1, D_2, D_3, \ldots . D_n$are data collected from the dataset. Then the Multivariate Jaspen's correlation is measured as given below,

$$\rho = \frac{n*\sum D_t*D_r-(\sum D_t)(\sum D_r)}{\sqrt{[n*\sum {D_t}^2-(\sum D_t)^2][n*\sum {D_r}^2-(\sum D_r)^2]}} \quad (5)$$

From (5), ρ denotes Jaspen's correlation coefficient. $'n'$ represents a number of data. $\sum D_t * D_r$ denotes a product of paired score of two data. ${D_t}^2$ denotes a squared score of D_t and ${D_r}^2$ denotes a squared score of D_r. The correlation coefficient provides the resultant value from "-1" to +1. If coefficient provides '+1', then the positive correlation and it provides '-1'provides a negative correlation between two data. Based on the correlation measure, the big data prediction is performed with higher accuracy. Hence, hidden layer is computed by,

$$R(t)^l = [\sum_i \alpha_i^l \, x_i^l + \varphi_i^l] + [{\alpha_{ih}}^l * r_i^{l-1}] \quad (6)$$

Where, '$R(t)^l$' denotes the hidden layer result, '${\alpha_{ih}}^l$' denotes the weight among input as well as hidden layerr_i^{l-1}indicatespreceding hidden layer. Finally, hidden layer output was sent to output layer. It is expressed as follows,

$$Z(t) = [{\alpha_{ho}}^l * R(t)^l] \quad (7)$$

From equation (7), '$Z(t)$' denotes the output layer result, '${\alpha_{ho}}^l$' represents the weight among hidden as well as output layer, $R(t)^l$indicates previous hidden layer. Data is properly predicted within different classes. Algorithmic description of the proposed HDMPJCR-DMPFFN is explained below,

// Algorithm 1: Hellinger divergenced matching pursuit Jaspen's correlative regression-based deep multilayer perceptive feed-forward Network

Input: Dataset, Number of features$k_1, k_2, k_3, \ldots . k_n$, Number of data $D_1, D_2, D_3, \ldots . D_n$
Output: Increase the prediction accuracy

Begin
Step 1: Collect number of features $k_1, k_2, k_3, \ldots . k_n$ **and** data $D_1, D_2, D_3, \ldots . D_n$taken as input at the input layer
Step 2: **For each** feature**// hidden layer 1**
Step 3: Measure the divergence 'H_D'
Step 4: **if**$(H_D < T)$**then**
Step 5: Feature is said to be a relevant
Step 6: else
Step 7: Feature is said to be an irrelevant
Step 8: **end if**
Step 9: Select the relevant feature subset
Step 10: Remove the irrelevant features
Step 11: **For** each training data 'D_i' with extracted features **// hidden layer 2**
Step 12: Apply regression function
Step 13: Measure correlation 'ρ' between training and testing data
Step 14:If $(\rho = +1)$ **then**
Step 15: Data is classified into one class
Step 16: **else**
Step 17: Data is classified into another class
Step 18: **End if**
Step 19:Obtain the prediction results at the output layer
Step 20: **End for**
End

Algorithm 1 explains big data prediction with higher accuracy. Deep multilayer perceptive feed-forward Network comprises multiple layers for identifying input features. Input layer receives amount of features. Hellinger divergencive target matching pursuit was utilized for identifying relevant and irrelevant features. If divergence is lesser than the thresholds, then the features are projected into a relevant and. Otherwise, the features are projected into an irrelevant subset. With similar feature subsets, the Multivariate Jaspen's correlative Theil–Sen regression is applied in the second hidden layer to perform the prediction. The accurate prediction is performed using the Multivariate Jaspen's correlation. Finally, the correlation output is obtained at the output layer. Depend on analysis, prediction was achieved with minimum time consumption.

Experimental Evaluation

Simulation of HDMPJCR-DMPFFN and Deep Yield [1] ADANN [2] were developed using JAVA by Wazihub Soil Moisture Prediction Challenge are taken from (https://zindi.africa/competitions/wazihub-soil-moisture-prediction-challenge/data). This dataset was collected as part of an experiment conducted for over 4 months in 4 fields growing maize and peanuts in Senegal. Dataset is precisely predicted growing maize and peanuts based on soil moisture level, weather conditions in advance. This helps to farmers for preparing the irrigation schedules more efficiently. The IoT soil moisture sensors were set up in each of the maize and peanuts fields and collected the weather station. . The collected agriculture dataset is applied to the deep learning algorithm for training purposes. HDMPJCR-DMPFFN is compared by the outcome obtained over conventional techniques. The dataset comprises following attribute information about the soil, climate conditions of 4 fields of growing two crops namely maize and peanuts in Senegal.

Performance Results Analysis

The performance of the HDMPJCR-DMPFFN and existing Deep Yield [1], ADANN [2] is determined by various numbers of information.

Prediction accuracy: It is referred by proportion of number of data were properly classified to entire amount of input data. It was measured by,

$$Pre_a = \left[\frac{ACd_i}{d_n}\right] * 100 \quad (8)$$

From (8), 'Pre_a' represents the prediction accuracy, 'ACd_i' designates the amount of data properly classified and 'd_n' indicates total amount of data. It was calculated by percentage (%).

False Positive Rate: It was referred by number of data wrongly classified to entire amount of data as input. It was calculated using the formula,

$$FPR = \left[\frac{NICd_i}{d_n}\right] * 100 \quad (9)$$

In (9) 'FPR' indicates false positive rate, '$NICd_i$' represents number of data incorrectly classified 'd_n' be the total number of data. FPR was computed by percentage (%).

Prediction time: It was formulated by the number of time consumed for prediction of future results on classification procedure. It is expressed by,

$$T_p = [d_n] * T(d_i) \quad (10)$$

In Where 'T_p' indicates the prediction time, d_n indicates the number of data and '$T[d_i]$' denotes the time taken for single data. It is calculated by milliseconds (ms).

Space complexity: It was measured by number of storage necessary with algorithm for achieving big data. It was measured as given below,

$$S_{com} = [d_n] * MS\,[d_i] \quad (12)$$

Where, 'S_{com}' indicates space complexity, 'd_n' denotes number of data and '$MS\,[d_i]$' indicates memory consumed to single data. It was measured in terms of Megabytes (MB).

As given from table 2, HDMPJCR-DMPFFN is compared with existing methods namely Deep Yield [1] ADANN [2] respectively. The prediction accuracy is measured based on a amount of data ranges of 2500 to 25000. HDMPJCR-DMPFFN achieves higher prediction accuracy upon comparison with the other two existing methods [1] and [2]. This is proved through quantitative analysis. When considering the number of data as 2500, the proposed HDMPJCR-DMPFFN correctly predicts the 2385 data whereas by applying[1] and [2] correctly predicted data are2200 and 2150 respectively. Thus, prediction accuracy of HDMPJCR-DMPFFN was 95.4% and the prediction accuracy of existing Deep Yield [1] ADANN [2] is 88% and 86% respectively. Followed by which, the different results are observed along with the various input data. Finally, the performance of HDMPJCR-DMPFFN was compared with existing methods. Prediction accuracy of HDMPJCR-DMPFFN was significantly improved as 8% and 11% when compared to Deep Yield [1] ADANN [2]. The graphical representation of prediction accuracy was explained from figure 5.

Figure 5 shows prediction accuracy by 25000 with different amount of data instances collected over soil moisture prediction. As shown in figure 5, the amount of data were taken to horizontal axis as well as performance results of accuracy using three methods are observed on the vertical axis. Accuracy is improved using the proposed HDMPJCR-DMPFFN method when compared to Deep Yield [1] ADANN [2]. This is due to the application of deep multilayer perceptive feed-forward Network uses the Multivariate Jaspen's correlative Theil–Sen regression is applied in the second hidden layer to perform the accurate prediction by analyzing the testing and training data. Lastly, analyzed outcome were detected by output layer. From analysis, an accurate prediction is performed. Table 3 explains false-positive rate with three different methods namely HDMPJCR-DMPFFN, Deep Yield [1], ADANN [2]. False-positive rate is estimated by number of data taken of 2500 to 25000. The obtained results reveal the false positive rate was considerably decreased using HDMPJCR-DMPFFN than existing methods. With consideration of 2500 data to perform experiments. False-positive rate of HDMPJCR-DMPFFN is 4.6% whereas false-positive rate of the Deep Yield [1] ADANN [2] is12% and 14% respectively. The average of ten observed results indicates that the false-positive rate of HDMPJCR-DMPFFN was decreased as58% and 65% compared with Deep Yield [1] ADANN [2] respectively. Figure 6 given above illustrates the false positive rate of HDMPJCR-DMPFFN, Deep Yield [1] ADANN [2]. The figure inferred that the HDMPJCR-DMPFFN is comparatively better in terms of providing the lesser false positive rate. This is because of Multivariate Jaspen's correlative Theil–Sen regression for detecting input training data by test information Based on regression analysis, accurate prediction is obtained as well as reduces wrong data at the output layer.

Prediction time using three methods HDMPJCR-DMPFFN,[1], and [2] are reported in table 4 and figure 7 with respect to 25000 samples of data. In the above figure, the horizontal axis represents the number of data instances collected for the dataset and the vertical axis represents the prediction time of three methods. From the graph, the prediction time of HDMPJCR-DMPFFN is relatively lesser than that of Deep Yield [1] and ADANN [2]. Also, the prediction time is increased gradually by amount of data instances increased. Moreover, with the experiment is conducted using 25000 sample data instances, the time consumed for prediction was found to be 15.4ms using HDMPJCR-DMPFFN, 19.6ms using [1] and 22.4ms using [2]. With this result, the prediction time was observed to be minimized using HDMPJCR-DMPFFN. The reason behind the Deep feed forward Network includes several layers for processing the given input data. Deep feed-forward network collects a large volume of data. Input was transformed within initial hidden as feature selection process was carried out using Hellinger divergensive target matching pursuit. By applying the Hellinger divergensive, the target features are selected for prediction hence the proposed technique minimizes the time consumption. Table 5 and figure 8 portrays performance analysis of space

complexity comparison of three different methods, namely HDMPJCR-DMPFFN, Deep Yield [1] ADANN [2].Amount of data was considered by input rangesof2500, 5000, …25000. Consider the amount of data as 2500 to perform experimentation. The memory consumption for prediction is found to be 15ms using HDMPJCR-DMPFFN whereas the memory consumption of Deep Yield [1] and ADANN [2] were 17.75ms and 20ms. HDMPJCR-DMPFFN attains minimum space complexity than the existing methods. Space complexity of HDMPJCR-DMPFFN was decreasedas12% and 20% compared with existing methods. This is because of applying the target feature selection process before the prediction. Hellinger's divergensive target matching pursuit helps to project the significant features and remove the divergent features. This helps to minimize the space consumption for prediction.

CONCLUSION

In this paper, big data prediction is performed in agriculture through the application of HDMPJCR-DMPFFN. The proposed deep learning-based methods are appropriate preferences for evolving the larger data, as they often obtain higher performance of prediction with minimum time consumption. Deep learning technology has made a great fast in the traditional prediction analysis. The integration of a Deep neural Network includes for predictive analysis ensures that the agricultural land for crop prediction is considered based on soil and climate changes. In this work, an HDMPJCR-DMPFFN is first considered as input computationally efficient, and find the target features are selected for robust predictive mining. With the obtained target features, classification is performed by analyzing the testing and training feature for predictive mining with the assistance of Multivariate Jaspen's correlative Theil–Sen regression. Simulation outcome illustrates the performance of HDMPJCR-DMPFFN. HDMPJCR-DMPFFN outperforms current state-of-the-art for agriculture within analyzing the sample data. Also, it is shown that the HDMPJCR-DMPFFN increases the accuracy as well as reduces time, false-positive rate and space complexity than conventional approaches.

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Table 1 Dataset Description

S. No	Feature name	Description
1	Timestamp	Time of recording
2	Soil_humidity_1	Soil humidity of field 1
3	Irrigation_field_1	1 = irrigation on; 0 = irrigation off
4	Soil_humidity_2	Soil humidity of field 2
5	Irrigation_field_2	1 = irrigation on; 0 = irrigation off
6	Soil_humidity_3	Soil humidity of field 3
7	Irrigation_field_3	1 = irrigation on; 0 = irrigation off
8	Soil_humidity_4	Soil humidity of field 4
9	Irrigation_field_4	1 = irrigation on; 0 = irrigation off
10	Air_temperature	The temperature of the air
11	Air_humidity	The temperature of the humidity
12	Air_pressure	Temperature of the pressure
13	Wind_speed	Speed of the wind
14	Wind_gust	Speed of the gust of the wind
15	Wind_direction	Direction of the wind
16	Solar_irradiance	Power per unit area
17	Sun	Radiant energy emitted by the sun
18	Kc	Crop coefficient
19	ETc	Evapotranspiration rate (testing crop)

Table 2 Comparative analysis for Prediction accuracy

Number of data	Prediction accuracy (%)		
	HDMPJCR-DMPFFN	DeepYield	ADANN
2500	95.4	88	86
5000	94	86	84
7500	96	88	86
10000	95	87	84
12500	94.4	86.4	84.8
15000	94.66	87.33	83.33
17500	96	86.85	84
20000	95	90	87.5
22500	95.55	89.77	88.88
25000	94	90.4	87.2

Table 3 Comparative analysis for false positive rate

Number of data	False positive rate (%)		
	HDMPJCR-DMPFFN	DeepYield	ADANN
2500	4.6	12	14
5000	6	14	16
7500	4	12	14
10000	5	13	16
12500	5.6	13.6	15.2
15000	5.34	12.67	16.67
17500	4	13.15	16
20000	5	10	12.5
22500	4.45	10.23	11.12
25000	6	9.6	12.8

Table 4 Comparative analysis for prediction time

Number of data	Prediction time (ms)		
	HDMPJCR-DMPFFN	DeepYield	ADANN
2500	15.4	19.6	22.4
5000	21.28	25.2	27.44
7500	25.2	29.4	31.92
10000	31.36	35.84	39.2
12500	37.8	40.6	44.8
15000	40.32	47.04	50.4
17500	45.08	50.96	54.88
20000	47.04	53.76	58.24
22500	55.44	57.96	60.48
25000	58.8	61.6	64.4

Table 5 Comparative analysis for space complexity

Number of data	Space complexity (MB)		
	HDMPJCR-DMPFFN	DeepYield	ADANN
2500	15	17.75	20
5000	17.5	22.5	25
7500	26.25	28.875	33.75
10000	30	35	38
12500	32.5	36.25	40
15000	36	43.5	45
17500	39.025	45.5	49
20000	44	46	52
22500	47.25	49.5	54
25000	50	53.75	60

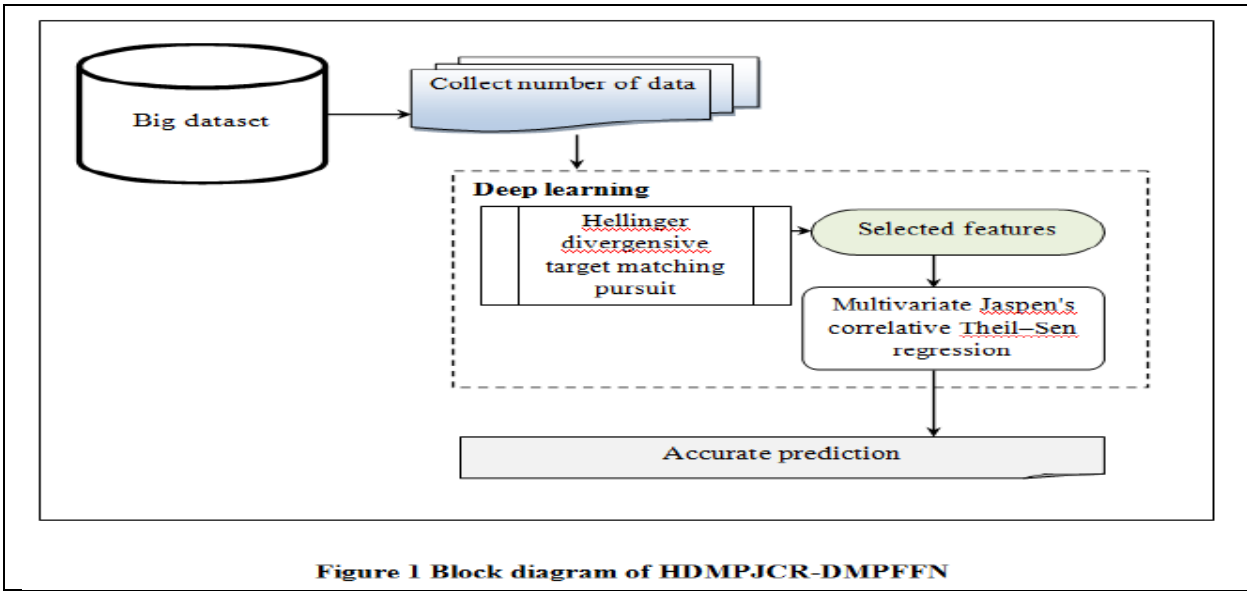


Figure 1 Block diagram of HDMPJCR-DMPFFN

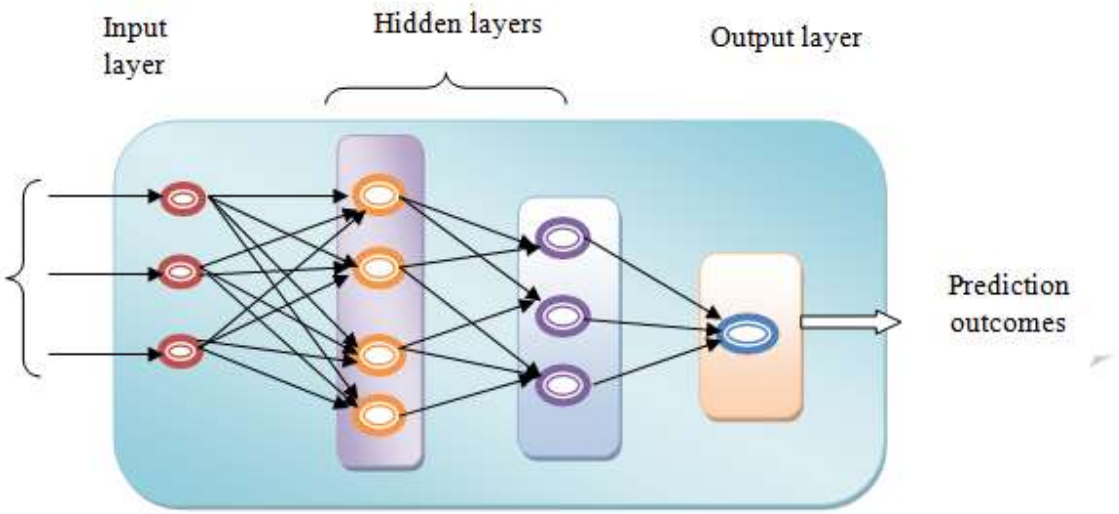


Figure 2 Structure of deep multilayer perceptive feed forward network

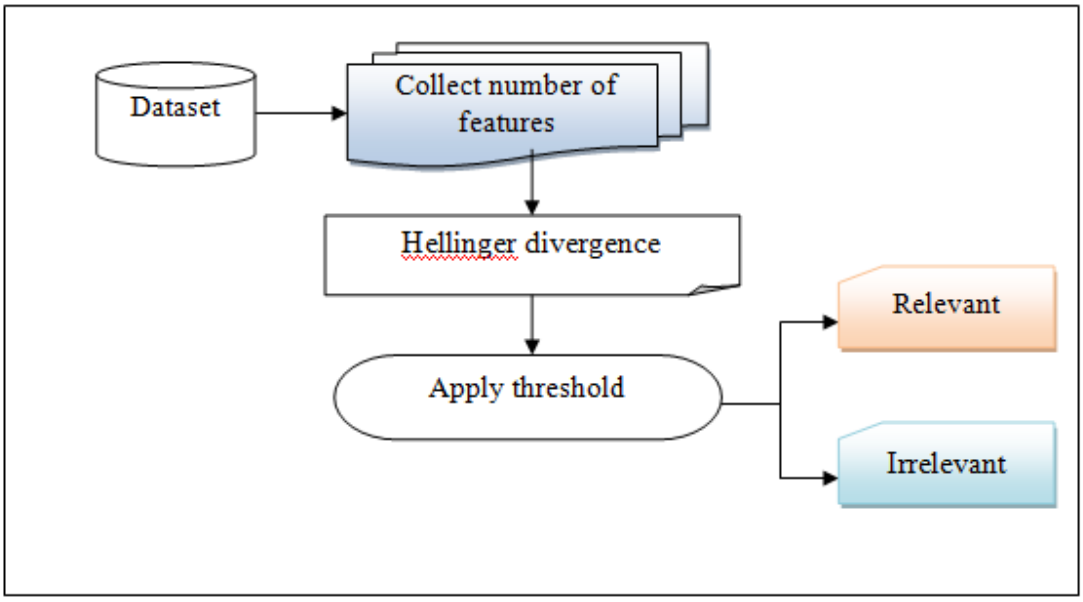


Figure 3 block diagram of the Hellinger divergencive target matching pursuit

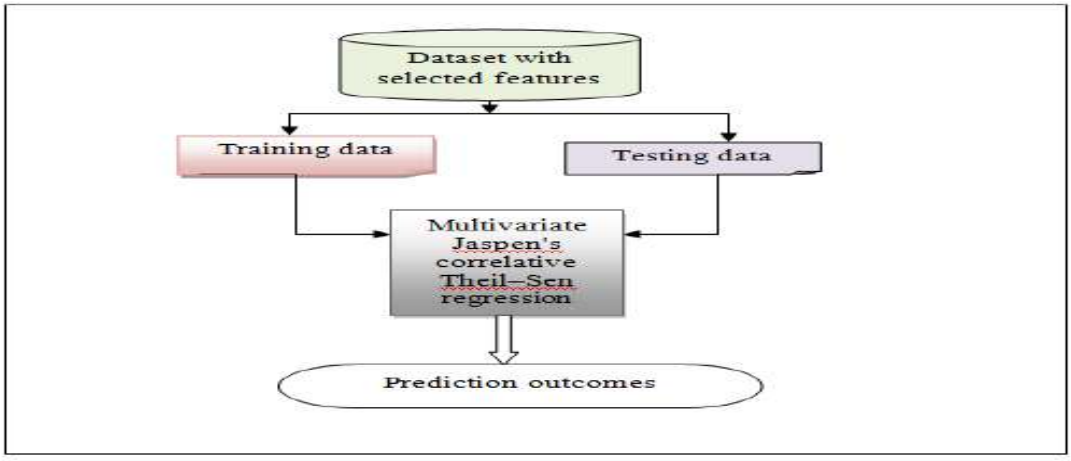


Figure 4 block diagram of Multivariate Jaspen's correlative Theil–Sen regression

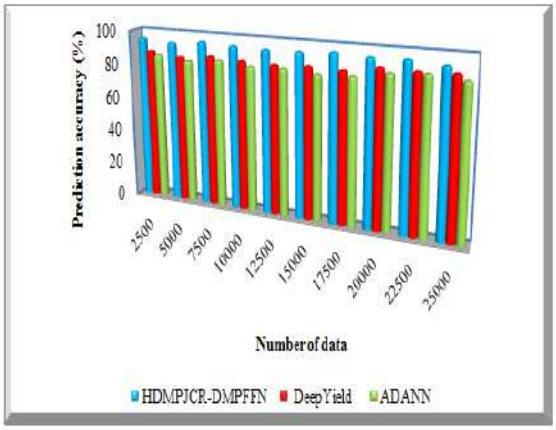


Figure 5 Graphical illustration of prediction accuracy

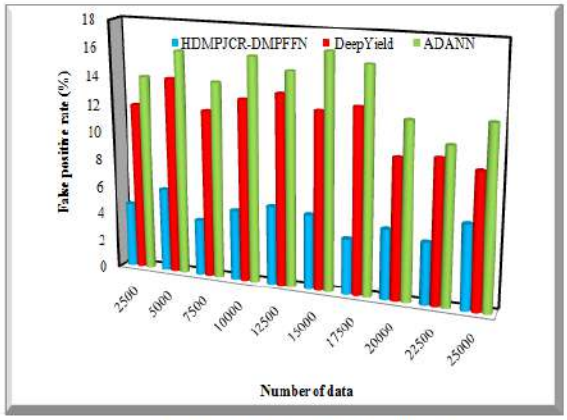


Figure 6 Graphical illustration of false-positive rate

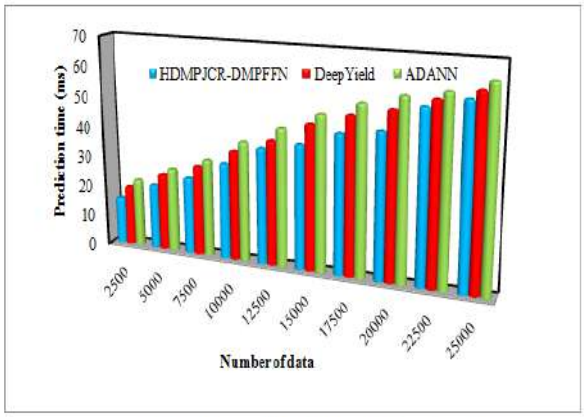


Figure 7 Graphical illustration of Prediction time

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RESEARCH ARTICLE

Challenges and Future Directions in Blackhole Attack Mitigation in Mobile Ad Hoc Networks

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ABSTRACT

The increasing use of Mobile Ad Hoc Networks (MANETs) in various applications has raised significant concerns about network security due to their decentralized nature, dynamic topology, and limited resources. Among the various threats, the blackhole attack is one of the most critical, where malicious nodes falsely advertise the shortest route to a destination and intercept or drop packets. Detecting and mitigating blackhole attacks have been widely explored in the literature, leading to the development of numerous approaches. This review provides a comprehensive analysis of the existing methods for detecting blackhole attacks in MANETs, including trust-based mechanisms, cryptographic approaches, machine learning techniques, and hybrid solutions. It examines the strengths and limitations of each method, focusing on their effectiveness, computational overhead, and scalability. The review also highlights key research gaps, such as handling multiple coordinated attackers, energy-efficient detection methods, and real-time implementation challenges. Furthermore, it emphasizes the importance of balancing security with the network's performance in resource-constrained environments. This literature review aims to provide researchers with a detailed understanding of the state-of-the-art in blackhole attack detection, guiding future efforts toward more robust, efficient, and scalable security solutions for MANETs.

Keywords: Mobile Ad Hoc Network, Attack Detection, Black Hole Attacks, Intrusion Detection

INTRODUCTION

Mobile Ad Hoc Networks (MANETs) have emerged as a key enabling technology in various fields such as military communication, disaster recovery, emergency rescue operations, and smart vehicular networks [1]. The decentralized nature of MANETs, where nodes communicate without relying on any fixed infrastructure or central authority, allows for quick deployment in environments where traditional networks are impractical. However, the unique characteristics of MANETs, including dynamic topology, limited bandwidth, constrained energy resources, and the absence of centralized control, make them highly vulnerable to a range of security threats. Among these threats, routing attacks are particularly problematic due to their ability to disrupt the fundamental communication processes in the network [2]. One of the most severe routing attacks in MANETs is the blackhole attack. In a blackhole attack, a malicious node advertises itself as having the shortest or optimal path to a specific destination node. Once this malicious node becomes part of the routing process, it drops all or most of the data packets it receives, disrupting the flow of information and causing severe network performance degradation. The distributed and self-organizing nature of MANETs makes detecting such attacks particularly challenging, as there is no central entity to oversee or authenticate the routing process.

The impact of blackhole attacks on MANETs can be devastating. These attacks not only reduce network throughput but also cause significant delays and packet loss, compromising the overall quality of service (QoS) [3]. In critical applications, such as military or emergency response systems, such disruptions can have life-threatening consequences. Therefore, developing effective methods for detecting and mitigating blackhole attacks is essential to ensure secure communication in MANET environments. Over the years, several techniques have been proposed to address the challenge of blackhole attack detection. These techniques can be broadly categorized into trust-based methods, cryptographic schemes, and machine learning approaches. Trust-based methods rely on monitoring node behavior to assess their trustworthiness, whereas cryptographic schemes use encryption and authentication to secure communication paths. Machine learning approaches leverage pattern recognition and data analysis to detect anomalous behavior indicative of a blackhole attack. Some hybrid approaches combine elements from multiple techniques to enhance detection accuracy and efficiency. Despite the significant progress made in this field, several challenges remain. Many detection methods introduce additional computational and energy overhead, which can be detrimental in resource-constrained MANET environments. Moreover, some techniques struggle to adapt to dynamic topologies or fail to handle scenarios with multiple or coordinated attackers. These challenges underscore the need for more advanced and efficient detection mechanisms that can balance security with performance in MANETs [4] [5]. This paper presents a detailed literature review of the existing blackhole attack detection techniques in MANETs. It examines the evolution of detection strategies, highlighting their key features, advantages, and limitations. The review also identifies critical gaps in the current research and suggests directions for future work to address the challenges of blackhole attack detection in MANETs.

Background Study on MANET

Mobile Ad Hoc Networks (MANETs) represent a transformative approach to wireless communication, providing a decentralized, dynamic, and self-configuring network architecture. Unlike traditional networks, MANETs operate without the need for a fixed infrastructure, such as base stations or access points. Each node in a MANET functions both as a host and a router, facilitating multi-hop communication across the network. MANETs are characterized by their ability to form and maintain connectivity autonomously, making them well-suited for a variety of applications in both civilian and military domains.

Architecture of MANET

The architecture of a MANET is characterized by its lack of centralized control or pre-established infrastructure. Instead, each node in the network acts as both a router and an end device, which means that data can be transmitted directly between nodes that are within communication range or relayed through intermediate nodes in a multi-hop fashion. The flexibility and decentralized nature of MANETs allow for rapid deployment in various environments,

including those where traditional networks may not be feasible or available [1] [2]. In a MANET, nodes are typically mobile devices such as Smartphone, laptops, tablets, or military equipment. These devices are equipped with wireless transceivers, which allow them to communicate over wireless links. Since the topology of a MANET changes frequently due to node mobility, the network must be able to adapt to these changes in real time, maintaining communication and routing functionality even as connections are formed or broken.
The basic building blocks of a MANET include:

Mobile Nodes: Devices that move independently and participate in routing and communication.
Wireless Links: Connections between nodes that enable communication. These links are often unreliable and prone to interference, making robust routing essential.
Routing Protocols: Algorithms used to determine optimal paths for data packets between nodes.

Characteristics of MANET
MANETs possess several unique characteristics that distinguish them from traditional networks:

Decentralized Architecture: MANETs lack a central controlling authority, which means that every node is responsible for routing and forwarding packets. This decentralization offers high flexibility and robustness in dynamic and challenging environments.

Dynamic Topology: The topology of a MANET can change frequently due to node mobility. Nodes may join or leave the network at any time, and connections between nodes may break or re-establish as nodes move in and out of communication range. This mobility-driven dynamic nature poses significant challenges for maintaining consistent and reliable communication.

Multi-Hop Communication: In MANETs, nodes must often rely on intermediate nodes to forward data to the destination, as the source and destination nodes may not always be within direct communication range. This requires sophisticated routing protocols that can handle frequent topology changes.

Limited Resources: MANET nodes typically operate in environments with constrained resources, such as limited battery life, processing power, and bandwidth. As a result, network protocols must be designed to operate efficiently while minimizing resource consumption.

Lack of Centralized Infrastructure: Since MANETs are infrastructure-less, the nodes themselves must handle network management tasks, such as route discovery, route maintenance, and resource allocation. This increases the complexity of network protocols and requires distributed algorithms to ensure network performance and reliability.

Scalability Challenges: MANETs can range from small, localized networks to large-scale networks involving hundreds or even thousands of nodes. As the network grows, maintaining effective communication and managing routing overhead becomes increasingly difficult, posing challenges in scalability.

Routingin MANET
One of the most critical functions in a MANET is the routing process. Due to the lack of centralized control and dynamic topology, efficient and reliable routing is essential for network performance [3] [11] [12]. MANET routing protocols can be broadly classified into three categories:

Proactive Routing Protocols: Also known as table-driven protocols, these protocols maintain up-to-date routing information to all nodes in the network by periodically exchanging control messages. Examples include Destination-Sequenced Distance-Vector (DSDV) and Optimized Link State Routing (OLSR). Proactive protocols aim to reduce route discovery delay but incur overhead due to frequent updates, especially in highly dynamic environments.

Reactive Routing Protocols: Also known as on-demand protocols, these protocols create routes only when needed by the source node. Examples include Ad hoc On-Demand Distance Vector (AODV) and Dynamic Source Routing (DSR). Reactive protocols reduce routing overhead but can introduce delay due to route discovery processes.

Hybrid Routing Protocols: These protocols combine features of both proactive and reactive approaches to balance the trade-offs between routing overhead and delay. One example is the Zone Routing Protocol (ZRP), which uses proactive routing within a local zone and reactive routing outside the zone.

Background Study on Black Hole Attacks in MANETS

Mobile Ad Hoc Networks (MANETs) offer significant advantages in terms of flexibility, ease of deployment, and scalability, making them highly suitable for dynamic, infrastructure-less environments [6] [7]. However, these benefits come at a cost, as MANETs are highly vulnerable to various security threats due to their decentralized nature, dynamic topology, and absence of centralized control mechanisms.

The blackhole attack is one of the most severe routing attacks in MANETs due to its ability to disrupt communication by intercepting and dropping packets.

Blackhole Attack Mechanism

A blackhole attack targets the network layer, specifically the routing protocols, by exploiting the trust that nodes have in the routing information exchanged within the network. In a typical MANET, nodes use reactive routing protocols like the Ad Hoc On-Demand Distance Vector (AODV), which discover routes only when a node has data to send. The route discovery process involves broadcasting route request (RREQ) messages to neighboring nodes, which are propagated throughout the network until the destination is reached or an intermediate node has a valid route to the destination [8] [9] [10].

In a blackhole attack, the malicious node exploits this process by falsely advertising itself as having the shortest or most optimal route to the destination, even though it does not have a valid route. The following steps illustrate how a blackhole attack unfolds:

Route Discovery: When a source node initiates a route discovery process by broadcasting an RREQ, the blackhole node responds with a route reply (RREP) message, claiming it has a direct and optimal path to the destination.

Route Establishment: The source node selects the route advertised by the blackhole node, assuming it to be the most efficient.

Packet Dropping: Once the source node begins sending data through the malicious node, the blackhole node either drops or selectively forwards the packets, leading to data loss and communication disruption.

Types of Blackhole Attacks

Blackhole attacks can be further categorized based on the attacker's behavior:

Single Blackhole Attack: In this scenario, only one malicious node is involved in the attack. It advertises a fake route and drops all incoming packets.

Collaborative Blackhole Attack: Multiple malicious nodes cooperate to form a virtual blackhole. One node advertises the false route, while others assist by dropping or rerouting packets, making detection more challenging.

Impact of Blackhole Attacks on MANETs

The impact of a blackhole attack on MANET performance can be severe. Some of the critical consequences include:

- **Data Loss**: As the malicious node drops or discards packets, legitimate data fails to reach its intended destination, resulting in significant data loss.

- **Network Congestion**: The attack causes an increase in retransmissions and additional route discovery processes, which can congest the network and consume valuable bandwidth.
- **Degraded Throughput**: With packets being dropped or misrouted, the overall network throughput is reduced, affecting the quality of service (QoS).
- **Increased Latency**: The source node may experience delays in data transmission as it continuously attempts to resend lost packets or initiate new route discoveries.
- **Trust Compromise**: In a collaborative blackhole attack, multiple malicious nodes work together to deceive the network, undermining the trust in legitimate nodes and protocols.

LITERATURE REVIEW

Yazdanypoor, Mohammad, Stefano Cirillo, and Giandomenico Solimando [11] suggested a comprehensive hybrid detection method that markedly improves the identification and mitigation of black hole and grey hole assaults. Our methodology incorporates anomaly detection, sophisticated data mining tools, and cryptographic validation to create a multi-tiered defence system. Comprehensive simulations indicate that the suggested hybrid technique attains enhanced detection accuracy, minimises false positives, and sustains elevated packet delivery ratios, even in the presence of attacks. This technique offers superior reliability and resilience in network performance, dynamically adjusting to emerging threats compared to previous systems. This research signifies a substantial progress in MANET security, providing a scalable and efficient method for protecting essential MANET applications from advanced cyber-attacks. Ramachandran, Dhanagopal, *et al* [12] A black hole node is designed to deceive other access points into believing they must utilise it as their pathway to a certain destination. The black hole node in a cable network is undetectable and irreparable within an AODV network. In this study, we enhanced AODV by employing a lightweight method grounded in time and baiting to identify and differentiate between individual and collaborative black hole attacks. MANETs exhibit a dynamic topology, utilise an open medium, and lack a centralised monitoring point, all of which provide security challenges. Security assaults constitute one category of attacks. In MANETs, there is no central administration, and mobile devices connect to one another wirelessly. Black holes, insider assaults, grey holes, parallel worlds, defective nodes, and packet losses are all hazards that can significantly interrupt secure communication. Simulation results indicate that the suggested method substantially surpasses prior techniques regarding end-to-end delay, throughput, packet delivery ratio, and average energy consumption. Our proposed technique employs a multipath methodology to alleviate the black hole attack in MANET. The suggested technique is evaluated in a simulated environment to assess its stability under attack conditions.

Abdallah, Ashraf Abdelhamid, *et al* [13] The primary objective of this project is to develop a methodology for detecting blackhole attacks using anomaly detection techniques using Support Vector Machines (SVM). Our detection system analyses node activity to examine network traffic for anomalies. In blackhole circumstances, attackers display unique behavioural traits that differentiate them from other nodes. The suggested SVM-based detection method can efficiently identify this. The suggested detection system aims to analyse network data and discover anomalies through the examination of node behaviours. In the context of black hole threats, it differentiates attackers from legitimate nodes based on behavioural traits. This method enables the system to efficiently identify blackhole attacks. The results indicate a high degree of accuracy in detecting blackhole attacks, validating its effectiveness in safeguarding mobile ad hoc networks (MANETs) by identifying and isolating rogue nodes. This method is especially beneficial in contexts such as military operations and crisis management, when a dependable communication system is essential. Mohanraj, Mr K., and B. Arivazhagan [14] Devised a technique for identifying and mitigating black hole attacks in wireless ad hoc networks through fuzzy heuristics. The methodology entails establishing fuzzy logic rules and heuristics to detect anomalous behaviour indicative of black hole assaults within network traffic. Algorithms are formulated to assess network metrics including packet routing, signal strength, and node behaviour through fuzzy logic methodologies. Attack detection algorithms are employed to dynamically modify network parameters utilising fuzzy inference to alleviate the effects of black hole assaults. Anomaly detection

and prevention modules are incorporated into current network protocols to bolster security against black hole attacks.

Mekadem, Lahcene, and Malika Bourenane [15] Proposed the construction of a cross-layer intrusion detection system to counteract black hole assaults in mobile wireless networks. The suggested methodology has two tiers. At the initial level, data obtained from several layers serves as input to the fuzzy logic system to ascertain the classification of a specific node (malicious, normal, or suspicious). At the secondary level, if a node is deemed suspect, the Dempster-Shafer theory will be utilised to validate that node. Sivanesh, S., and V. R. Sarma Dhulipala [16] Presented the innovative host-based intrusion detection system (HIDS) termed analytical termination of malicious nodes (ATOM), which methodically identifies a prominent black hole attack that impacts the efficacy of the AODV routing protocol. ATOM IDS detects by calculating the RREP count (Route Reply) and the packet drop rate for each node individually. This system has been simulated using the AODV routing protocol integrated with black hole nodes, and the resulting simulation scenario has been produced in NS2. The trace indicates a significant enhancement in the packet delivery ratio (PDR) and throughput. The findings demonstrate the effectiveness of the proposed system.

Shukla, Mukul, and Brijendra Kumar Joshi [17] The suggested solution employs a trust-based fuzzy method that incorporates energy auditing, evaluates the trustworthiness of nearby nodes, verifies packet integrity, and authenticates node members. Trust values in fuzzy logic span from 0 to 1. If the node's trust value is greater than or equal to 0.6, the node is deemed trusted, and its type is utilised for communication between the source and destination in our case. If the node trust rating in the routing table is below 0.6, it indicates that the node is a blackhole node, rendering it an unsafe route. This work proposes a solution called Trust-based Fuzzy Ad hoc On-Demand Distance Vector (TFAODV) to address this attack scenario. Khosa, Thabiso N., Topside E. Mathonsi, and Deon P. Du Plessis [18] The literature assessment indicated that current solutions do not consistently guarantee accurate node classification. The cooperative nature of MANET occasionally results in the erroneous exclusion of innocent nodes and/or the inaccurate classification of malicious nodes. This study proposes a novel Grey Hole Prevention (GRAY-HP) technique for the detection of malicious nodes, achieving a high accuracy rate in node categorisation. The proposed algorithm utilises and adapts the gray-attack prevention method termed Secure Detection Prevention and Elimination Grey Hole (SDPEGH), together with a proactive strategy.

Suma, S., and Bharati Harsoor [19] To distinguish packet loss caused by congestion from that induced by a malicious node, our approach employs an on-demand link and energy-aware dynamic multipath (O-LEADM) routing scheme for mobile ad hoc networks (MANETs) to identify black-hole nodes through the integration of a bait method. The node's behaviour is assessed using control messages, specifically destination-sequence (des-Seq) and reply-sequence (rep-Seq), during channel access. During route discovery, each intermediate node in the network transmits the des-Seq message to all its neighbouring nodes, which subsequently respond to the intermediate node by delivering the rep-Seq message. If the des-Seq and req-Seq from neighbouring nodes do not align, the node is deemed malevolent. Access to the network layer is permitted for an intermediate node if the des-Seq and rep-Seq are congruent. The channel availability and link quality parameters assess link stability, enabling nodes to chose forwarding based on their behaviour and their capacity to achieve Quality of Service (QoS) metrics, including link quality, residual energy, and enhanced packet delivery. Pullagura, Joshua Reginald, and Venkata Rao Dhulipalla [20] examined the detection technique for black hole attacks within the standard ad hoc on-demand distance vector (AODV) routing protocol. The initial phase of the planned work involved a black-hole attack configured on the ordinary AODV protocol. The black-hole node will respond to route requests with the greatest sequence number to incentivise the sender to establish a route through it. The threshold mechanism of the intruder detection system identifies and isolates black-hole nodes. This article estimates the maximal destination sequence number using a linear regression approach. A performance comparison is conducted among standard, black hole-based, and black hole-detection routing systems.

Abdelhamid, Ashraf, *et al* [21] Proposed a solution for identifying black hole assaults utilising anomaly detection with a support vector machine (SVM). This detection system is designed to analyse network data and find anomalies by examining node behaviours. In instances of black hole attacks, the attacking nodes exhibit behavioural traits that

distinguish them from regular nodes. These attributes can be efficiently identified with our streamlined detection technology. An OMNET++ simulator is employed to assess the efficacy of this method by generating traffic during a black hole attack. Traffic is subsequently categorised into harmful and non-malicious, facilitating the identification of the malicious node. The proposed approach demonstrated exceptional accuracy in identifying black hole attacks. Reddy, Bhaskar, and B. Dhananjaya [22] The intermediate nodes transmit data to the designated destination, considering the necessary locations for accurate delivery. The routing protocol in an Ad hoc network employs nodes to assess various device locations and methodologies for potential data paths before determining the optimal route and methods for data exchange. The anomaly arises from the existing trust among various nodes and the dynamic topology, rendering routing protocols vulnerable to Denial of Service attacks, including black hole and wormhole attacks. The lack of integration into a central infrastructure subjects MANETs to conditions that conventional networks typically mitigate by injecting control packets and monitoring the target's movement once the user is connected to the wireless network. In a MANET, the attacker operates prior to the mark entering the wireless medium. Maliciously exploiting diverse routing information might precipitate further disorder within the system, ultimately resulting in extensive network failure. The current AODV attack, known as the Blackhole attack, operates by deliberately withholding critical routing information from end-users who could have utilised it, precisely as the adversary executes in this scenario. In this situation, the data packets remain undelivered, resulting in complete data loss for the system. The array of detection and protection methods utilised against the blackhole attacker substantially reduces the number of suspects. This article advocates for the inclusion of the OSPFV protocol for wireless LANs, incorporating built-in security through threshold evaluation and cryptographic verification. This paper simulates two protocols, the blackhole attack and the proposed AODV-BS, across various MANET models. It employs two additional network metrics: Network Packet Delivery Ratio and normalised Out of Routing Overhead Utilisation, alongside Network Delay, to analyse their performance and derive conclusions.

Kaushik, Sheetal, *et al* [23] concentrated on the Ad Hoc On-Demand Multi-Path Distance Vector Routing (AOMDV) protocol, favoured for its enhanced efficiency relative to a single-path routing protocol in MANETs. We analyse, examine, and assess the optimisation of routes in wireless ad-hoc networks by minimising packet hops across nodes. This study proposes a unique method, the K-AOMDV protocol, which use K-means clustering to mitigate routing misbehaviour. The efficacy of the proposed K-AOMDV (KNN-Ad-hoc On-Demand Multi-Path Distance Vector) routing protocol is assessed by a supervised machine learning methodology to forecast ideal routes considering latency and security threats. Utilising multiple pathways and dynamic route discovery guarantees reliable data transmission despite the existence of hostile nodes. Srilakshmi, R., and Jayabhaskar Muthukuru [24] The unruly nodes that contravene the norm significantly undermine the performance of the virtuous nodes. Consequently, an intrusion detection system should be incorporated into the mobile ad-hoc network (MANET). This study examines wormhole and other deleterious malignant assaults in MANET. A wireless ad-hoc network, also known as a mobile ad-hoc network (MANET), is a collection of nodes that employs a wireless channel to transmit data and collaborate to facilitate information exchange between any two nodes, without a centralised framework. The security concern is a significant challenge in the utilisation of MANETs.

Sunitha, D., and P. H. Latha. [25] concentrated on identifying Black Hole assaults with sophisticated optimisation algorithms, specifically Grey Wolf Optimisation (GWO), Ant Colony Optimisation (ACO), Genetic Algorithm (GA), and Particle Swarm Optimisation (PSO). This survey seeks to improve the performance of MANETs by accurately recognising and minimising the effects of malicious nodes. The proposed method utilises the GWO algorithm to enhance routing pathways, hence increasing throughput and packet delivery ratio while minimising end-to-end delay. The ACO employed a systematic approach for routing decisions, incorporating pheromone updates and heuristic values to improve the efficacy of Black Hole attack detection. The GA framework incorporates Crossover and Mutation operators, facilitating a more systematic generation of nodes and enhancing flexibility to fluctuating network conditions. The PSO method employs a multidimensional strategy, including diversity optimisation and energy-efficient routing for Black Hole discovery. Therefore, the proposed method improves packet transmission in MANET and effectively secures the routing layer. Kaur, Arshdeep, and Jaspreet Kaur [26] presented a security mechanism based on trust. The trust parameters, determined by two factors: (i) Current Energy and (ii) Packed Drop

Count of a node, are utilised to select IDS. The designated IDS node aids the source node in determining a data transmission pathway and thereafter oversees that route until the transmission concludes. The effects of each scenario are evaluated using PDR, NRL, and PLR, and the efficacy of the suggested approach is assessed through three different scenarios featuring varying quantities of attackers, mobility, and nodes.

Cherkaoui, Badreddine, *et al* [27] Proposed a black hole attack detection system utilising the Kolmogorov-Smirnov statistical approach. This technology is engineered to detect communication interruptions induced by such assaults without necessitating structural alterations to the routing protocol. The findings indicate that the suggested strategy can identify the occurrence of the assault through the observation of network activity. Malik, Abdul, *et al* [28] A novel method termed Detection and Prevention of a BHA (DPBHA) is presented to enhance the security and performance of VANETs by identifying BHA at an early stage of the route discovery process. The suggested approach involves computing a dynamic threshold value and creating a counterfeit route request (RREQ) packet. The solution is executed and assessed in the NS-2 simulator, and its performance and effectiveness are juxtaposed with the benchmark schemes.

Olanrewaju, Oyenike Mary, Abdulwasiu Adebayo Abdulhafeez Abdulwasiu, and Abdulhafiz Nuhu [29] Proposed an Enhanced On-demand Distance Vector (AODV) routing protocol to mitigate Blackhole attacks on MANETs utilising Diffie-Hellman and Message Digest 5 (DHMD), executed via Network Simulator 2 (NS2). The efficacy of the proposed protocol was assessed based on the following metrics: Packet Delivery Ratio, throughput, End-to-End (E2E) Delay, and routing overhead. It was determined that DHMD decreased network overhead to 23%, but AODV recorded 38%. Additionally, memory consumption for DHMD was 0.52 ms, in contrast to AODV's 0.81 ms, attributable to Blackhole prevention. This research aims to alleviate the impact of blackhole attacks on a network and enhance network performance by minimising overhead and memory usage. Kancharakuntla, Deepika, and Hosam El-Ocla [30] suggested an Enhanced Blackhole Resistance (EBR) protocol to detect and mitigate nodes accountable for blackhole attacks. EBR can circumvent congested traffic by routing data packets along a secure path with the minimal round-trip time (RTT). The EBR protocol employs a mix of time to live (TTL) and round trip time (RTT), referred to as a TR mechanism, to identify blackhole assaults. Our approach does not necessitate any cryptography or authentication procedures. Simulation studies demonstrate that EBR outperforms competing protocols for throughput, end-to-end delay, packet delivery ratio, energy efficiency, and routing overhead.

Research Gap

Detecting blackhole attacks is a significant challenge due to several factors:

- **Lack of Centralized Authority**: MANETs lack a central authority to monitor and validate the authenticity of routing information.
- **Dynamic Topology**: Frequent topology changes make it difficult to identify abnormal routing behavior or malicious nodes.
- **Resource Constraints**: Nodes in MANETs are often resource-constrained, with limited battery power, processing capability, and memory. Therefore, resource-intensive detection techniques may not be feasible.
- **False Positives**: Some detection methods may wrongly classify legitimate nodes as malicious, leading to unnecessary route changes and further degrading network performance.

Future Research Direction

The detection and mitigation of blackhole attacks in Mobile Ad Hoc Networks (MANETs) remain challenging due to the dynamic and decentralized nature of the network. While several detection methods have been proposed, each with its advantages and limitations, there are still significant gaps in developing robust and efficient solutions. Future research should focus on overcoming these challenges, exploring new techniques, and improving existing methods. Below are key future research directions for the detection of blackhole attacks in MANETs:

Trust-based and AI Integration: Combining trust-based models that monitor node behavior with AI techniques to enhance detection accuracy while adapting to dynamic network changes.

Cross-layer Approaches: Investigating methods that gather information from multiple layers of the network (physical, data link, and network layers) to better understand node behavior and identify potential blackhole attackers.

Lightweight Hybrid Models: Developing resource-efficient hybrid detection mechanisms that do not impose excessive computational or energy burdens on resource-constrained nodes.

Energy-aware Detection Models: Designing lightweight algorithms that optimize energy consumption while maintaining high detection accuracy. Techniques like data aggregation and selective monitoring of nodes can help reduce unnecessary overhead.

Cooperative Trust Models: Developing trust models that allow nodes to collaboratively assess the behavior of their neighbors. A consensus-based approach can ensure that malicious nodes are detected more reliably, reducing false positives.

Advanced Collaborative Detection Algorithms: Developing advanced techniques to detect coordinated attacks involving multiple blackhole nodes. These methods could analyze node interactions and packet flow to identify suspicious patterns indicative of a collaborative attack.

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REVIEW ARTICLE

Application of Deep Learning Technique in the Detection of Knee Arthritis – A Literature Survey

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ABSTRACT

Knee arthritis is a prevalent degenerative joint disease, affecting millions globally and posing significant healthcare challenges. The early detection and accurate diagnosis of knee arthritis are crucial for effective treatment and management. Recent advancements in Deep Learning (DL), Machine Learning (ML), and Image Processing (IP) techniques have opened new avenues for improving diagnostic accuracy and automating the detection process. This literature survey explores the state-of-the-art methodologies employed in knee arthritis detection using these technologies. Key approaches discussed include convolutional neural networks (CNNs) for image classification, support vector machines (SVMs) and decision trees in ML-based classification, and image processing methods like edge detection and segmentation for enhancing radiographic images. The survey also reviews feature extraction techniques, such as texture analysis and wavelet transforms, along with optimization strategies for enhancing prediction performance. Furthermore, challenges such as imbalanced datasets, feature selection, and model interpretability are highlighted. This survey aims to provide a comprehensive understanding of the current landscape, addressing the gaps and future directions for improving knee arthritis detection through advanced computational techniques.

Keywords: Knee arthritis detection, Deep Learning, Machine Learning, Preprocessing, Classification, Image Processing

INTRODUCTION

Knee arthritis, a leading cause of disability worldwide, is characterized by the progressive degeneration of joint cartilage, leading to pain, stiffness, and reduced mobility. Osteoarthritis (OA) and rheumatoid arthritis (RA) are the most common forms of knee arthritis, and early detection is critical for slowing disease progression and improving patient outcomes. Traditionally, clinical diagnosis relies on patient history, physical examinations, and radiographic imaging, such as X-rays and MRI scans. However, these methods can be subjective and time-consuming, often resulting in delayed or inaccurate diagnosis [1]. In recent years, the integration of advanced computational techniques, including Deep Learning (DL), Machine Learning (ML), and Image Processing (IP), has shown significant promise in improving the detection and classification of knee arthritis. These methods offer automated, objective, and scalable solutions for analyzing medical images and identifying patterns that may not be apparent to the human eye. By leveraging large datasets and sophisticated algorithms, DL and ML techniques, such as Convolutional Neural Networks (CNNs), Support Vector Machines (SVMs), and Random Forests, can accurately classify the presence and severity of arthritis. Image processing methods, including image segmentation, feature extraction, and enhancement techniques, further aid in isolating key features within radiographic images for more precise diagnosis [2]. This literature survey aims to provide a comprehensive overview of the various DL, ML, and IP techniques employed for the detection of knee arthritis. It covers recent advancements, commonly used models, and innovative image processing approaches, highlighting their potential and limitations. The review also addresses key challenges such as data imbalance, model interpretability, and the need for better feature selection and optimization strategies. By examining existing methodologies, this survey seeks to identify gaps in current research and suggest directions for future work, with the ultimate goal of advancing the field of arthritis diagnosis through technological innovation.

Image Processing Techniques for the Detection of Knee Arthritis

Image processing [3] [4]plays a pivotal role in the detection and diagnosis of knee arthritis, enabling the enhancement, segmentation, and analysis of medical images to reveal critical features for accurate classification. Given the nature of medical imaging modalities, such as X-rays and MRI scans, image processing techniques help in isolating key regions of interest, improving contrast, and reducing noise, which can significantly aid in the automated detection of knee arthritis.

Image Preprocessing

Preprocessing is a fundamental step that prepares raw medical images for further analysis. Common preprocessing techniques [3] include:

Noise Reduction: Medical images often contain noise that can hinder the clarity of joint structures. Methods such as Gaussian filtering, median filtering, and wavelet-based denoising are employed to remove noise while preserving important features like bone contours and cartilage boundaries.

Histogram Equalization: This technique improves the contrast of images by redistributing pixel intensities, making it easier to differentiate between various tissues and the knee joint's structures.

Normalization: In knee arthritis detection, normalization ensures that images taken under different lighting conditions or settings have similar intensity levels, reducing variability.

Image Segmentation

Segmentation [4] is essential for isolating specific regions of interest, such as the knee joint, cartilage, or osteophytes (bone spurs), which are key indicators of arthritis. Common segmentation techniques include:

Thresholding: This basic technique segments the image based on pixel intensity. Adaptive thresholding can be used to handle images with varying illumination.

Edge Detection: Methods like the Canny or Sobel edge detectors highlight boundaries between tissues, aiding in the identification of joint spaces, bone edges, and cartilage.

Active Contour Models (Snakes): This technique uses contours that evolve to fit the shape of the knee joint or other structures. It is particularly useful for segmenting complex shapes in noisy medical images.

Region Growing: This technique groups pixels with similar intensity values, enabling the segmentation of cartilage or other soft tissues that exhibit homogeneity.
Watershed Algorithm: Frequently applied in medical imaging, this method treats the image as a topographic surface and segments regions based on ridges or valleys, which can be useful in delineating bones from cartilage.

Feature Extraction
Feature extraction focuses on isolating and identifying specific attributes within the images that are indicative of arthritis [5]. Key techniques include:

Texture Analysis: Texture features, such as the coarseness or smoothness of cartilage, can be analyzed using techniques like Gray Level Co-occurrence Matrix (GLCM) and Local Binary Patterns (LBP). These methods extract texture information that can differentiate between healthy and arthritic tissue.

Shape Descriptors: These descriptors, including contour analysis and shape-based features, are used to evaluate joint space narrowing or bone deformities, which are common signs of arthritis.

Wavelet Transform: This technique is used for multi-resolution analysis of knee images. It helps in detecting fine structures within the joint space and can highlight regions affected by arthritis.

Image Enhancement
Image enhancement techniques are employed to improve the visibility of key features, such as cartilage degradation or bone spurs, which are essential for diagnosing arthritis:

Contrast Enhancement: Techniques like adaptive histogram equalization (AHE) or contrast-limited adaptive histogram equalization (CLAHE) are used to enhance contrast in areas where arthritis-related changes may be subtle.

Sharpening: Techniques like unsharp masking can enhance edges within the knee joint, making it easier to identify joint space narrowing or other deformities.

Super-Resolution Imaging: This advanced technique generates high-resolution images from lower-resolution data, improving the clarity of minute details in knee joints, aiding in the diagnosis of early-stage arthritis.

Deep Learning Techniques for the Detection of Knee Arthritis
Deep Learning (DL) [6] has revolutionized the field of medical image analysis, offering highly accurate and automated solutions for the detection of knee arthritis. By leveraging vast amounts of data and powerful computational architectures, DL techniques, particularly Convolutional Neural Networks (CNNs), have demonstrated exceptional performance in identifying arthritis-related features from medical images. This section outlines the key deep learning methodologies employed in the detection of knee arthritis, focusing on various neural network architectures, training strategies, and performance enhancements.

Convolutional Neural Networks (CNNs)
CNNs are the backbone of deep learning-based image analysis. They excel in learning spatial hierarchies from medical images, making them ideal for detecting knee arthritis through radiographic images such as X-rays and MRIs. Key CNN [7] [8] techniques used for knee arthritis detection include:

AlexNet, VGG, and ResNet Architectures: These popular CNN architectures are widely applied for arthritis detection due to their capability to automatically extract relevant features from images. ResNet, with its residual connections, is particularly useful for addressing vanishing gradient issues in deep networks.

Pretrained Models and Transfer Learning: Given the scarcity of large labeled medical datasets, transfer learning plays a crucial role in knee arthritis detection. Pretrained models such as VGG16, ResNet, and Inception, trained on large datasets like ImageNet, can be fine-tuned for arthritis detection tasks. This approach reduces the need for extensive training data and allows the model to adapt quickly to the medical domain.

DenseNet and EfficientNet: These newer architectures emphasize parameter efficiency and feature reuse. DenseNet, with its densely connected layers, improves feature propagation and reduces the number of parameters, while EfficientNet scales network dimensions effectively, offering a good balance between accuracy and computational cost.

Fully Convolutional Networks (FCNs)

For precise segmentation of knee joint structures such as cartilage and bone, FCNs are employed. Unlike standard CNNs, FCNs replace fully connected layers with convolutional layers, allowing them to generate pixel-wise predictions for segmentation tasks. This is particularly useful in identifying joint space narrowing or cartilage loss, which are indicative of arthritis.

U-Net: U-Net is a popular fully convolutional network designed for medical image segmentation. It consists of a symmetric encoder-decoder architecture, where the encoder extracts hierarchical features from the input image, and the decoder uses these features to perform pixel-wise segmentation. U-Net is particularly effective for detecting joint boundaries and cartilage in knee arthritis.

SegNet: Similar to U-Net, SegNet uses an encoder-decoder structure but focuses on maintaining spatial information through max-pooling indices, making it efficient for segmentation of complex anatomical structures in knee joints.

Recurrent Neural Networks (RNNs) and Long Short-Term Memory (LSTM)

While CNNs are primarily used for spatial data, Recurrent Neural Networks (RNNs), particularly Long Short-Term Memory (LSTM) networks, can be integrated to handle temporal sequences [9][10]. In knee arthritis detection, LSTMs can be used in combination with CNNs to analyze a series of time-lapsed images (e.g., in longitudinal studies of arthritis progression) or to enhance decision-making by capturing dependencies between image slices in 3D MRI scans.

Attention Mechanisms

Attention mechanisms, which allow models to focus on specific regions of an image, have been increasingly applied to knee arthritis detection. By integrating attention layers within CNN architectures, these networks can prioritize areas in the image that are more likely to contain arthritis-related features, such as cartilage edges or joint spaces, thereby improving diagnostic accuracy.

Self-Attention and Transformers: Inspired by natural language processing, self-attention mechanisms and transformer-based architectures are now being explored for image analysis tasks. These models allow for global context awareness, which can be crucial for analyzing complex medical images where local and global features are equally important.

Generative Adversarial Networks (GANs)

Generative Adversarial Networks (GANs) have shown potential in the medical imaging field, including in knee arthritis detection. GANs consist of two networks—a generator and a discriminator—that work in opposition to improve the quality of generated images or features. In knee arthritis, GANs can be used for:

Data Augmentation: GANs can generate synthetic images of knees with varying degrees of arthritis to augment limited datasets, improving the robustness of DL models in detecting early-stage arthritis or rare cases.

Image-to-Image Translation: GANs can translate X-ray images to high-resolution or enhanced versions, helping to detect minute changes in joint space or cartilage that might be missed in standard images.

Related Works

Sikkandar, Mohamed Yacin, *et al.* [11] A novel automatic classification of KOA images utilising an unsupervised local centre of mass (LCM) segmentation technique and a deep Siamese Convolutional Neural Network (CNN) is introduced. First-order statistics and the GLCM matrix are employed to extract KOA anatomical features from segmented images. Bayramoglu, Neslihan, Miika T. Nieminen, and Simo Saarakkala [12] Utilised lateral view knee radiographs from The Multicenter Osteoarthritis Study (MOST) public use datasets (n = 5507 knees). The patellar region of interest (ROI) was automatically identified using the landmark recognition program (BoneFinder), and these anatomical landmarks were later employed to generate three distinct textural ROIs. Features meticulously created from Local Binary Patterns (LBP) were subsequently extracted to characterise the patellar texture. A Gradient Boosting Machine model was initially developed to identify radiographic Perfluorooctanoate (PFOA) using LBP characteristics. Additionally, we employed end-to-end trained deep convolutional neural networks (CNNs) directly on the texture patches for the detection of PFOA.

Supriya, M., and Thayyaba Khatoon Mohammed [13] suggested a hybrid model that integrates sophisticated computer vision methodologies, including Scale-Invariant Feature Transform (SIFT) and Speeded Up Robust Features (SURF), with Support Vector Machines (SVM) and Random Forests. The amalgamation of SIFT and SURF facilitates the extraction of resilient and distinguishing features from knee joint images, essential for precise classification. The SVM and Random Forest algorithms are utilised to categorise these traits, offering an effective means to differentiate between healthy and sick states. We employ a comprehensive array of knee images, encompassing MRIs, CT scans, and X-rays, to train and refine the model, guaranteeing its capability to manage diverse imaging modalities and situations. Abdullah, S. Sheik, and M. Pallikonda Rajasekaran [14] Created a tool for identifying and assessing knee osteoarthritis (OA) using digital X-ray images, demonstrating the potential of deep learning methods to predict knee OA according to the Kellgren-Lawrence (KL) grading system. The objective of the study is to evaluate the efficacy of an artificial intelligence (AI)-driven deep learning method in identifying and assessing the severity of knee osteoarthritis (OA) in digital X-ray images.

Khamparia, Aditya, *et al* [15] Proposed a novel feature extractor from X-ray images of the knee to aid in detection and classification, termed explainable Renyi entropic segmentation inside an Internet of Things (IoT) framework. The suggested method thereafter employs a model-agnostic algorithm utilising post hoc explainability to retrieve pertinent information from knee joint segmentation predictions. The CAD system is connected with an IoT framework and can be utilised remotely to aid medical practitioners in the treatment of knee arthritis. Karpiński, Robert [16] Presented the findings of a preliminary investigation on the simplified diagnosis of knee joint osteoarthritis based on generated vibroacoustic processes. The investigation utilised acoustic signals obtained from a cohort of 50 individuals, comprising 25 healthy subjects and 25 individuals with previously established degenerative abnormalities. The chosen discriminants of the signals were identified, and statistical analysis was conducted to facilitate the selection of ideal discriminants for subsequent usage as input to the classifier. The optimal outcomes of classification utilising artificial neural networks (ANN) of Radial Basis Function (RBF) and Multilayer Perceptron (MLP) kinds are shown.

Trejo-Chavez, Omar, *et al* [17] The primary contribution described is a methodology utilising infrared thermography (IT) and convolutional neural networks (CNNs) to autonomously distinguish between a healthy knee and an injured knee, serving as an alternative tool to assist medical professionals. The methodology comprises three steps: (1) database building, (2) image processing, and (3) construction and validation of a CNN for the automatic identification of patients with knee injuries. During the image-processing phase, greyscale images, equalised images,

and thermal images serve as inputs for the CNN, achieving an accuracy of 98.72% with the suggested technique. Bose, Anandh Sam Chandra, C. Srinivasan, and S. Immaculate Joy [18] This research examines the crucial function of FS in improving the precision and reliability of ML models employed in KOA detection and severity categorisation. The data were sourced from Kaggle, reflecting diverse grades of KOA. We utilise a Convolutional Neural Network (CNN) model to extract characteristics from medical imaging data. Employing sophisticated methodologies like Particle Swarm Optimisation (PSO) and Genetic Bee Colony (GBC), we methodically discern important features to improve our machine learning models.

Sharma, Neha, Riya Sapra, and Parneeta Dhaliwal [19] Examined numerous medical imaging modalities applicable for the detection or diagnosis of Knee Osteoarthritis (KOA) and explored diverse Machine Learning algorithms that facilitate the automated identification of KOA with minimal human involvement. "Joint inflammation" is the synonym for arthritis. Joints are defined as the anatomical regions where two bones converge, facilitating movement, exemplified by the elbow and knee. Arthritis is a prevalent condition that is among the leading causes of global disability. Osteoarthritis is a form of arthritis that mostly arises from recurrent stress on joint cartilage. Osteoarthritis is also referred to as "degenerative" arthritis. Utilising machine learning concepts on medical data can substantially enhance disease detection and early diagnosis. This research provides a comprehensive overview of several medical imaging approaches that enable automated diagnosis of KOA using advanced machine learning methods. Song, Jiangling, and Rui Zhang [20] Concentrate on researching the computer-assisted diagnosis technique for knee osteoarthritis (KOA-CAD) utilising multivariate data, specifically vascular activity graphs (VAGs) and fundamental physiological signals, through an enhanced deep learning model (DLM). A novel Laplace distribution-based technique (LD-S) for classification in DLM is developed. Secondly, an aggregated multiscale dilated convolution network (AMD-CNN) is developed to extract features from the multivariate data of KOA patients. A novel KOA-CAD method is introduced, combining the AMD-CNN with the LD-S to achieve three CAD objectives: automatic KOA identification, early KOA detection, and KOA grading detection.

Zhao, Zhengkuan, *et a*l [21] The primary purpose was to employ machine learning techniques to discern critical structural features correlated with pain severity in patients with knee osteoarthritis. Furthermore, we evaluated the efficacy of several categories of imaging data through machine learning methodologies to determine the degree of knee discomfort. Data from semi-quantitative evaluations of knee radiographs, semi-quantitative assessments of knee magnetic resonance imaging (MRI), and MRI images of 567 participants in the Osteoarthritis Initiative (OAI) were employed to build a set of machine learning models. Models were developed employing five machine learning techniques: random forests (RF), support vector machines (SVM), logistic regression (LR), decision trees (DT), and Bayesian approaches (Bayes). Utilising tenfold cross-validation, we identified the optimal models based on the area under the curve (AUC). Patil, Pradnya, *et al.* [22] Formulated a prediction model for Knee Osteoarthritis (KOA) utilising X-ray images and the Kellgren-Lawrence (KL) scale to ascertain the existence of KOA. Medical images, namely knee X-rays, were gathered and categorised by radiologists according to the KL scale, which ranges from 0 (absence of KOA) to 4 (severe KOA). Convolutional neural network (CNN) modelling is employed to analyse X-ray images and predict the KL score.

Zebari, Dilovan Asaad, Shereen Saleem Sadiq, and Dawlat Mustafa Sulaiman [23] Introduced a technique utilising deep features. We utilised a Convolutional Neural Network to extract deep information from images of Knee Osteoarthritis. The collected characteristics are subsequently input into various machine learning classifiers, specifically Support Vector Machine, K-Nearest Neighbour, and Naive Bayes. This study has been classified to distinguish between healthy and unhealthy Knee Osteoarthritis images. Kijowski, Richard, Jan Fritz, and Cem M. Deniz [24] Various deep learning methodologies have been delineated for the fully automated segmentation of cartilage and other knee tissues, attaining superior segmentation accuracy compared to existing techniques while significantly decreasing segmentation durations. Multiple deep learning models have been created for the assessment of osteoarthritis risk by analysing baseline X-rays and MRIs. These models have demonstrated superior diagnostic efficacy in forecasting several outcomes of osteoarthritis (OA), including the incidence and advancement of radiographic knee OA, the emergence and progression of knee pain, and the likelihood of future total knee

arthroplasty. The initial outcomes of deep learning applications in optical coherence imaging have proven promising. Nonetheless, numerous deep learning techniques necessitate additional technical enhancement to optimise diagnostic efficacy. Sharmila Begum, M., *et al* [25]. Proposed an artificial intelligence process for selecting an abstract set of characteristics from the provided raw data, with classification performed via Hybrid Isolation Forest (HIF). The chapter has three steps, beginning with the processing of raw images and the extraction of the pre-processed dataset. The second phase delineates the abstract feature set through statistical and regressive parameters. The third phase introduces a hybrid isolation forest methodology that amalgamates probability distribution with isolation forest techniques to achieve precise classification of normal and anomalous data samples. The suggested AI model is evaluated using the knee joint dysfunction image dataset.

Research Gap

Despite significant advancements in image processing and deep learning (DL) techniques for the detection of knee arthritis, several challenges and research gaps remain. These limitations present opportunities for further research to improve diagnostic accuracy, model robustness, and clinical applicability. The following outlines key research gaps in this domain:

Data Scarcity: One of the major challenges is the lack of large, annotated datasets specific to knee arthritis. Existing datasets, such as the Osteoarthritis Initiative (OAI), are valuable but often limited in terms of diversity, image types (e.g., X-rays versus MRI), and varying levels of disease severity.

Diversity in Imaging Modalities: Most studies focus on a single imaging modality, such as X-rays, while limited work has been done on multi-modal approaches (e.g., combining MRI, X-rays, and CT scans). Integrating data from different modalities could improve diagnosis, but it also introduces challenges in data alignment and fusion.

Class Imbalance: Datasets are often heavily skewed, with a higher prevalence of moderate or severe arthritis cases, leading to biased models that may underperform in detecting early-stage arthritis.

Overfitting: Deep learning models trained on limited datasets are prone to overfitting, where they perform well on the training data but fail to generalize to new, unseen images. This is a particularly challenging issue in medical imaging, where obtaining large, high-quality labeled datasets is difficult.

Lack of Optimal Feature Selection Techniques: Identifying the most relevant features for arthritis detection is crucial, yet many models rely on deep learning's automatic feature extraction without fully exploring optimal feature selection methods. Techniques such as wavelet transforms, texture analysis, or hybrid feature extraction approaches (e.g., combining spatial and frequency domain features) could be further explored to enhance detection performance.

Future Research Direction

Given the current research gaps in knee arthritis detection using image processing and deep learning techniques, several promising avenues for future exploration can be pursued. These research directions aim to enhance model performance, clinical applicability, and the development of real-time, deployable solutions for early and accurate detection of knee arthritis.

Hybrid Models for Enhanced Feature Extraction: Combining CNNs with traditional image processing techniques (e.g., wavelets, texture analysis) or using advanced feature selection methods could improve model performance. Such hybrid models would benefit from the interpretability of classical methods while leveraging the powerful feature extraction capabilities of deep learning.

CNN + RNN/LSTM Architectures: Developing hybrid models that combine spatial feature extraction (via CNNs) with temporal analysis (via LSTMs or RNNs) can allow for more accurate predictions based on image sequences or longitudinal data.

Unsupervised Learning for Feature Discovery: In addition to supervised learning, unsupervised or semi-supervised learning methods should be investigated to discover new, clinically relevant features in knee images. This could lead to the identification of novel biomarkers for early arthritis detection.

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RESEARCH ARTICLE

A Generic Approach for Software Metrics Based Software Defect Prediction

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ABSTRACT

Software performance error detection is an essential non-functional requirement, which appears in many fields such as complex applications and real-time application development. In this work, he focuses on early detection of performance bugs. The proposed work finds a robust and reliable solution to enforce and predict performance errors. Compared with the proposed new algorithm for defect prediction, we construct several methods using ML algorithms: C4.5 decision tree, naive Bayes, Bayesian network and logistic regression. That's what our exact outcomes show the model proposed using the modified line of code MCCABE/HALSTEAD can be used to predict performance errors with an accuracy of 0.94 and 0.96.We show that reducing the number of committed changes in a commit reduces the chance of injecting performance bugs. This approach helps professionals eliminate performance bugs early in the development cycle. Our results are also of interest to theorists, as they establish a link between functional errors and performance errors, and clearly show that attributes are used to predict functional metrics.

Keywords: Defect prediction, features based, machine learning, performance analysis, regression model, SDLC.

INTRODUCTION

Data mining is the business of analyzing information from different angles and fusion or compressing it into important and meaningful data. Data mining techniques such as feature extraction and classification techniques have proven to be very effective in predicting defects in biological substances, irregularities in clinical data, and revealing important medical facts that inspire the exploration of such treatments, pharmacology, and clinical decision-making pathway of interest. Feature extraction is the technique of deciding on effective methods or subsets of features to create powerful unsupervised learning models. Classification is a data analysis technique used to distinguish important categories/categories of data. This work aims to identify the optimal and minimal set of software defect models for more accurate identification of software failure propensities in programmed systems. The final performance metrics used to evaluate the current method include precision, sensitivity, and specificity.

Software bugs are often not discovered until late in the development cycle, at which point it is expensive to go back and fix them. Addressing these bugs is a critical flaw that can build an application developer's reputation for delivering products or creating life-threatening situations when the software is part of a larger system or device, such as defense equipment or medical equipment. Therefore, methods for predicting software failures Further improving the quality of programming used in Defense Force programs is the rationale for this research effort. In the literature, several articles have been presented on software faults using mining strategies by predictive methods. Some papers discuss failure prediction methods such as measures of size and complexity, multivariate analysis, and multicollinearity using Bayesian conviction systems. NB is widely used to build classifiers. When building a defect predictor, the probability of each class is computed, given the extracted properties of a module, to predict a defective module using an applicable measure, such as Halstead and McCabe *et al*. This work develops prediction rules for fault attributes using a Naive Bayesian classifier (NB). The focus of this work is to construct effective methods for software fault prediction. We summarize this work for three fundamental reasons: the work creates datasets from publicly available procedural resources; the reported accuracy of combined techniques shows much room for development; the design of more accurate failure prediction techniques can Significantly currently used in the defense framework.

Related Work

Several previous studies analyzed the impact of current contribution behavior on software quality. Examined the effects of ownership and experience on the nature of various open-source projects using a detailed approach based on fix-inducing code fragments and reported similar findings to our paper (Malhotra, Ruchika, and Juhi Jain.2020). However, they operate differently on ownership, and ownership policies and practices in OSS and commercial software are very different. So, the similarity in effect is surprising. Furthermore, Rahman and Devanbu. 2010 did not study the secondary contribution relationship of software dependencies; nor did they consider social media metrics. Concentrated on the impact of counting group size in predictive models (Banga, Manu, and Abhay Bansal. 2020). They use the number of developers for each component, but don't check the percentage of work we explain. They found that failure prediction accuracy could be improved by trivially adding device dimensions to the model. We are different in that we examine the proportion of each developer's contribution to the component. Also, we are not interested in predictions, but there is a statistically significant relationship between attribute determination and failure.

Similarly, Reddy, K. Narsimha, and Polaiah Bojja. 2022studied the relationship between some developers and security vulnerabilities. They found that a security breach was 16 times more likely to occur if more than nine developers contributed to a source file. New approaches such as Extreme Programming (XP) (Chakrabort*et. al.* 2020) claim ownership of collective code, but there is little empirical evidence or support for such information in considerably larger or more difficult applications. Our study is the first to empirically quantify the impact of code owners (and inexperienced contributors) on overall code quality. Execution bugs are more diligently to uncover during the testing stage since they don't cause lethal side effects and don't affect the overall results. Pant *et. al.*2022.

Furthermore, it is difficult to find the root cause of performance bugs (compared to other types of bugs); they also take longer to resolve (Goyal and Somya 2020).

The closest work to ours is that of Eken*et al.* 2021 , who studied a set of 109 real-world performance bugs. They study the lifecycle of errors from creation to correction, root causes, and introduction mechanisms to create rule-based detectors. We use a similar approach to create detectors (called "patterns" in our research) to identify similar performance errors.They examined software written in Java, C, C++, and JavaScript; our program was written in MATLAB. Additionally, we focused on finding an efficient way to automatically detect performance bugs (197 real-world performance bugs in our example) based on data extracted from usage patterns. In summary, focused on analyzing performance bug characteristics, whereas in this study we aim to understand the contribution of each source code attribute retrieved from a source code repository to the predictive power of various algorithms (Malhotra, Ruchika. 2020).We use automatic algorithms. Finally, our general approach and methodology for building predictive models is designed to be easily reproducible in the future. Therefore, our work is complementary.

Automatic performance bug detection has been implemented in the past (Banga,*et. al.* 2020), (Hosseinalipour, *et. al.* 2022). However, the authors use dynamic analysis tools, namely execution traces and historical performance data, to detect slow-running code. Additionally, dynamic analysis tools often require a dedicated test environment to get accurate performance readings. On the other hand, we leverage code properties pulled from source code repositories and automatically catch performance bugs before the code is executed (and put into production). Accordingly, our work is reciprocal. Static examination devices can likewise dispose of execution bugs (Reddy, *et. al.*2022.). In any case, this approach requires information on pattern formats, while our approach does not (since we omit schema type information from the model), so our work is relevant. RTS has formal and comprehensive coding standards. However, standards are usually language-specific (for example, C (Dereli, and Serkan, 2022.) and C++ (Sharma, *et. al.*2022). Apparently, there is no finished furthermore, formal RTS coding standard for MATLAB. At last, since in our review we relate execution to the continuous idea of the framework, it can be argued that programming languages may not be suitable for this situation. While this is an inquiry.We grasp its significance and legitimacy outside the extent of this review. This programming language (with a suitable runtime (Nitta, *et. al.*2022)) is used in known large-scale RTS.

The Table 1 presents a comparative analysis of previous research and the current study on software defect prediction, focusing specifically on performance bugs. Malhotra and Ruchika's work shares similarities with the current research in analyzing ownership and experience effects on software quality but lacks exploration of secondary contribution relationships in software dependencies. Banga and Manu's study highlights the impact of group size on predictive models, improving prediction accuracy, yet it overlooks the proportion of each developer's contribution. Menely and Williams emphasize the relationship between developers and security vulnerabilities, diverging from performance bug analysis. Jin *et al*. undertake a lifecycle study of real-world performance bugs, albeit in different programming languages than the current study. Previous works generally analyze performance bug characteristics, but lack focus on automatic algorithms and reproducibility. Past implementations prioritize dynamic analysis, while the current study emphasizes static examination, though omitting schema type information and relevance to MATLAB coding standards. Overall, the current study bridges gaps in previous research by focusing on automatic algorithms, reproducibility, and relevance to MATLAB coding standards for performance bug detection.

METHODOLOGY

Data Preparation

We removed all records that didn't go into the indicator extraction library, namely: readme, test scripts and help documents.Additionally, we eliminated 0.2% (9 out of 4623 extraordinary tuples) of "commit ID-filename" records connected with source code documents. These records are outliers, corner cases. For instance, we exclude source files that have been moved or deleted. More specifically, version control systems by default recognize index

changes/refactoring's as complete cancellations of the actual records.So, whenever a file moves up or down at least one levels in the registry structure, we notice an unusual number of lines being added or removed. In some of these cases (particularly registries with huge records)in excess of 10,000 lines were added or taken out in a solitary commit. The above cleanups lead to more accurate model building, mainly due to the evacuation of sections that won't be found in future commits. The "Data Preparation Workflow" Figure 1 provides a visual overview of the steps involved in preparing the data for analysis. The process begins with data cleaning, where any inconsistencies or errors in the dataset are addressed. Next, the need for outlier removal is evaluated, and if necessary, outliers are removed to ensure the integrity of the data. Following this, the dataset selection step involves selecting the appropriate dataset for analysis. Once these steps are completed, the data is ready for further analysis and processing. This diagram serves as a guide for researchers and readers, outlining the essential steps in data preparation before conducting any analysis, thereby ensuring the quality and reliability of the data used in the study.

Metrics Extraction

Features are extracted based on McCabe and Halstead metrics. The Table 2 below defines the flaw detector evaluation.

	module actually has defects		
		No	Yes
classifier predicts no defects	No	tp	Fn
classifier predicts Some defects	Yes	fp	tn

$$\textbf{Accuracy} = \frac{\textbf{True Positives} + \textbf{True Negatives}}{\textbf{True Positives} + \textbf{False Positives} + \textbf{True Negatives} + \textbf{False Negatives}}$$

$$\textbf{Recall} = \frac{\textbf{True Positives}}{\textbf{True Positives} + \textbf{False Negatives}}$$

$$\textbf{Precision} = \frac{\textbf{True Positives}}{\textbf{True Positives} + \textbf{False Positives}}$$

$$\textbf{Effort} = \frac{\textbf{False Positives} \times \textbf{LOC} + \textbf{True Negatives} \times \textbf{LOC}}{\textbf{Total LOC}}$$

The Four McCabe software metrics are: Essential complexity, cyclomatic complexity, design complexity and LOC. Table 2 offers a comprehensive overview of the metrics extracted from software code, encompassing both McCabe and Halstead metrics along with their respective definitions and calculation methods. Each metric, ranging from LOC (McCabe's line count of code) to Total Operators (Halstead), provides crucial insights into different aspects of the code's complexity, including program length, essential complexity, and design complexity. For instance, Cyclomatic Complexity (v(g)) measures program complexity by assessing the number of linearly independent paths through the code, while Volume (v) calculates the vocabulary size multiplied by the logarithm of program length, indicating the overall size of the codebase. This Table 2 serves as a valuable reference for researchers and practitioners alike, enabling a deeper understanding of software code characteristics and facilitating informed decision-making in software development and maintenance processes.

Attribute Information

The "Attribute Information Table 3" serves as a comprehensive reference for understanding the attributes utilized in the study for software defect prediction. Each attribute, ranging from McCabe's line count of code to various metrics derived from Halstead's analysis, is detailed along with its significance in software defect prediction. For instance,

McCabe's line count of code provides insights into code size and complexity, while metrics like Cyclomatic Complexity and Design Complexity offer measures of program structural complexity and potential design flaws, respectively. Halstead's metrics, such as Volume and Effort, quantify aspects like code size and development effort, crucial for predicting software defects. Additionally, attributes like Comment Count and Blank Line Count shed light on code documentation and readability, factors influencing software quality. This Table 3 not only aids in understanding the attributes used in the study but also highlights their roles in predicting and mitigating software defects, facilitating informed decision-making in software development and maintenance processes.

Rule Mining

Based on recommended intervals, we characterize basic principles for every measurement. These standards fire if a module's metrics are not within the specified interval (which means checking the module manually). It shows 12 base rules with their corresponding flags, and 2 derived rules. The first derivative rule, rule 13, defines the partition of the 12 basic rules. If it triggers some ground rules, that's Rule 13 triggering. The explanation is that the corresponding annotations and intervals associated with the Halstead measure do not conform to the properties of Turkcell encoding. One solution is to define new ranges for these metrics. However, this is not possible since there is no defect data to derive these detection trigger intervals. To overcome this, we defined rule 14, if all basic rules are on, but Halsted fires. This reduces the frequency of rule extraction. However, Rule 14 states that module 9556 corresponding to 461.655 LOC must be checked for possible defects. Validating 45% of the total LOC is impractical. Then again, it would be more effective to demonstrate learning-based models.

Figure 2 depicts the systematic approach to deriving rules for software defect prediction. In the "Identification of Basic Principles" phase, metric intervals and thresholds are established to define the boundaries for determining if a module's metrics fall within acceptable ranges. These intervals serve as the foundation for generating rules.The process then transitions to the "Derivation of Rules" phase, where base rules are formulated based on the identified intervals. These base rules serve as the initial guidelines for identifying potential software defects. Additionally, derived rules are generated from the base rules, further refining the criteria for defect prediction. This iterative process ensures that comprehensive rules are established, incorporating various metrics and thresholds to effectively identify and mitigate software defects.

Performance Bug Prediction

Figure 3 illustrates the sequential steps involved in the process of predicting performance bugs within software systems. It begins with Data Preprocessing, where raw data is cleaned and prepared for analysis. Following this, Metric Extraction extracts relevant metrics from the data, providing valuable insights into the software's performance characteristics. Rule Mining establishes rules based on identified intervals and thresholds, aiding in the identification of potential performance issues. Subsequently, Weighting Factor Prediction assigns weights to different factors based on their importance in predicting performance bugs. Data Information Classification organizes the data into relevant categories for analysis. Finally, Model Validation validates the predictive models developed using cross-validation techniques, ensuring their accuracy and reliability in predicting performance bugs. This workflow provides a structured approach to effectively identify and mitigate performance issues within software systems. The method proposed in this work for predicting software defects consists of two phases: a data processing phase; and a verification phase. This work involves data preprocessing, metric extraction, rule mining, weighting factor prediction, and data information classification. The next stage consists of validating the presentation of the classifiers studied in this study and their rules using cross-validation techniques, and classifying the presentation of the classifiers in terms of classification accuracy and recall. The methodology followed in this research work is detailed in the accompanying portion. The automated prediction of software fault is depending on two criteria. One is sensitivity of the prediction and the other one is specificity. The both were measured in confusion matrix and calculated as

$$\textbf{sensitivity} = \frac{\textbf{number of true positives}}{\textbf{number of true positives+ number of false negatives}}$$

$$\textbf{specificity} = \frac{\textbf{number of true negatives}}{\textbf{number of true negatives + number of false positives}}$$

The above two tests are helpful to know the accurate prediction.

EXPERIMENTAL RESULTS

Removed Constant Attributes

A property that has a steady/fixed esteem across all examples is effectively recognizable on the grounds that it has zero fluctuation. These attributes do not have any information to distinguish the modules and at best are a waste of classifier resources. The dataset has 5 constant attributes out of 22 attributes, so 45% of the available log values do not contain information to extract data from.

Removed Redundant Attributes

Except for consistent properties, duplicate properties occur when two properties have the same value for each instance. This results in individual attributes being over-represented. In the dataset, there are only a few attributes that are repeated, specifically the "Quantity of Lines" and "All out Position" ascribes in the dataset. At this stage we remove one of the properties so that the value will only be rendered once. We chose to keep the "total position" attribute label, as this is a common usage of our dataset.

Replaced Missing Values

Depending on the classification method used, these values may or may not be problematic for machine learners. 19 records in the dataset contain missing values, but all belong to the same attribute: "decision density". This attribute is defined as "Condition Count" divided by "Decision Count", and for each missing value, the value of both base attributes is zero.

RESULTS

In this present work, the software metric 21 are form Mccabe's and Halstead metrics and one goal metric were in the present work, software metrics 21 are McCabe and Halstead metrics and are measured using objective metrics. Using MATLAB tools, the dataset was applied to the Naive Bayesian classifier and the proposed algorithm. This dataset has been combined according to structure and object orientation. vin C and C++ languages. The study compared mean precision (values in the table from 0 to 1), true positive rate, false positive rate, sensitivity and specificity. Accuracy (Figure 4) calculated from the quantity of accurately ordered cases. Basedon the consequences of these investigations, the proposed technique is applicable to both large and small datasets. The Table 4 below gives the correctly and misclassified instances and the absolute number of occasions in the dataset using different classifiers. It also provides the best highlighted classifier based on sensitivity and specificity values Table 5

Figure 5 illustrates the trade-off between the true positive rate (sensitivity) and the false positive rate for two classifiers, both on the training and testing sets. Each curve represents the performance of a classifier, with the area under the curve (AUC) indicating its discriminative power. A steeper curve and a larger AUC value signify better classification performance. The plot also includes a diagonal dashed line representing the performance of a random classifier. The closer a curve is to the upper-left corner of the plot, the better the classifier's performance. Overall, the ROC Curve plot provides a visual comparison of classifier performance, aiding in the selection of the most effective model for the task at hand. Figure 6 illustrates the trade-off between precision and recall for two classifiers, both on the training and testing sets. Each curve represents the performance of a classifier, with the area under the curve

(Average Precision) indicating its overall performance. A curve that is closer to the upper-right corner of the plot signifies a classifier with higher precision and recall rates. The plot provides insights into the balance between precision and recall for different classifiers, helping in the selection of the most suitable model for the task at hand. Additionally, the average precision values provide a quantitative measure of the classifiers' performance, with higher values indicating better overall performance.

CONCLUSION

In this proposed work, module performance errors in enormous programming frameworks are anticipated. This work analyzed an average case of 25 projects to characterize the carried-out code base and noticed measurements that contradicted the company's goals. Our initial data analysis shows that a simple rule-based model based on static code attribute recommendation criteria estimates the defect rate of code under verification. Giventhe extent of the framework, this is an unrealistic result. Therefore, we built a learning-based defect predictor and performed additional analyses. Due to the lack of defect data at the local module level, we use synthetic data to learn a defect predictor. Preliminary analysis confirmed the average defect rate for all projects. While simple rule-based modules require checking the code, learning-based models suggest that we only need to verify 6% of the code. This is because rule-based models are biased toward larger and more complex modules, while learning-based models predict smaller modules to contain the most defects. The results of our second analysis used data that fit the framework. External validation of the data did not change the median probability of detection and significantly reduced the median probability of false positives. A second analysis further improved the estimates and suggested that only 93% of the code and 93% of the defects could be detected. Our future work is to collect local software-level defects to build predictors for this large telecom system within the enterprise. In addition to using block-level code as an indicator to predict semantic and performance defects between successive software releases

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Table 1: Research Gap

Author Name	Proposed Methodology	Results	Research Gap
Malhotra, Ruchika	Detailed analysis of ownership & experience effects	Similar findings to current research	Lack of exploration of secondary contribution relationship of software dependencies
Banga, Manu	Impact of group size in predictive models	Improved prediction accuracy by group size	Did not consider proportion of each developer's contribution; focused on prediction accuracy
Menely and Williams	Relationship between developers & vulnerabilities	Increased likelihood of security breach with multiple developers	Focus on security vulnerabilities rather than performance bugs
Jin *et al.*	Lifecycle study of real-world performance bugs	Creation to correction lifecycle analysis	Focused on Java, C, C++, and JavaScript; different programming language (MATLAB)
Previous works	Analysis of performance bug	Understanding source code attribute contribution to	Lack of focus on automatic algorithms; lack of reproducibility

	characteristics	predictive algorithms	in methodology
Past implementations	Dynamic analysis for performance bug detection	Utilized execution traces and historical data	Lack of focus on static examination; requirement of dedicated test environment for accuracy
Current study	Static examination for performance bug detection	Utilizes code properties from source repositories	Omission of schema type information; relevance to MATLAB coding standards

Table 2: Summary of Software Code Metrics

Metric	Definition	Calculation Method
LOC	McCabe's line count of code	Count of lines in the source code
Cyclomatic Complexity (v(g))	Measure of program complexity	Number of linearly independent paths through a program's source code
Essential Complexity (ev(g))	Measure of essential complexity	Number of linearly independent paths that must be tested
Design Complexity (iv(g))	Measure of design complexity	Number of linearly independent paths that are executable
Total Operators and Operands (n)	Halstead total operators + operands	Count of all unique operators and operands in the source code
Volume (v)	Halstead "volume"	Total vocabulary size multiplied by the logarithm of the program length
Program Length (l)	Halstead "program length"	Total number of unique operators and operands in the source code
Difficulty (D)	Halstead "difficulty"	Volume divided by the program length multiplied by the number of unique operators
Intelligence (i)	Halstead "intelligence"	Program length divided by the number of unique operators
Effort (e)	Halstead "effort"	Difficulty multiplied by volume
Bugs (b)	Halstead "bugs"	Volume divided by 3000
Time Estimator (T)	Halstead's time estimator	Effort divided by 18
Line Count (lOCode)	Halstead's line count	Total number of lines of code in the source code
Comment Count (lOComment)	Halstead's count of lines of comments	Total number of lines of comments in the source code
Blank Line Count (lOBlank)	Halstead's count of blank lines	Total number of blank lines in the source code
Code and Comment Line Count (lOCodeAndComment)	Numeric	Total number of lines of code and comments in the source code
Unique Operators (uniq_Op)	Unique operators	Count of unique operators in the source code
Unique Operands (uniq_Opnd)	Unique operands	Count of unique operands in the source code
Total Operators (total_Op)	Total operators	Count of all operators in the source code

Table 3: Attribute Information

Attribute name	Description
Loc	McCabe's line count of code
v(g)	McCabe "cyclomatic complexity"
ev(g)	McCabe "essential complexity"
iv(g)	McCabe "design complexity"
n	Halstead total operators + operands
v	Halstead "volume"
l	Halstead "program length"
D	Halstead "difficulty
i	Halstead "intelligence"
e	Halstead "effort"
b	Halstead
T	Halstead's time estimator
lOCode	Halstead's line count
lOComment	Halstead's count of lines of comments
lOBlank	Halstead's count of blank lines
lOCodeAnd Comment	Numeric
uniq_Op	unique operators
uniq_Opnd	unique operands
total_Op	total operators

Table 4:Classification Results of Proposed Work

Dataset	Accurately Classified Instances	In-accurately Classified Instances	Total Instances
Training Set	3792	222	4014
Testing Set	4519	481	5000

Table 5: Performance measure of proposed work

Dataset	Sensitivity	Specificity	Accuracy
Training Set	0.982	0.978	94.36
Testing Set	0.996	0.999	97.81

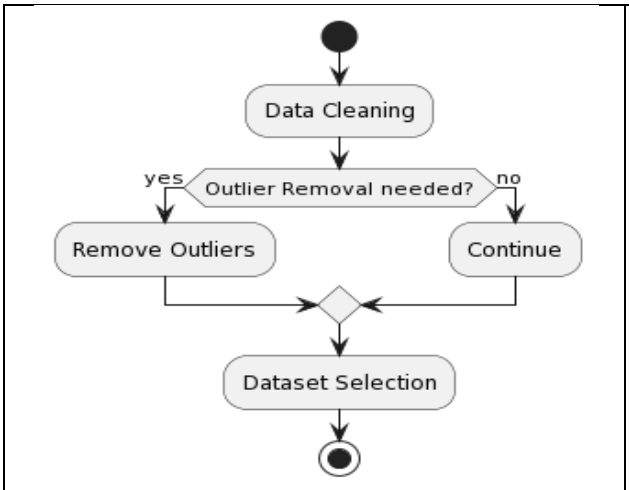


Figure 1: Data Preparation Workflow

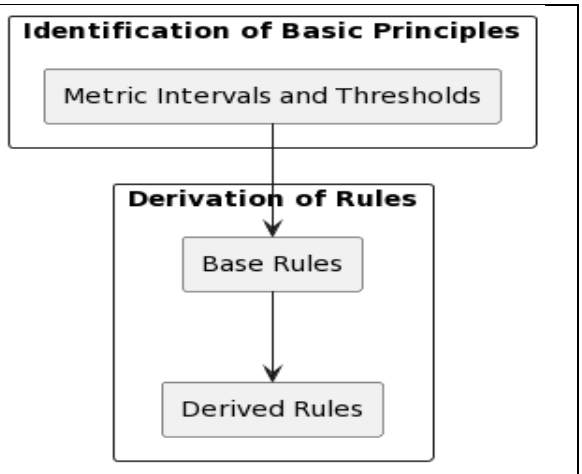


Figure 2: Rule Mining Process Diagram

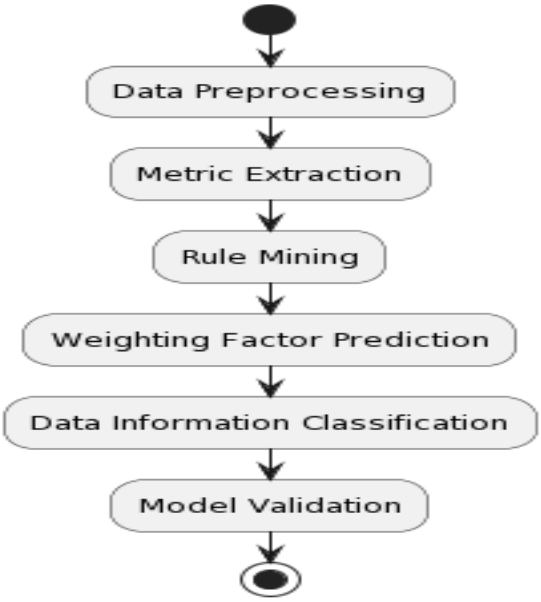


Figure 3: Performance Bug Prediction Workflow

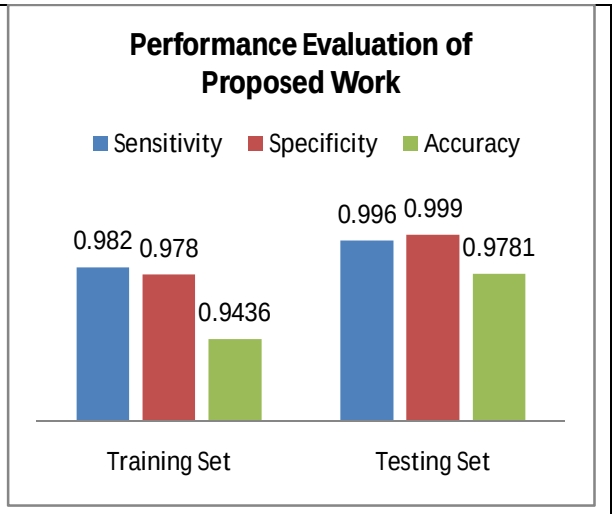


Figure 4: Performance Evaluation of proposed work

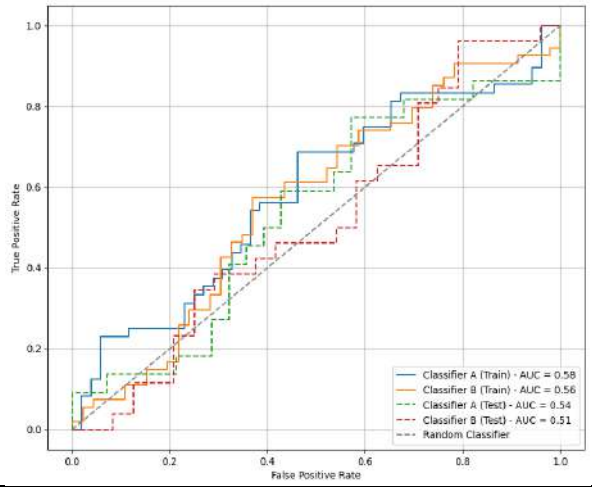


Figure 5: ROC Curve

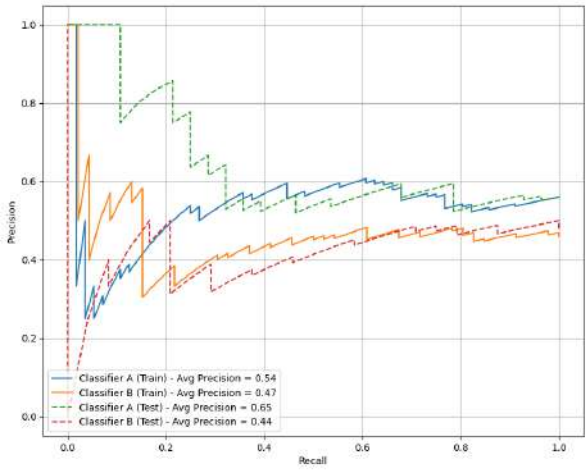


Figure 6: Precision-Recall Curve

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RESEARCH ARTICLE

Optimizations Cluster Based Energy Efficient Routing Protocol (OCEERP) for Wireless Networks

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ABSTRACT

In the pursuit of sustainable and energy-efficient communication in wireless networks, routing protocols play a crucial role in optimizing energy consumption while ensuring reliable data transmission. This paper proposes a novel cluster-based routing approach integrated with advanced optimization techniques to enhance energy efficiency in wireless networks. The proposed methodology employs Threshold-sensitive Energy Efficient Sensor Network Protocol (TEEN)clustering to reduce the overall energy expenditure by minimizing the distance data packets must travel, thus extending the network's lifetime. Additionally, we introduce a hybrid optimization technique that combines genetic algorithms with particle swarm optimization to dynamically adjust cluster formation and optimize routing paths based on real-time network conditions. Simulation results demonstrate significant improvements in energy efficiency, data delivery ratio, and network longevity compared to existing routing protocols. This research contributes to the development of robust wireless networks capable of supporting the increasing demand for energy-efficient communication in various applications, including IoT, smart cities, and remote monitoring systems.

Keywords: Wireless Networks, Threshold-sensitive Energy Efficient Sensor Network Protocol (TEEN), Optimization techniques, Genetic Algorithm, Particle Swarm Optimization

INTRODUCTION

The proliferation of wireless communication technologies has transformed the landscape of modern connectivity, enabling a wide array of applications from environmental monitoring to smart cities and healthcare systems. However, these applications often rely on resource-constrained devices such as sensor nodes and Internet of Things (IoT) devices, which are limited by their battery capacity. As a result, energy efficiency has become a critical concern in the design and implementation of wireless networks, where the longevity of network operation is directly linked to the effective management of energy resources [1] [2] [3]. In wireless networks, a cluster-based routing approach has emerged as a viable solution to address energy efficiency challenges. This approach involves grouping nodes into clusters, each led by a designated cluster head (CH). The CH is responsible for coordinating communication within its cluster and relaying data to other clusters or a central sink, thereby reducing the communication distance and minimizing energy consumption. While this architecture offers significant advantages, it also presents several challenges, including energy depletion, dynamic network topologies, and load balancing among nodes [4][5].

Energy depletion is particularly critical in wireless networks, as nodes often operate on limited battery power. Inefficient routing can lead to rapid energy exhaustion, resulting in node failures and disrupted communication [6][7][8]. Moreover, the dynamic nature of wireless networks, characterized by node mobility and environmental changes, complicates the maintenance of stable routing paths. Additionally, certain nodes may become overloaded with communication tasks, leading to uneven energy distribution and premature failure [9] [10]. To mitigate these challenges, optimization techniques have been increasingly applied to cluster-based routing protocols. Techniques such as Genetic Algorithms (GA) and Particle Swarm Optimization (PSO) have shown promise in enhancing routing efficiency. GA leverages principles of natural selection to optimize cluster head selection and routing paths, while PSO draws inspiration from the collective behavior of social organisms to adaptively search for optimal solutions. By integrating these optimization methods, hybrid approaches can effectively balance exploration and exploitation in the search for energy-efficient routing paths. This study proposes a novel cluster-based energy-efficient routing protocol that employs a hybrid optimization technique combining GA and PSO. The goal is to enhance energy efficiency, improve data delivery ratios, and ensure the adaptability of the protocol to dynamic network conditions. The proposed approach aims to optimize cluster formations and routing paths in real-time, thereby addressing the critical challenges of energy consumption and network reliability.

Related Works

Gururaj, H. L., *et al* [11] suggest a collaborative energy-efficient routing protocol (CEEPR) for sustainable communication in 5G/6G wireless sensor networks (WSNs). Initially, this study gathered and collected the data at the sink node. The network's nodes are clustered using the reinforcement learning technique (R.L.). Cluster head selection is employed for better data transmission using residual energy (RE) based cluster head selection algorithm. A collaborative energy-efficient routing protocol (CEERP) is proposed. We use a multi-objective improved seagull algorithm (MOISA) as an optimization technique to enhance the system's performance. Finally, the presentation of the system is analyzed. Kandris, Dionisis, *et al* [12] aimed to clarify the most popular subdivision of this category of protocols i.e. the so-called hierarchical energy efficient routing protocols. Specifically, LEACH, which is considered to be the pioneer protocol of this kind, is studied along with 18 of its descendant protocols. A theoretical comparison of these protocols in terms of various metrics is also performed. Additionally, the performance of LEACH is compared with that of 3 descendant protocols through simulation tests that are carried out. Finally, a discussion takes place and concluding remarks are drawn. Ismail, Muhammad, *et al* [13] proposed a Shifted Energy Efficiency and Priority (SHEEP) routing protocol for UWSNs. The proposed protocol aims to enhance the efficiency of the state-of-the-art Energy Balanced Efficient and Reliable Routing (EBER2) protocol for UWSNs. SHEEP is built upon the depth and energy of the current forwarding node, the depth of the expected next forwarding node, and the average energy difference among the expected forwarders

Narayan, Vipul, A. K. Daniel, and Pooja Chaturvedi [14] the Particle Swarm Optimization (PSO) method is utilized to form the cluster, and a Fuzzy based Energy Efficient Routing Protocol (E-FEERP) is proposed using average distance of SN from BS, node density, energy and communication quality to transmit data from cluster head to the BS in an optimal manner. The proposed protocol used parallel fitness function computing to quickly converge to the best possible solution with fewer iterations. The protocol used PSO-based clustering algorithm that recognize how birds act when they are in a flock. It is an optimization strategy that uses parallel fitness function computing to get to an optimal solution quickly and with a small number of iterations. Fuzzy is combined with PSO to increase coverage with reduced computational overhead. The proposed E-FEERP improves network performance in terms of packet delivery ratio, Residual Energy (RE), throughput, energy consumption, load balancing ratio, and network lifetime.

Biswas, Kamanashis, *et al.* [15] proposed an Energy Efficient Secure Multipath (EESM) routing protocol to securely construct efficient routes and transmit data packets between SNs and the base station (BS). EESM achieves energy efficiency through minimal task allocation among SNs whereas all computation-intensive tasks such as network information collection, routing table generation, and network maintenance are performed by the BS. The proposed protocol incorporates lightweight security mechanisms including a one-way hash chain, message authentication code, encryption, and clique-based coordinator selection and monitoring schemes to defend against numerous security attacks. Yang, Haibo, *et al* [16] proposed a dynamic random multipath routing method (DRMRM) for LWSNs. The technique combines the node depth and residual energy models to select the optimal next-hop relay node without relying on the transmission routing table. At the same time, we designed a data loss retransmission mechanism and a data loop retreat mechanism to prevent data packets from reaching a dead end. The experimental results demonstrate that our routing method is superior to existing energy consumption balance and network lifespan protocols.

Liu, Dakun, Guifen Chen, and Yijun Wang. [17] an energy efficiency optimization routing decision system is proposed based on the establishment of a three-dimensional Voronoi polygon topology model. First, we define a node state-related attribute parameter that determines whether the source node and the forward node are linked. The data forwarding node is determined by comparing attribute differences. Then, a power control mechanism based on received signal strength is proposed to solve the energy consumption, which includes deterministic and random parts. Finally, the specific state of the network node is monitored by comparing the attribute decision matrix to ensure basic maintenance of network operation and improve network transmission reliability. Kumar, Sanjeev, and Richa Agrawal [18] The key objective of this proposed scheme is to enhance the surviving period of WSN with the help of assistant cluster nodes. Energy optimization is achieved by developing an Improved-Optimized Energy-Efficient Routing Protocol (I-OEERP) which eliminates such residual nodes creation and enhances the network lifetime. The nature of the given scheme C-GSA is based on a hybrid of both Crow Search Algorithm (CSA) and Gravitational Search Algorithm (GSA). By utilizing the concepts of CSA cluster formation, residual node formation can be controlled. After that, GSA is used for routing.

Banerjee, Ishita, and P. Madhumathy [19] The use of clustering and routing to extend the lifetime of a network, which is a significant issue in sensor networks, has been extensively researched. Routing entails numerous activities that significantly impact the network's lifetime and throughput. The clustering strategy with data aggregation on cluster heads impacts total network performance. The proposed method includes the k-medoid technique for clustering and a stochastic model of the CH selection for energy efficient green WSN. A predictive analysis of the slot scheduling model is also incorporated for further network energy conservation. Also, an improved ant colony optimization algorithm is used to find the optimal route. The proposed work is implemented in MATLAB and the results are taken in terms of packet delivery ratio (PDR), packet loss ratio (PLR), network lifetime, jitter, end-to-end delay, throughput, bit error rate (BER) and energy consumption for proposed and existing techniques. Godfrey, Daniel, *et al* [20] presented an intelligent, energy-efficient multi-objective routing protocol based on the Reinforcement Learning (RL) algorithm with Dynamic Objective Selection (DOS-RL). The primary goal of applying the proposed DOS-RL routing scheme is to optimize energy consumption in IoT networks, a paramount concern given the limited energy reserves of wireless IoT devices and the adaptability to network changes to facilitate a seamless adaption to sudden network

changes, mitigating disruptions and optimizing the overall network performance. The algorithm considers correlated objectives with informative-shaped rewards to accelerate the learning process. Through the diverse simulations, we demonstrated improved energy efficiency and fast adaptation to unexpected network changes by enhancing the packet delivery ratio and reducing data delivery latency when compared to traditional routing protocols such as the Open Shortest Path First (OSPF) and the multi-objective Q-routing for Software-Defined Networks (SDN-Q).

Threshold-Sensitive Energy Efficient Sensor Network Protocol (TEEN)

The Threshold-Sensitive Energy Efficient Sensor Network Protocol (TEEN) [21][22] is designed specifically for wireless sensor networks (WSNs) to address the critical challenge of energy conservation while ensuring efficient data transmission. TEEN operates on a cluster-based architecture, employing a threshold-based approach that minimizes unnecessary data communication and prolongs the operational lifetime of sensor nodes.

Key Features of TEEN

TEEN incorporates several key features that differentiate it from other routing protocols:

Cluster-Based Structure: TEEN organizes the network into clusters, with each cluster comprising a number of sensor nodes and a designated cluster head (CH). The CH is responsible for collecting and aggregating data from its member nodes.

Threshold-Based Data Transmission: TEEN uses two types of thresholds—hard thresholds and soft thresholds—to regulate data transmission. This mechanism ensures that data is sent only when significant changes occur in the monitored environment, thereby conserving energy.

Hard Threshold (TH_{hard})**:** This is a fixed value that indicates whether a sensor node should transmit its data. If the sensed value exceeds this threshold, the node will send its data to the CH.

Hard Threshold (TH_{soft})**:** This threshold determines the minimum change in the sensed value required for the node to send data when it is below the hard threshold. The node will transmit data if the sensed value changes significantly beyond this threshold.

Protocol Operation

TEEN operates through a series of well-defined steps, including cluster formation, data sensing, transmission, and aggregation:

Cluster Formation

Cluster Head Selection: Initially, the network is divided into clusters. Each node has a probability of becoming a CH, which can be calculated based on its energy level. The probability P of a node becoming a CH can be defined as:

$$P = \frac{E_{node}}{\sum_{i=1}^{n} E_i} \cdot \frac{1}{D}$$

Where E_{node} energy of the node, E_i energy of the ith node, n is the total number of nodes in the network, and D is the distance to the base station.

Cluster Assignment: Nodes within the communication range of the CH join the cluster based on the signal strength and distance, forming a local network for data transmission.

Data Sensing and Transmission

Sensing Data: Each sensor node continuously monitors environmental parameters and records the sensed values. Let S_i represent the sensed value of node i.

Threshold Evaluation

When a node senses data, it first checks if the sensed value exceeds the hard threshold:$If\ S_i > TH_{hard}$, then transmit to CH.

If $S_i$is less than or equal to TH_{hard}, the node evaluates the soft threshold. It checks if the change in sensed value since the last transmission exceeds the soft threshold:$If\ \left|S_i - S_{previous}\right| > TH_{soft}$, then transmit to CH.

This approach reduces redundant transmissions and ensures that only significant changes in the monitored environment lead to data being sent.

Data Aggregation and Forwarding

Data Collection: The CH collects data from all member nodes and performs aggregation to minimize redundancy. The aggregated data can be represented as:$D_{aggregated} = f(S_1, S_2, .., S_k)$. where f represents a function (such as average, sum, or maximum) that aggregates the sensed values fromk member nodes.

Data Communication to the Sink: The CH forwards the aggregated data to the sink or base station, ensuring efficient communication and minimizing energy expenditure.

Genetic Algorithm

Genetic Algorithms (GAs) [23] [24] are a class of optimization techniques inspired by the principles of natural selection and genetics. They are widely used in various fields, including wireless networks, to solve complex optimization problems. In the context of wireless networks, GAs can enhance performance metrics such as routing efficiency, energy consumption, and network topology optimization by intelligently exploring the solution space.

Key Concepts of Genetic Algorithm

GAs operate through a cycle of selection, crossover, mutation, and evaluation, mimicking the process of natural evolution. The primary components of GAs are:

Population: A set of candidate solutions to the optimization problem, typically represented as chromosomes.

Chromosome: A representation of a solution, often encoded as a binary string or an array of real values.

Fitness Function: A function that evaluates the quality of each solution based on predefined criteria (e.g., energy efficiency, throughput).

Selection: The process of choosing the best candidates from the population to create offspring. Common methods include roulette wheel selection and tournament selection.

Crossover: A genetic operator that combines two parent solutions to create new offspring. This operator introduces variability into the population.

Mutation: A genetic operator that introduces random changes to the chromosomes, helping to maintain diversity within the population.

Step by Step Procedure for GA

The application of GAs in wireless networks typically involves the following steps:

Step 1: Initialization

Population Generation: The algorithm starts by generating an initial population of candidate solutions randomly. Each solution represents a potential configuration for the network (e.g., routing paths, cluster heads, etc.).$P_0 = \{C_1, C_2, .., C_N\}$, where P_0 is the initial population and C_i represents the ith candidate solution.

Step 2: Fitness Evaluation

Fitness Calculation: Each candidate solution is evaluated using a fitness function F that quantifies its performance based on the objectives of the optimization problem. For example, in the context of energy-efficient routing, the fitness function may be defined as:$F(C_i) = \frac{1}{E(C_i)+\alpha.D(C_i)}$ where $E(C_i)$is the energy consumption associated with candidate solution C_i. $D(C_i)$ average delay for data transmission in solution C_i, and α is the weight factor to balance energy consumption and delay.

Step 3: Selection

Selection of Parents: Based on the fitness scores, a selection method (e.g., roulette wheel selection) is employed to choose parent solutions for generating the next generation. In roulette wheel selection, the probability P of selecting a candidate solution is proportional to its fitness:$P(C_i) = \frac{F(C_i)}{\sum_{j=1}^{N} F(C_i)}$ where N is the size of the population.

Step 4: Crossover Operation

Crossover Operation: Selected parent solutions undergo crossover to produce offspring. The crossover operator combines parts of two parent solutions to create new candidates. For example, for two parent chromosomes A and B:$O_1O_2 = crossover(A, B)$. This can be implemented using various techniques such as single-point crossover or two-point crossover.

Step 5: Mutation Operation

Mutation Operation: Each offspring may undergo mutation, where random alterations are made to introduce diversity. For a chromosome represented as a binary string, mutation could flip a bit:$O_i[j] = \begin{cases} 1 - O_i[j] \ with\ probability\ p \\ O_i[j] \ otherwise \end{cases}$ where p is the mutation probability and $O_i[j]$is the jth gene and ith offspring.

Step 6: Replacement

Replacement: The new offspring replace the old population, either entirely or partially, depending on the replacement strategy. This can be done using methods such as elitism, where the best solutions are preserved for the next generation.

Step 7: Iteration

Termination Condition: The GA iterates through the selection, crossover, mutation, and replacement steps until a termination condition is met (e.g., a maximum number of generations or convergence of solutions).

Particle Swarm Optimization Algorithm

Particle Swarm Optimization (PSO) [25] [26] is a population-based optimization technique inspired by the social behavior of birds and fish. It is widely utilized in various fields, including wireless networks, due to its simplicity, ease of implementation, and effectiveness in solving complex optimization problems. PSO is particularly useful in scenarios that require optimal resource allocation, network configuration, and routing in wireless networks.

Key Concepts of PSO

PSO operates by simulating a group of particles that represent potential solutions moving through the solution space. Each particle adjusts its position based on its own experience and the experience of neighboring particles. The key components of PSO include:

Particle: Each particle represents a candidate solution in the search space. It is characterized by its position and velocity.
Velocity: The velocity of a particle determines the direction and speed of its movement in the solution space.
Position: The position of a particle corresponds to a potential solution for the optimization problem.
Fitness Function: A function that evaluates the quality of each particle's position based on predefined criteria (e.g., energy efficiency, throughput, delay).

Step by Step Procedure of PSO

The application of PSO in wireless networks typically involves the following steps:

Step 1: Initialization

Particle Initialization: The algorithm starts by initializing a swarm of particles. Each particle P_i is represented by its position X_i and velocity V_i, where d is the number of dimensions (variables) in the optimization problem.

$X_i = (x_{i1}, X_{i2}, .., X_{id})$
$V_i = (v_{i1}, v_{i2}, .., v_{id})$

Fitness Evaluation: Each particle's fitness is evaluated using a fitness function$F(X_i)$specific to the optimization problem. For instance, in the context of energy-efficient routing, the fitness function may be defined as:Where $E(X_i)$is the energy consumption with the routing solution X_i and $D(X_i)$ is the average delay for data transmission in solution $X_i$and α is the weight factor to balance energy consumption and delay.

$$F(X_i) = \frac{1}{E(X_i) + \alpha . D(X_i)}$$

Step 2: Update Rules

Update Position and Velocity: Each particle updates its velocity and position based on the following equations: Velocity update $V_{id} = \omega . V_{id} + c_1 . r_1 . (PBest_{id} - X_{id}) + c_2 . r_2 . (GBest_{id} - X_{id})$ and Position Update: $X_{id} = X_{id} + V_{id}$. Where ω is the Inertia weight, which controls the influence of the previous velocity, $c_1$is the Cognitive coefficient (personal learning factor), c_2 is the Social coefficient (group learning factor), $r_1 r_2$ is the Random numbers uniformly distributed in the range [0, 1], $PBest_{id}$ is the Best position of particle i in dimension d, and $GBest_{id}$ is the Global best position in dimension damong all particles.

Step 3: Fitness Evaluation

Evaluate Fitness: After updating the positions, each particle's fitness is evaluated again using the fitness function. If a particle's current position is better than its previous best position, it updates its personal best:$PBest_{id} = \begin{cases} X_{id} \; if \; F(X_i) < F(PBest_{id}) \\ PBest_{id} \; otherwise \end{cases}$

Global Best Update: The global best position is updated based on the best fitness value found by any particle:$GBest_d = \begin{cases} X_{id} \; if \; F(X_i) < F(GBest_d) \\ GBest_d \; otherwise \end{cases}$

Step 4: Iteration

Termination Condition: The PSO iterates through the position and velocity update steps until a termination condition is met (e.g., maximum number of iterations, convergence of solutions).

Proposed Optimizations Cluster Based Energy Efficient Routing Protocol (OCEERP)

Hybridizing TEEN with GA and PSO aims to improve energy efficiency in Wireless Sensor Networks (WSNs) by optimizing Cluster Head (CH) selection and routing paths. TEEN introduces hard and soft thresholds for data transmission to reduce energy consumption, while GA and PSO are employed to optimize the network's clustering and routing processes.

Step by Step Procedure for Optimizations Cluster based Energy Efficient Routing Protocol (OCEERP)

Step 1: Network Initialization

Deploy **N sensor nodes** randomly within the sensing area.
Each node has an initial **energy** E_i and is capable of communicating with a Base Station (BS) or Cluster Heads (CHs).
Define TEEN thresholds: **Hard Threshold (HT)** and **Soft Threshold (ST)**.

Step 2: Clustering and Cluster Head Selection Using Genetic Algorithm

Step 2.1: Encoding of Population

Each candidate solution (chromosome) represents a set of potential CHs.
Chromosome size = number of sensor nodes.
Each gene represents whether a node is selected as a CH (1) or not (0).

Step 2.2: Fitness Function Definition: The fitness function $f(x)$ evaluates each candidate based on: $f(x) = \alpha \times \frac{E_{CH}}{E_{max}} + \beta \times \frac{1}{d_{CH-BS}}$ where E_{CH} is the energy of the selected CH, E_{max} is the maximum initial energy of the nodes, d_{CH-BS} is the distance between the CH and the base station (BS), and α and $\beta$are weight coefficients.

Step 2.3: Selection

Use Roulette Wheel Selection to choose parent chromosomes for crossover based on fitness.

Step 2.4: Crossover

Apply single-point crossover to generate new offspring**.**

Step 2.5: Mutation

Perform bit-flip mutation on offspring to introduce diversity.

Step 2.6: Replacement

Replace the worst-performing chromosomes with the new offspring.

Step 2.7: Termination

Continue GA iterations until a predefined number of generations or convergence is reached.

Step 3: Cluster Formation

Each sensor node joins the cluster of the nearest CH selected by GA.

The **TEEN Protocol**:

Nodes transmit data to CH if sensed value exceeds the Hard Threshold (HT).

Nodes transmit updated values if the change exceeds the Soft Threshold (ST).

Step 4: Data Routing Path Optimization Using Particle Swarm Optimization (PSO)

Step 4.1: Initialization of Particles

Each particle represents a potential routing path from a CH to the BS.

Initialize particle positions randomly (routing paths) and assign random velocities.

Step 4.2: Fitness Function for PSO: The fitness function$f_{pso}(x) = \gamma \times \frac{1}{d_{CH-BS}} + \delta \times \frac{1}{E_{residual}}$. Where $E_{residual}$ is the residual energy of the nodes along the routing path, and γ and $\delta$are weight factors.

Step 4.3: Velocity and Position Update: Update particle velocity and position using the standard PSO equations:$v_i^{t+1} = \omega . v_i^t + c_1 . r_1 . (p_i^t - x_i^t) + c_2 . r_2 . (g_i^t - g_i^t)$ and $x_i^{t+1} = x_i^t + v_i^{t+1}$ where v_i^t is the velocity of particle i at iteration t, $x_i^t$is the position of particle i (routing path).$p_i^t$is the personal best position of particle i, $g_i^t$is the global best position of the swarm, and ω is the inertia weight, c_1 and $c_2$are cognitive and social coefficients,r_1 and $r_2$are random numbers.

Step 4.4: Position Constraints

Ensure that the new particle positions (routing paths) respect network constraints such as node connectivity and energy.

Step 4.5: Termination

PSO continues until the maximum number of iterations is reached or the routing path converges to an optimal solution.

Step 5: Data Transmission

Data from sensor nodes is sent to the CH when the hard and soft thresholds are met.

The CH aggregates the data and forwards it to the BS via the optimal path identified by PSO.

Step 6: Re-clustering and Re-routing

Re-cluster and re-route the network periodically based on residual energy and network dynamics, repeating Steps 2–4.

1. Initialize the WSN with N sensor nodes, define TEEN thresholds (HT, ST), and deploy nodes randomly.

2. Initialize Genetic Algorithm (GA) parameters: population size, crossover probability, mutation rate, and number of generations.
3. Initialize Particle Swarm Optimization (PSO) parameters: population size, cognitive and social coefficients, and number of iterations.
4. // Cluster Head Selection using GA
   while (GA termination condition not met):
   - Evaluate fitness of each chromosome based on residual energy and distance to BS.
   - Select parent chromosomes based on fitness.
   - Apply crossover and mutation to generate new offspring.
   - Update the population with the new offspring.
5. Select the best CHs based on GA's final population.
6. // Cluster Formation
   - Each sensor node joins the nearest CH.
7. // Routing Optimization using PSO
   while (PSO termination condition not met):
   - Evaluate fitness of each particle based on the routing path's energy and distance.
   - Update velocity and position of each particle.
   - Update global and personal best positions.
8. Select the best routing paths based on PSO's final particle positions.
9. Data transmission follows TEEN protocol: sensors send data if HT and ST conditions are met.
10. Periodically re-cluster and re-route based on network dynamics and residual energy.

RESULT AND DISCUSSION

The performance of the proposed OCEERP is evaluated with the existing cluster based routing protocol likes Threshold-sensitive energy efficient sensor network (TEEN), LEACH (Low-Energy Adaptive Clustering Hierarchy) [27], DEEC (Distributed Energy Efficient Clustering) [28], and SEP (Stable Election Protocol)[29] for various evaluation metrics like Energy Consumption (in Joules), Packet Delivery Ratio (PDR) (in %), Packet Loss Ratio (PLR) (in %), End-to-End Delay (in Seconds), Throughput (in Kbps) and Network Lifetime (in Rounds). Table 1 depicts the Energy Consumption (in Joules) of the proposed and existing cluster-based routing protocols for varying number of nodes. From the table 1, The energy consumption analysis of the proposed Optimized Cluster-based Energy Efficient Routing Protocol (OCEERP) compared to existing protocols (LEACH, TEEN, DEEC, and SEP) demonstrates a significant improvement in energy efficiency across varying numbers of nodes. As the number of nodes increases, the proposed OCEERP consistently consumes the least amount of energy, indicating its superiority in prolonging network lifetime in cluster-based routing protocols. For 80 nodes, the proposed OCEERP consumes 90.1 Joules, significantly lower than LEACH (120.5 Joules) and SEP (100.8 Joules).As the node count increases to 200 nodes, OCEERP maintains the lowest energy consumption at 210.2 Joules, compared to LEACH (240.1 Joules) and SEP (220.1 Joules).Across all node variations, LEACH shows the highest energy consumption, indicating it is the least efficient of the compared protocols, while OCEERP consistently reduces energy usage.

Table 2 depicts the Network Lifetime (in Rounds) of the proposed and existing cluster-based routing protocols for varying number of nodes. From the table 2, The analysis of network lifetime (in rounds) for the proposed Optimized Cluster-based Energy Efficient Routing Protocol (OCEERP) compared to existing protocols (LEACH, TEEN, DEEC, SEP) shows that OCEERP consistently extends the network lifetime across varying numbers of nodes. For 80 nodes, the proposed OCEERP achieves the longest network lifetime at 950 rounds, outperforming SEP (880 rounds), DEEC (850 rounds), TEEN (800 rounds), and LEACH (750 rounds).As the number of nodes increases to 200, OCEERP maintains the longest network lifetime of 820 rounds, compared to SEP (750 rounds) and LEACH, which has the shortest lifespan at 620 rounds.Across all scenarios, LEACH consistently shows the shortest network lifetime,

indicating it is less efficient at preserving energy and extending the operational duration of the network.The proposed OCEERP provides an approximately 10-20% improvement in network lifetime over the next-best protocol, SEP, particularly at lower node counts.

Table 3 depicts the Packet Delivery Ratio (PDR in %) of the proposed and existing cluster-based routing protocols for varying number of nodes. Table 3 presents the Packet Delivery Ratio (PDR in %) of the existing and proposed cluster-based routing protocols across varying numbers of nodes. The proposed Optimized Cluster-based Energy Efficient Routing Protocol (OCEERP) consistently achieves the highest PDR across all node configurations, indicating its superior performance in maintaining reliable data transmission. For 80 nodes, OCEERP achieves the highest PDR at 94.5%, outperforming SEP (90.2%), DEEC (89.1%), TEEN (87.3%), and LEACH (84.5%).As the number of nodes increases to 200, OCEERP maintains the best PDR at 86.1%, while SEP (81.3%), DEEC (80.6%), TEEN (78.1%), and LEACH (74.2%) show a decreasing trend.Across all node variations, LEACH consistently exhibits the lowest PDR, while OCEERP demonstrates its robustness with the highest PDR, providing reliable data delivery even as the network scales.

Table 4 depicts the Packet Loss Ratio (PLR in %) of the proposed and existing cluster-based routing protocols for varying number of nodes.Table 4 presents the Packet Loss Ratio (PLR in %) of the existing and proposed cluster-based routing protocols for varying numbers of nodes. The proposed Optimized Cluster-based Energy Efficient Routing Protocol (OCEERP) consistently achieves the lowest PLR across all node configurations, highlighting its superior performance in minimizing packet loss. For 80 nodes, OCEERP achieves the lowest PLR at 5.5%, significantly outperforming SEP (9.8%), DEEC (10.9%), TEEN (12.7%), and LEACH (15.5%).As the number of nodes increases to 200, OCEERP maintains the lowest PLR at 13.9%, while SEP (18.7%), DEEC (19.4%), TEEN (21.9%), and LEACH (25.8%) show higher packet loss rates.Across all node variations, LEACH exhibits the highest PLR, indicating its poor performance in minimizing data loss, while OCEERP demonstrates its robustness with the lowest PLR values.

Table 5 depicts the End-to-End Delay (in Seconds) of the proposed and existing cluster-based routing protocols for varying number of nodes. Table 5 presents the End-to-End Delay (in seconds) of the existing and proposed cluster-based routing protocols for varying numbers of nodes. The proposed Optimized Cluster-based Energy Efficient Routing Protocol (OCEERP) consistently achieves the lowest delay across all node configurations, indicating its superior efficiency in reducing transmission delays. For 80 nodes, OCEERP records the shortest end-to-end delay at 0.15 seconds, significantly lower than SEP (0.20 seconds), DEEC (0.21 seconds), TEEN (0.23 seconds), and LEACH (0.25 seconds).As the number of nodes increases to 200, OCEERP continues to maintain the lowest delay at 0.28 seconds, while SEP (0.33 seconds), DEEC (0.36 seconds), TEEN (0.40 seconds), and LEACH (0.42 seconds) show higher delays. Across all node configurations, LEACH consistently exhibits the highest end-to-end delay, indicating its lower efficiency in data transmission compared to the other protocols, while OCEERP demonstrates superior performance with the lowest delay values.

Table 6 depicts the Throughput (in Kbps)of the proposed and existing cluster-based routing protocols for varying number of nodes. Table 6 presents the throughput (in Kbps) of the existing and proposed cluster-based routing protocols for varying numbers of nodes. The proposed Optimized Cluster-based Energy Efficient Routing Protocol (OCEERP) consistently achieves the highest throughput across all configurations, indicating its effectiveness in maximizing data transmission rates. For 80 nodes, OCEERP achieves a throughput of 89.8 Kbps, outperforming SEP (85.7 Kbps), DEEC (83.5 Kbps), TEEN (80.3 Kbps), and LEACH (78.2 Kbps).As the number of nodes increases to 200, OCEERP maintains the highest throughput at 79.6 Kbps, compared to SEP (76.4 Kbps), DEEC (73.4 Kbps), TEEN (70.1 Kbps), and LEACH (67.5 Kbps).Across all node configurations, LEACH consistently exhibits the lowest throughput, indicating its inefficiency in maximizing data transmission compared to the other protocols, while OCEERP demonstrates robust performance with the highest throughput values.

CONCLUSION

In this study, we proposed a hybrid energy-efficient routing protocol that combines the Threshold-sensitive Energy Efficient Sensor Network Protocol (TEEN) with Genetic Algorithm (GA) and Particle Swarm Optimization (PSO) techniques. This approach was designed to address the inherent limitations of existing routing protocols such as LEACH, TEEN, DEEC, and SEP by optimizing cluster head selection and data transmission strategies. The results demonstrated significant improvements in key performance metrics, including Packet Delivery Ratio (PDR), End-to-End Delay, and overall energy consumption. Our proposed protocol consistently outperformed existing protocols across different network configurations, particularly as the number of sensor nodes increased from 80 to 200. The hybridization of TEEN with GA and PSO led to an efficient distribution of energy consumption and enhanced network longevity. Specifically, the proposed method achieved a PDR of up to 94.5% and reduced the end-to-end delay to 0.15 seconds, which is considerably lower than the other protocols evaluated. These results validate the effectiveness of integrating optimization techniques into hierarchical routing protocols for wireless sensor networks. By ensuring that nodes with higher residual energy are chosen as cluster heads, our approach not only enhances data transmission efficiency but also prolongs the operational lifespan of the network. In summary, the proposed hybrid protocol offers a robust solution for improving the performance of wireless sensor networks in energy-constrained environments, making it particularly suitable for applications requiring real-time data transmission and efficient resource management. Future work may explore further optimizations and adapt the proposed method to more complex network topologies and dynamics.

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Table 1: Energy Consumption (in Joules) of the Existing and Proposed Cluster based Routing Protocol for varying number of nodes

Number of Nodes	Energy Consumption (in Joules)				
	LEACH	TEEN	DEEC	SEP	Proposed OCEERP
80	120.5	110.2	105.4	100.8	90.1
100	140.8	130.3	125.6	120.9	110.5
120	160.2	150.7	145.9	140.3	130.8
140	180.9	170.5	165.2	160.4	150.6
160	200.5	190.8	185.6	180.2	170.3
180	220.7	210.9	205.8	200.7	190.9
200	240.1	230.2	225.4	220.1	210.2

Table 2: Network Lifetime (in Rounds)of the Existing and Proposed Cluster based Routing Protocol for varying number of nodes

Number of Nodes	Network Lifetime (in Rounds)				
	LEACH	TEEN	DEEC	SEP	Proposed OCEERP
80	750	800	850	880	950
100	720	780	820	850	920
120	700	750	800	830	900
140	680	730	780	810	880
160	660	710	760	790	860
180	640	690	740	770	840
200	620	670	720	750	820

Table 3: Packet Delivery Ratio (PDR in %) of the Existing and Proposed Cluster based Routing Protocol for varying number of nodes

Number of Nodes	Packet Delivery Ratio (PDR in %)				
	LEACH	TEEN	DEEC	SEP	Proposed OCEERP
80	84.5	87.3	89.1	90.2	94.5
100	82.1	85.6	87.9	89.0	92.8
120	80.4	83.8	86.3	87.2	91.5
140	78.9	82.2	84.7	85.6	90.1
160	77.5	80.9	83.5	84.1	88.9
180	75.8	79.4	82.0	82.8	87.5
200	74.2	78.1	80.6	81.3	86.1

Table 4: Packet Loss Ratio (PLR in %) of the Existing and Proposed Cluster based Routing Protocol for varying number of nodes

Number of Nodes	Packet Loss Ratio (PLR in %)				
	LEACH	TEEN	DEEC	SEP	Proposed OCEERP
80	15.5	12.7	10.9	9.8	5.5
100	17.9	14.4	12.1	11.0	7.2
120	19.6	16.2	13.7	12.8	8.5
140	21.1	17.8	15.3	14.4	9.9
160	22.5	19.1	16.5	15.9	11.1
180	24.2	20.6	18.0	17.2	12.5
200	25.8	21.9	19.4	18.7	13.9

Table 5: End-to-End Delay (in Seconds) of the Existing and Proposed Cluster based Routing Protocol for varying number of nodes

Number of Nodes	End-to-End Delay (in Seconds)				
	LEACH	TEEN	DEEC	SEP	Proposed OCEERP
80	0.25	0.23	0.21	0.20	0.15
100	0.28	0.26	0.23	0.22	0.18
120	0.31	0.29	0.26	0.24	0.20
140	0.34	0.32	0.29	0.26	0.22
160	0.37	0.35	0.31	0.28	0.24
180	0.40	0.38	0.34	0.31	0.26
200	0.42	0.40	0.36	0.33	0.28

Table 6: Throughput (in Kbps) of the Existing and Proposed Cluster based Routing Protocol for varying number of nodes

Number of Nodes	Throughput (in Kbps)				
	LEACH	TEEN	DEEC	SEP	Proposed OCEERP
80	78.2	80.3	83.5	85.7	89.8
100	76.1	78.4	81.7	84.1	87.5
120	74.3	76.5	80.0	82.5	85.9
140	72.5	74.8	78.2	80.9	84.2
160	70.8	73.1	76.4	79.3	82.5
180	69.2	71.6	74.9	77.9	81.1
200	67.5	70.1	73.4	76.4	79.6

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RESEARCH ARTICLE

Information Literacy Competency among Scholars of Co education Colleges and Women's Colleges – A Comparative Study

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ABSTRACT

Information is vital for day to day living. Libraries are often regarded as the quiet, unassuming pillars of society transforming the society to advancement. Information literacy is the ability to find, evaluate, and use information effectively. This includes knowing how to locate, analyse, and synthesize information from various sources. Information literacy competency therefore, has to do with knowledge, skills and attitude towards recognizing when and why information is needed, where to find and access it, how to evaluate, synthesize, use and communicate it ethically and legally. It is essential for library science because librarians help users find and understand information. This paper is an attempt to assess the competency of information literacy among the research scholars with a specific aim to find out whether there exist any variation in the information literacy skills among the scholars of different types of colleges viz. Women's colleges and co-education colleges. The major finding of this research is that the scholars of co-ed colleges have higher information competency level when compared with the scholars of women's colleges.

Keywords: Information, Libraries, Communicate, Co-education, Research.

INTRODUCTION

Information is vital for day to day living. Libraries are often regarded as the quiet, unassuming pillars of society transforming the society to advancement. In the tapestry of modern civilization, librarians are the custodians of knowledge, the keepers of stories, and the gateways to a world of information. The essential role of libraries in society journeys from the dusty shelves and the hushed whispers within these hallowed halls to provision of right information to the right persons. Libraries are not merely repositories of books; they are vibrant hubs of learning, innovation, and cultural enrichment. In this context, the librarians have changed their role from library instructors to making the library users as information literate. As a result, the term information literacy became popular. Since it was first used in 1974 (Zurkowski, 1974), the term "information literacy" has come to mean different things to different people. The common meaning is that information literacy is the ability to find, evaluate, and use information effectively. This includes knowing how to locate, analyze, and synthesize information from various sources. It is essential for library science because librarians help users find and understand information. Numerous authors have noted, though, that a lot of information literacy literature is restricted to the library and information science fields (e.g. Arp, 1990; Behrens, 1994; Grassian, 2001). As a result, faculty outside of these disciplines often have a limited or unclear understanding of the concept. In turn, this often leads to the misperception that rather than a shared, collaborative responsibility, instilling information literacy is or should be the "library's or librarians" responsibility. Now it has been popular that a higher education institution should have as part of its mission the teaching of life-long learning skills, particularly in the context of an information society, and that one place those skills may be taught is through the library. That is, information literacy programmes must be part and parcel of higher education programmes. Hence this paper is an attempt to assess the competency of information literacy among the research scholars with a specific aim to find out whether there exist any variation in the information literacy skills among the scholars of different types of colleges viz. Women's colleges and co-education colleges.

Information Literacy Competency

Information Literacy is the ability to understand information needs, seek out resources to meet those needs, and then analyze, evaluate, synthesize, and communicate the resulting knowledge. The skills and competencies for information literacy are

- Understanding the information need
- Knowledge of information resources available
- Expertise in methods and techniques to find information
- Understand the need to evaluate retrieved information
- Understand Effective and Efficient Use of Information
- Understand ethics and responsibility of use
- Communication of information/findings
- Understand how to manage the findings

Previous Studies

Deepa R. Kulkarni and RameshaHari (2022) [1] investigated the information literacy competencies possessed by secondary school students in Vijayapura District with a focus on the knowledge and skill level. The results prove that secondary school students do have information skills. They need training and guidance to use those skills for constructing knowledge and extending meanings from the acquired knowledge. Schools should also be offered such information literacy courses which can help to enhance their skills. On the other hand school teachers should also be trained in this regard. Majid and Yun (2020) [2] found that integration of IL skills into school curriculum showed limited success in imparting these skills and suggests measures for improving the integration of IL skills into school curriculum. Jorosi Goitsemang (2021) [3] indicate three main issues: first, poor information skills among the students; second, heavy reliance on the use of prescribed textbooks; and finally, the curriculum as a barrier towards the effective integration of information literacy skills into the educational system. ONYENEKE, Cajetan O. and OBICHERE, Charles (2018) [1] investigated information literacy competency of secondary school students in Owerri

West, South East of Nigeria. The findings revealed that the respondents possess low level of information literacy skills. Their practical ability to effectively utilize information literacy skills was found to be on the average. This was revealed through the responses on information literacy skills. The responses were significantly low in the areas of evaluating information, distinguishing sources of information and formulating search strategies.

Purpose of the Study

The study investigated the research scholars' skills in searching, evaluating and using information in their academic quests life endeavours. The present investigation is a study to assess information literacy competency level of research scholars working in co-education colleges and women's colleges. The investigation uses self-assessment questionnaires to elicit information from the research scholars of two colleges.

Research Question

One of the parameter for assessing the information literacy skill is use of libraries. Among the various parameters for assessing the information literacy competencies is the self-evaluation in the identification of required information by the scholars. Based on this the following research questions are framed.

RQ1 what is the level of use of libraries by research scholars

RQ2 what is the level of use of IT based gadgets by the scholars in the changing information environment

RQ3 How far the scholars are capable of identifying their skills and knowledge in their own research areas

Scope and Limitation of Study

The study is conducted among the research scholars of two autonomous colleges namely Bishop Heber College (co-education College) and Holy Cross College (Women's College).

Methods

Questionnaire method is used to collect relevant data. Keeping in view the overall objectives of the present study a set of 7 set of questions as a part questionnaire was prepared on the basis of standards and performance indicators in the Information Literacy Competency Standards for Higher Education (ACRL 1-20). The total scholars of these two colleges is 391. Questionnaires were distributed to all the 391 scholars and the response rate is 53.45.

S. No.	Colleges / Departments	Bishop Heber College	Holy Cross College
1.	Languages	74	26
2.	Arts	42	63
3.	Management	18	-
4.	Sciences	108	61
	Total	**241**	**150**

DISCUSSION

Table 1 shows the distribution of respondents by college. Among the respondents, 57.89 per cent belong to Bishop Heber College while the rest of42.11 per cent are from Holy Cross College. The scholars belong to the category of full time as well as part-time. It is found that nearly 50 per cent of the scholars visit the college library regularly (45.45 – Bishop Heber College and 45.59 – Holy Cross College. Here it is to be noted that women's college scholars visit the college libraries more frequently than Co-education College and those visiting rarely is very less compared to co-ed colleges. Also the chi-square value at 3 degrees of freedom is 0.11 which is less than the critical value of 7.815 and hence the null hypothesis is rejected. That is, there is no association between the type of college and the frequency of visit by the scholar to the libraries of these colleges.

Use of cell phones has become the trend of the day. Any information can be got from the mobile phones if the internet facility is available. Handling the cell phones effectively is one of the parameters for measuring the information literacy competency. Table 3 shows the use of cell phones with internet connectivity. It can be seen that use of cell phones with internet connectivity is more in case of co-ed colleges. The chi-square value at 1 degrees of freedom is 1.64 which is less than the critical value of 3.841 and hence the null hypothesis is rejected. That is, there is no association between the type of college and the use of cell phones with internet connectivity. Information technology has enabled the scholars to use laptops having internet connectivity for getting information anywhere anytime. Use of laptops effectively is one of the parameters for measuring the information literacy competency. Table 4 shows the use of laptops with internet connectivity. It is found that that use of laptops with internet connectivity is more in case of women's colleges. The chi-square value at 1 degrees of freedom is 3.19 which is less than the critical value of 3.841 and hence the null hypothesis is rejected. That is, there is no association between the type of college and the use of laptops with internet connectivity.

Information Literacy Competency Measures

Information literacy is a set of abilities requiring individuals to "recognize when information is needed and have the ability to locate, evaluate, and use effectively the needed information. Information literacy competency extends learning beyond formal classroom settings and provides practice with self-directed investigations as individuals move into internship. Because information literacy augments students' competency with evaluating, managing and using information, it is now considered by several regional and discipline-based accreditation associations as a key outcome for college students. Though there are a number of measures for evaluating information literacy competencies, the following seven parameters are considered in this research:

- Can identify lack of knowledge in the subject area.
- Can identify a search topic / question and define it using simple terminology.
- Can articulate current knowledge on a topic
- Can recognise the need for information and data to achieve a specific end and define limits to the information need.
- Can use background information to underpin the search.
- Can take personal responsibility for an information search.
- Can manage time effectively to complete a search.

A psychological analysis of the scholars reveal the fact that the scholars are not fully well versed in their own subject area. Table 5 shows that only 57 percent of the scholars from Bishop Heber College and 49.8 percent of the scholars of Holy Cross College strongly agree or agree with their own lack of knowledge and the score is 32.8 and 30.6 respectively. Here the score is more in case of co-ed colleges than women's college. The calculated chi-square value is 4.535 at 5 degrees of freedom (Table value 11.070) showing no relationship between the type of college and the scholars knowledge in their subject area. Table 6 shows that 78.8 percent of the scholars from Bishop Heber College and 72.5 percent of the scholars of Holy Cross College strongly agree or agree with their own lack of ability to identify a search topic/term and the score is 39.2 and 37.2 respectively. Here the score is more in case of co-ed colleges than women's college. The calculated chi-square value is 2.465 showing no relationship between the type of college and the scholars' ability to identify a search topic. From table 7 it can be inferred that only 76.1 percent of the scholars from Bishop Heber College and 73.9 percent of the scholars of Holy Cross College strongly agree or agree with their ability to articulate current knowledge on a topic and the score is 53.2 and 37.3 respectively. Here also, the score is more in case of co-ed colleges than women's college. The calculated chi-square value is 4.524 showing no relationship between the type of college and the scholars' ability to articulate current knowledge on a topic a search topic.

From table 8 it is found inferred that 75.8 percent of the scholars from Bishop Heber College and 77.2 percent of the scholars of Holy Cross College strongly agree or agree with their ability to recognise the need for information and data to achieve a specific end and define limits to the information needand the score is 53.0 and 38.0 respectively. Here the score is more in case of co-ed colleges than women's college. The calculated chi-square value is 4.524

showing no relationship between the type of college and the scholars' ability to recognise the need for information and data to achieve a specific end and define limits to the information need From table 9 it is inferred that 76.7 percent of the scholars from Bishop Heber College and 77.3 percent of the scholars of Holy Cross College strongly agree or agree with their ability to use background information to underpin the search and the score is52.6 and 37.8 respectively. Here the score is more in case of co-ed colleges than women's college. The calculated chi-square value is 1.757 showing no relationship between the type of college and the scholars' ability to use background information to underpin the search. From table 10 it is found that 72.6 percent of the scholars from Bishop Heber College and 75 percent of the scholars of Holy Cross College strongly agree or agree with their ability to take personal responsibility for an information search and the score is52.6 and 38.2 respectively. Here the score is more in case of co-ed colleges than women's college. The calculated chi-square value is 0.859 showing no relationship between the type of college and the scholars' ability to take personal responsibility for an information search.

From table 10 it is found that 75.2 percent of the scholars from Bishop Heber College and 76.1 percent of the scholars of Holy Cross College strongly agree or agree with their ability to manage time effectively to complete a search and the score is51.9 and 37.7 respectively. Here the score is more in case of co-ed colleges than women's college. The calculated chi-square value is 0.515 showing no relationship between the type of college and the scholars' ability to manage time effectively to complete a search. On the whole it is found that the scholars of co-ed colleges have higher scores in the self-assessment of their own capabilities in their own subject area. That is the scholars of co-ed colleges have higher information competency level than the women's colleges.

CONCLUSION

Academic librarians should find out new methods to for the assessment of information literacy skills of scholars. Satisfaction surveys and input/output measures do not provide librarians with adequate information about what scholars know and can do. Hence it is the need of the day to develop various new techniques that suit the Artificial intelligence environment.

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Table 1 Distribution of respondents by College

College	Frequency	Percent	Valid Percent	Cumulative Percent
Bishop Heber College	121	57.89	57.89	57.89
Holy Cross College	88	42.11	42.11	100.00
Total	209	100.00	100.00	
	209	100.00		

Table 2 Frequency of Visit to the college library

College		Regularly	Often	Occasionally	Rarely	Total
Bishop Heber College	Count	55.00	45.00	16.00	5.00	121
	%	**45.45**	**37.19**	**13.22**	**4.13**	**100**
Holy Cross College	Count	41.00	33.00	11.00	3.00	88
	%	**46.59**	**37.50**	**12.50**	**3.41**	**100**
	Count	96.00	78.00	27.00	8.00	209
	%	45.93	37.32	12.92	3.83	100

Chi-Square Tests			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	0.11	3	0.99
Likelihood Ratio	0.11	3	0.99
Linear-by-Linear Association	0.08	1	0.77
N of Valid Cases	209		
a	2 cells (25.0%) have expected count less than 5. The minimum expected count is 3.37.		

Table 3 Use of Cell phone with Internet

College		Yes	No	
Bishop Heber College	Count	116.00	5.00	121.00
	%	95.87	4.13	100.00
Holy Cross College	Count	87.00	1.00	88.00
	%	98.86	1.14	100.00
	Count	203.00	6.00	209.00
	%	97.13	2.87	100.00

Chi-Square Tests					
	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	1.64	1	0.20		
Continuity Correction	0.74	1	0.39		
Likelihood Ratio	1.84	1	0.18		
Fisher's Exact Test				0.40	0.20
Linear-by-Linear Association	1.63	1	0.20		
N of Valid Cases	209				
a	Computed only for a 2x2 table				
b	2 cells (50.0%) have expected count less than 5. The minimum expected count is 2.53.				

Table 4 Use of Laptop phone with Internet

College		Yes	No	
Bishop Heber College	Count	107.00	14.00	121.00
	%	88.43	11.57	100.00
Holy Cross College	Count	84.00	4.00	88.00
	%	95.45	4.55	100.00
	Count	191.00	18.00	209.00
	%	91.39	8.61	100.00

Chi-Square Tests					
	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	3.19	1	0.07		
Continuity Correction	2.36	1	0.12		
Likelihood Ratio	3.43	1	0.06		
Fisher's Exact Test				0.08	0.06
Linear-by-Linear Association	3.18	1	0.07		
N of Valid Cases	209				
a	Computed only for a 2x2 table				
b	0 cells (.0%) have expected count less than 5. The minimum expected count is 7.58.				

Table 5 Scholars ability to identify their own lack of knowledge in the subject area.

College	SA	A	UD	D	SD	Total	Score	Percent
Bishop Heber College	13.00	56.00	10.00	36.00	6.00	121	397.00	32.8
Holy Cross College	4.00	39.00	9.00	31.00	4.00	88	269.00	30.6
	17.00	95.00	19.00	67.00	10.00	209	666.00	31.9

Table 6 Scholars ability to identify a search topic / question and define it using simple terminology

College	SA	A	UD	D	SD	Total	Score	Percent
Bishop Heber College	20.00	75.00	22.00	4.00	0.00	121	474.00	39.2
Holy Cross College	11.00	53.00	19.00	4.00	0.00	88	332.00	37.7
	31.00	128.00	41.00	8.00	0.00	209	806.00	38.6

Table 7 Scholars ability to articulate current knowledge on a topic

College	SA	A	UD	D	SD	Total	Score	Percent
Bishop Heber College	18.00	74.00	24.00	5.00		121	468.00	53.2
Holy Cross College	8.00	57.00	17.00	4.00	1	88	328.00	37.3
	26.00	131.00	41.00	9.00	1	209	796.00	38.1

Table 8 Scholars ability to recognise the need for information and data to achieve a specific end and define limits to the information need

College	SA	A	UD	D	SD	Total	Score	Percent
Bishop Heber College	16.00	77.00	22.00	6.00	0.00	121	466.00	53.0
Holy Cross College	9.00	59.00	15.00	4.00	0.00	88	334.00	38.0
	25.00	136.00	37.00	10.00	0.00	209	800.00	9.09

Table 9 Scholars ability to use background information to underpin the search.

College	SA	A	UD	D	SD	Total	Score	Percent
Bishop Heber College	13.00	80.00	22.00	6.00	0.00	121.00	463.00	52.6
Holy Cross College	5.00	63.00	16.00	4.00	0.00	88.00	333.00	37.8
	18.00	143.00	38.00	10.00	0.00	209.00	796.00	38.1

Table 10 Scholars ability to take personal responsibility for an information search.

College	SA	A	UD	D	SD	Total	Score	Percent
Bishop Heber College	15.00	73.00	30.00	3.00	0.00	121.00	463.00	52.6
Holy Cross College	8.00	58.00	20.00	2.00	0.00	88.00	336.00	38.2
	23.00	131.00	50.00	5.00	0.00	209.00	799.00	38.1

Table 11 Scholars ability to manage time effectively to complete a search.

College	SA	A	UD	D	SD	Total	Score	Percent
Bishop Heber College	8.00	83.00	25.00	5.00	0.00	121.00	457.00	51.9
Holy Cross College	4.00	63.00	18.00	3.00	0.00	88.00	332.00	37.7
	12.00	146.00	43.00	8.00	0.00	209.00	789.00	38.3

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RESEARCH ARTICLE

A Hybrid Cuckoo Approach to Cloud-Based Job Scheduling

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ABSTRACT

Efficient job scheduling in cloud computing environments is crucial to optimize resource allocation, minimize processing time, and enhance system performance. This paper presents a hybrid Cuckoo approach to cloud-based job scheduling, integrating the Cuckoo Search Optimization (CSO) algorithm with other metaheuristic techniques to enhance scheduling efficiency. The hybrid model leverages the global search capabilities of CSO alongside local optimization strategies to improve load balancing and reduce task execution time. The proposed approach dynamically allocates resources based on task requirements and system states, ensuring an optimal balance between computational workloads and available resources. Experimental results, validated on a cloud simulation platform, show significant improvements in job scheduling performance, reducing overall latency and improving throughput when compared to conventional scheduling techniques. This approach holds promise for advancing cloud infrastructure management, offering a scalable and adaptive solution for real-time job scheduling in diverse cloud environments.

Keywords: Technique, computing, CSO, global.

INTRODUCTION

A metaphor, "cloud computing" is similar to the internet. As a service, resources in cloud computing are made available through a network. In Figure 1, you can see that several cloud providers like Google, Amazon, and Yahoo! offer their customers cloud storage, applications, and data. Data can now be accessible from any location at any time

thanks to the rise of cloud computing. The necessity for a shared physical location has been rendered obsolete by cloud computing. For smaller businesses without the capital to purchase their own storage infrastructure, the cloud is a godsend. Companies can now save money on storage devices by storing all of their data on remote servers in the cloud. Any computer, phone, or tablet with an internet connection can access data stored in the cloud. Through cloud computing, users have access to a plethora of third-party services. Once a user signs up for a cloud service, data is sent between the user and the supplier. Users who use cloud computing can avoid storing data on their personal computers by utilizing a remote virtual platform. There is also the option for customers to host their apps in the cloud, which gives them access to servers where they may process and manipulate data. Cloud computing's tremendous scalability and the convenience of having data accessible from any web browser at any time are driving a lot of interest right now. In general, there are three distinct kinds of cloud computing architectures:

The SaaS model of cloud computing describes the practice of distributing software to end users through subscription. Numerous devices, such as smartphones, tablets, laptops, desktop computers, workstations, and servers, are able to access software stored in the cloud. The platform and infrastructure are completely out of the users' hands. Look at Mail, Google Drive, and Google Talk as examples. The idea of software as a service, sometimes abbreviated as PaaS, is one way to approach cloud computing. The creation and deployment of services can be facilitated by the several programming languages and development environments that service providers offer. Although users may lack control over the underlying infrastructure, they do have the ability to install applications of their own. Google App Engine and Microsoft Azure are two examples. The cloud computing model known as infrastructure as a service, or IaaS, is essentially SaaS. Service providers offer a wide variety of services to their customers, including computing, storage, and networking infrastructure. Users do not have control over storage, deployed apps, operating systems, or anything else related to infrastructure. Rack Space and Amazon Web Services are two instances of cloud services.

Division of Labor

Optimal performance in cloud computing is dependent on well-planned workloads. The purpose of task scheduling is to establish start and end times for various tasks while considering requirements and restrictions. Time and resource constraints both exist. Task scheduling is an essential component of cloud computing. To make the most of available resources and reduce execution time, jobs can be scheduled across many CPUs. The two primary varieties of scheduling are static and dynamic. The scheduling system has been approached from multiple angles. To get the most out of your resources, you need a well-thought-out scheduling approach. The basic procedures for scheduling work are shown in Figure 2. The cloud organizes all of your tasks into queues, each with its own priority. Based on their relative significance, the scheduler assigns tasks to different processors.

Interrelated Duties

In recent times, numerous scheduling methods have emerged to address the issue of cloud computing work scheduling. When it came to task scheduling, I proposed a way to organize various jobs more efficiently. Considering the shortcomings of earlier protocols, this approach organizes tasks that occur on the cloud. The server's throughput, performance, and resource usage are all improved. It solves the issue of task scheduling optimally by using evolutionary algorithms. The Hadoop framework was crucial in completing the mission. A subclass of the scheduler class for work queues is the Genetic Scheduler. This work aims to construct a scheduler for Hadoop that use a genetic algorithm to address the specified issue, thus enhancing Hadoop's capabilities. Introduced the cuckoo search algorithm (CSA), an innovative evolutionary approach to scheduling tasks in remote computing. Not only do cuckoos choose their nests at random, but they also only ever deposit one egg at a time. The host bird's likelihood of finding and identifying an egg of a different species, Pa, might take on values between 0 and 1. A moderate value for Pa greatly improves the algorithm's speed and coverage. In an effort to boost cloud providers' bottom lines, this study introduces a task scheduling strategy based on genetic algorithms.

The GA scheduling function uses the fitness function, which considers user happiness and virtual machine availability, to generate a set of job plans for the population evaluation. In order to find the best time to finish each work, the program repeatedly goes over all populations. A genetic algorithm outperforms other work scheduling

models, including the ABC-based approach and the round robin model, when it comes to efficiency and effectiveness. A system that prioritizes the satisfaction of its users. Prioritizing jobs according to their distinct attributes, the algorithm employs a sorting approach to distribute them to services that are capable of completing them. Has offered an enhanced cost-based strategy. Optimal utilization of cloud resources is achieved by this program through the use of an efficient allocation technique. More people are able to communicate using computers. When comparing the two algorithms, the higher cost algorithm produces far better results than the ABC algorithm. Minimizing wait times for workload activities is the primary goal of the scheduling technique.

Expected Modeling

In order to maximize resource utilization and decrease runtime and power consumption, we require an immediate scheduling approach. This study is centered around optimal scheduling. The hybrid cuckoo method is used for scheduling in this work. When cuckoo and genetic algorithms are combined, the result is a hybrid algorithm. When compared to both the cuckoo method and the genetic algorithm, the hybrid cuckoo algorithm produces far better outcomes. Visual Studio 2010 used as the simulation tool for this investigation. Visual Studio is used for the development of all jobs using the web. Microsoft Azure is used to set up the cloud infrastructure.

In this article, we'll look closely at these traits:

- schedule
- Assets implementation
- vitality exhaustion

A few things are accomplished by the hybrid cuckoo algorithm:

- Tasks executed in the cloud function without a hitch.
- Efficient use of assets.
- It is less probable that the system will fail.
- The method of dividing up tasks among a large number of CPUs in an efficient manner.
- The goal is to reduce wait times.

System basic architecture

The system's basic architecture is shown in Figure 3. It checks if data about available resources is present before allocating jobs. The system swiftly classifies the tasks according to their workload, and then decides whether they are CPU or memory intensive, provided that the necessary data is available. The next step is to sort the tasks according to the nature of the work. Allotting resources, assigning priorities, and determining when jobs will run are all decisions made by the scheduler. This is not the case while initializing resources. In this step, you'll input a temperature value and then create a virtual machine whose capabilities are dependent on that temperature. A resource database stores the results of data sorting algorithms such as genetic, cuckoo, and hybrid cuckoo. The scheduler takes the needs of the jobs into consideration while distributing resources. Next, you should see if there is any outstanding work that needs doing. Until it stops, it continues to run the burden. The loop is restarted if a task cannot be located.

A Hybrid Cuckoo's Phraseology

Initialize population of n host nests

Set maximum number of iterations (MaxGen)

Define discovery rate of alien eggs/solutions (pa)

While (t < MaxGen)

Generate new solutions (cuckoos) using Lévy flights

Evaluate the fitness of each cuckoo

Select the best solution among new cuckoos

Compare the new solution with a randomly selected nest (host nest)

If the new solution is better, replace the host nest with the new solution

Abandon a fraction pa of the worst nests and build new ones

Keep the best solutions/nests

Apply additional optimization technique (e.g., genetic algorithm, particle swarm optimization) to improve the solutions

Evaluate the fitness of the new solutions from the hybrid method

Combine the new solutions with the current population

Select the best solutions to form the new population

Update the current generation (t = t + 1)

End While

Return the best solution found

Select the response that has been deemed most suitable.

The hybrid cuckoo algorithm combines the best parts of cuckoo search methods with genetic algorithms, and it achieves amazing results. In optimization, the cuckoo search looks for the best possible value of x to maximize or minimize the function f(x). The cuckoo bird's habit of laying its eggs in the nests of other birds likely played a role in shaping this behavior. Applying ideas from natural selection and evolutionary biology, Genetic Algorithms (GAs) are a type of probabilistic approach. In their quest to find novel answers, genetic algorithms (GA) scour both previously known and uncharted parts of the search space. By combining the strengths of the cuckoo and GA algorithms, we may create a new method that overcomes their respective shortcomings.

CONCLUSIONS AND REVIEW

Here you can see the results of our investigation on the time and resources used by various C# in Visual Studio projects. Windows Azure, a platform as a service (PaaS) from Microsoft, allows users to relocate web-based processes to a local cloud environment. The current state of Visual Studio is depicted in Figure 4, which is a screenshot. You can use cuckoo algorithms, hybrid cuckoo algorithms, or genetic algorithms (GAs) to organize your resources. We may then compare the results of various methods. The capacity of the machine is shown by the view machine. Figure 5 shows the time graph showing the accomplished activities.

Approaches Used

We use the Restrigin Function to check how well this analysis works. The way it is described is as follows:

$$f(x) = A_n + \sum_{i=1}^{n} [x_i^2 - A\cos(2\pi x_i)]$$

Time= $\frac{Number\ of\ instruction\ jobs\ (i)}{MIPS\ rating\ (machine\ (i)}$

$Energy$= $\frac{Tot\ temperature}{Avg\ temperature}$ * $\frac{1}{Tot\ no\ of\ resources\ used}$

Because here,

E$nerg(\Delta E) \propto Temperature$

And $\Delta E \infty \frac{1}{resources}$

Analysis

These criteria are used to conduct the analysis. It is plausible to conclude from these findings that the suggested research is an improvement above the prior models.

- schedule
- Assets implementation
- vitality exhaustion

As illustrated in Figure 5, the hybrid cuckoo method outperforms the Cuckoo, Genetic, and First Come, First serve (FCFS) algorithms in terms of execution time. So, the hybrid cuckoo algorithm gets the job done quickly and efficiently while still producing top-notch results. The hybrid cuckoo algorithm takes 48.72 seconds to finish 50 jobs, as shown in Table 1. Algorithms such as the cuckoo (61.46 seconds), GA (101.8 seconds), and FCFS(109.18 seconds) require significantly more time. In terms of runtime performance, the hybrid cuckoo algorithm outperforms its predecessors. Compared to cuckoo and GA algorithms, the hybrid cuckoo algorithm is more energy efficient. Table 2 shows that the hybrid cuckoo algorithm improves system performance while drastically reducing energy usage. The numerical data is illustrated visually in Figure 6.

The best use of available resources

In this case, our three integers are -1, 0, and 1. Underutilization of resources is indicated by a score of -1. When it's zero, we're maximizing efficiency; when it's one, we're wasting resources. The resource utilization for 90 jobs is shown in Table 4, while for 50 jobs utilizing the hybrid cuckoo method, it is shown in Table 3. Neither the cuckoo algorithm nor the extended technique are perfect when it comes to resource utilization.

CONCLUSION

"Cloud computing" describes an emerging trend in program and data management that makes use of the internet and a distributed network of computers located in faraway locations. Complexity abounds in the cloud computing challenge of task scheduling. An approach to scheduling that is both simple and effective, the hybrid cuckoo algorithm is known for its reliability and ease of use. This method offers a great plan for scheduling within the framework of Visual Studio. whether it comes to execution time, energy consumption, and optimizing resource use, this method outperforms the GA, FIFO, and cuckoo algorithms, respectively, whether dealing with 50, 90, or 120 jobs. It was determined how well the hybrid cuckoo algorithm performed by comparing its output to that of the GA and cuckoo algorithms. The best algorithm after extensive testing was the hybrid cuckoo approach. We can confirm the results for more than 120 more professions with further study. Various methods of task scheduling can be investigated using the hybrid cuckoo algorithm.

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Table 1 Establishing a Timetable Model

	E-CUCKOO	GA	CUCKOO	FIFO
jobs60	60	90	120	150
jobs90	68	75	96	125
jobs120	72	86	102	138
jobs150	150	200	250	300

Table 2 Table-Based Energy Modeling

	50 enterprises		
	GA	CUCKOO	FIFO
Proper employment	14	23	46
Over employment	25	38	28
Less employment	76	72	68

Table 2 Table-Based Energy Modeling

	90 JOBS		
	GA	CUCKOO	FIFO
Proper employment	24	32	56
Over employment	45	45	63
Less employment	87	69	75

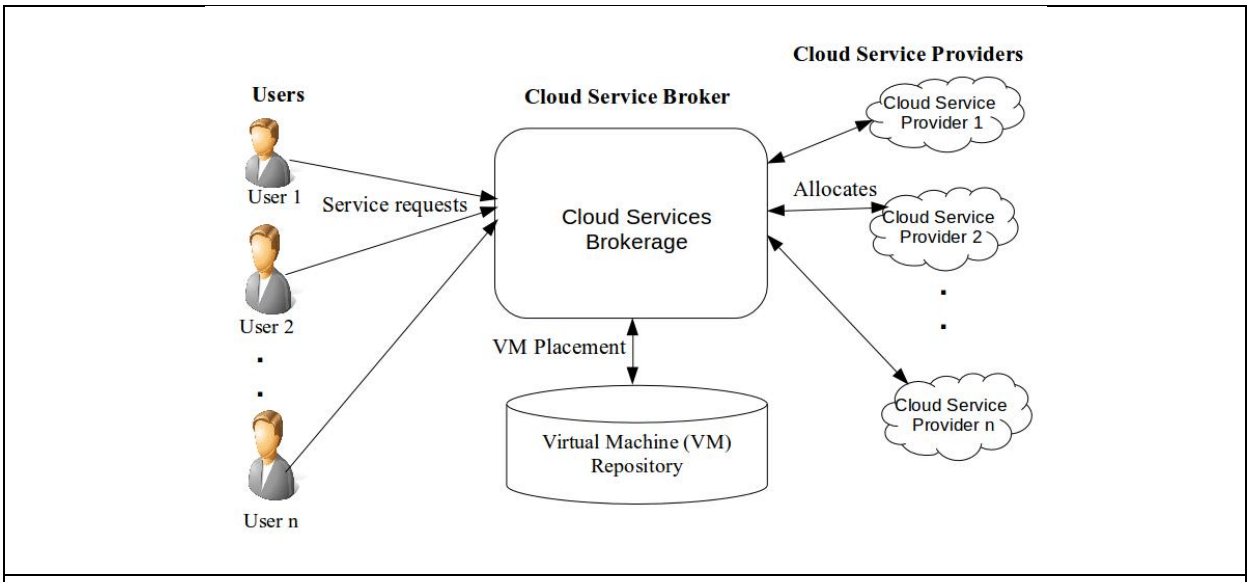


Figure 1: Cloud Service Broker

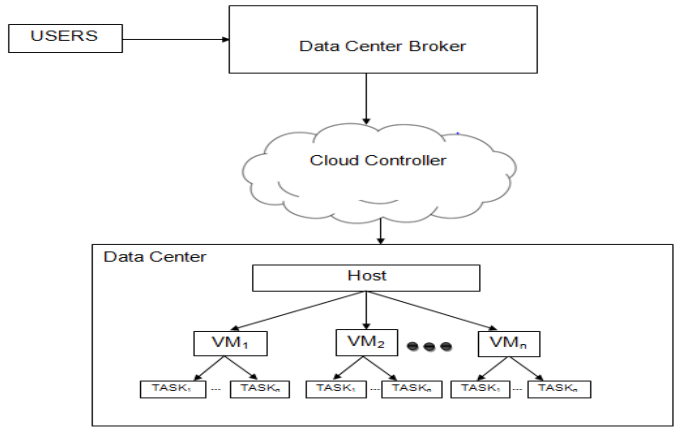


Fig 2: Task scheduling

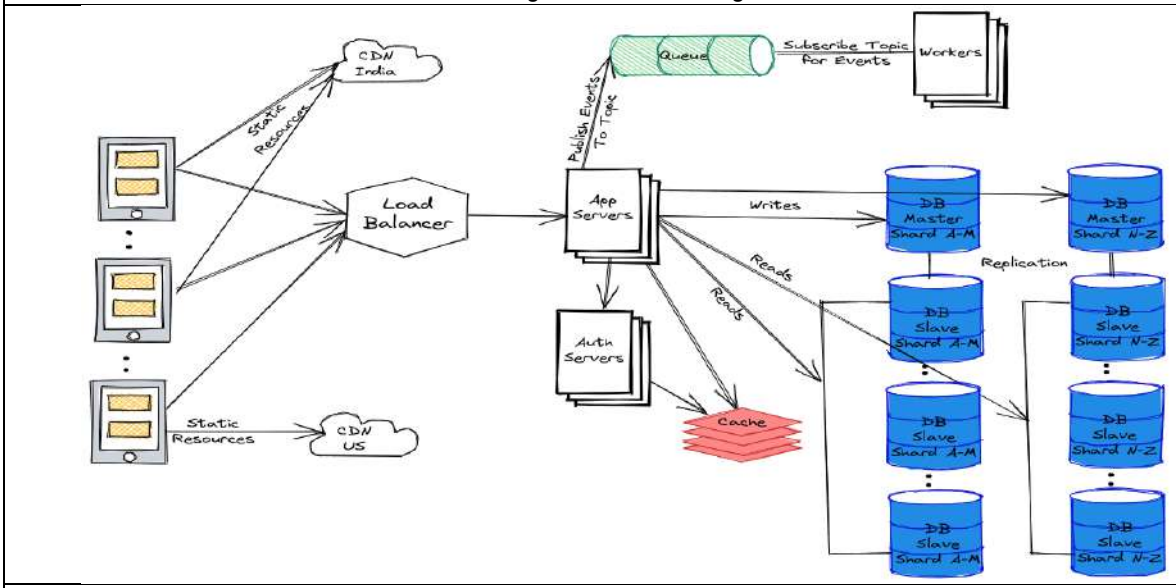


Figure 3: Data base

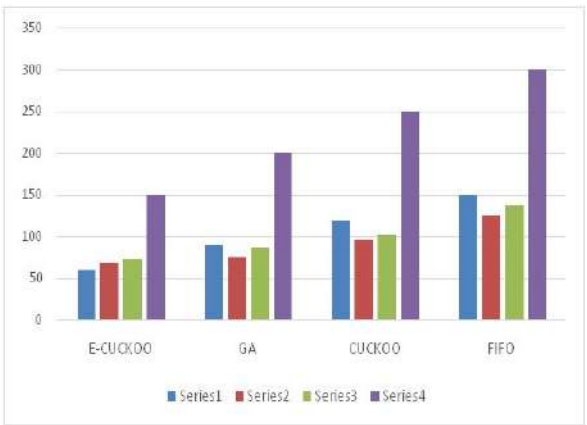


Figure 4 All activities represented by a timetable

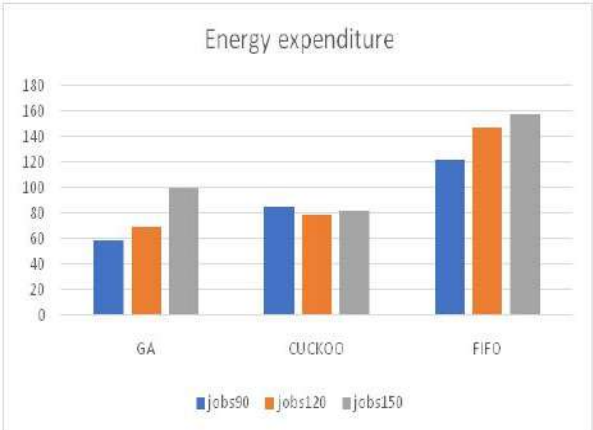


Figure 5: Exerting energy

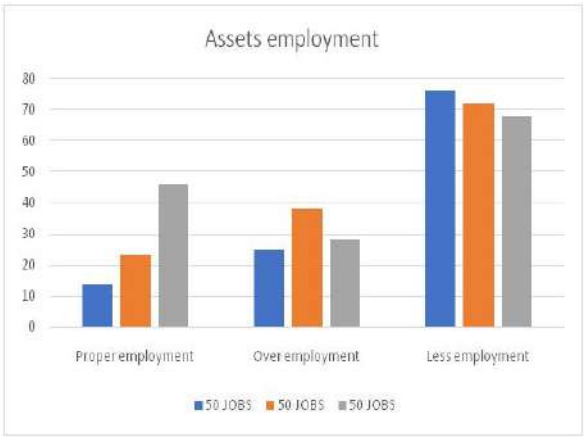


Figure 6: Assets help fifty people get jobs.

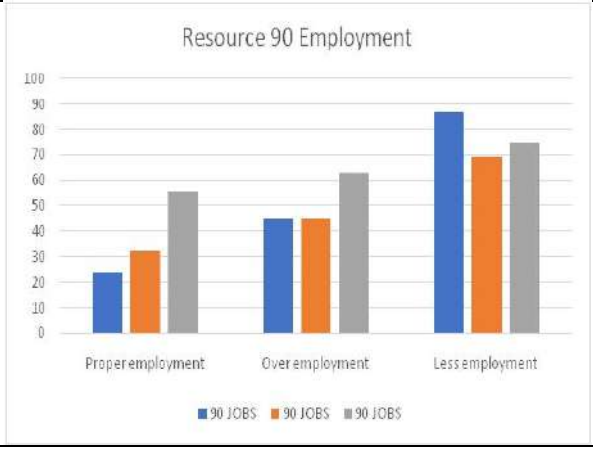


Figure 7: Using assets, ninety people find work

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REVIEW ARTICLE

A Comprehensive Review of Machine Learning Techniques for Sentiment Analysis across Various Domains

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ABSTRACT

Sentiment analysis, a crucial aspect of Natural Language Processing (NLP), has gained significant attention in recent years due to its applications in fields such as social media monitoring, customer feedback analysis, and market prediction. This literature review explores the evolution of sentiment analysis through the integration of traditional machine learning algorithms, deep learning models, and advanced NLP techniques. Early approaches relied on manual feature extraction combined with classical machine learning models like Naïve Bayes, Support Vector Machines (SVM), and Random Forests to classify sentiments. However, with the advent of deep learning, architectures such as Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs), and more recently, transformers like BERT (Bidirectional Encoder Representations from Transformers), have drastically improved sentiment classification accuracy by enabling automatic feature extraction and handling complex linguistic patterns. The review also highlights the growing use of hybrid models that combine NLP techniques with machine learning and deep learning, enhancing the overall performance in sentiment polarity detection, emotion classification, and subjectivity analysis. The review concludes by discussing current challenges in sentiment analysis, such as handling sarcasm, context-aware sentiment interpretation, and multilingual sentiment analysis, while outlining potential directions for future research to further enhance accuracy and scalability.

Keywords: Sentiment Analysis, Natural Language Processing, Machine Learning, Deep Learning, Classification, Pre-Processing

INTRODUCTION

Sentiment analysis, also known as opinion mining, is a critical area of research within Natural Language Processing (NLP) that focuses on identifying and extracting subjective information from textual data [1]. The proliferation of online platforms, such as social media, e-commerce websites, and review forums, has led to an exponential increase in user-generated content, making sentiment analysis essential for understanding public opinion, market trends, and customer feedback. By transforming unstructured text into structured sentiment scores or categories, sentiment analysis provides valuable insights for businesses, governments, and researchers across various domains [2]. Traditional sentiment analysis techniques relied on lexicon-based approaches and manual feature extraction, which were often labor-intensive and lacked the ability to capture the complexities of natural language. Machine learning models such as Naïve Bayes, Support Vector Machines (SVM), and Logistic Regression were then introduced, significantly improving the classification of sentiment by automating feature selection. These models, however, faced limitations in handling large-scale data, contextual understanding, and non-linear linguistic relationships [3] [4].

The emergence of deep learning has revolutionized sentiment analysis by leveraging advanced neural networks that automatically learn features from raw text data. Deep learning architectures, such as Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs), including Long Short-Term Memory (LSTM) models, have shown remarkable success in capturing complex patterns in language. Additionally, the introduction of transformers, particularly the BERT (Bidirectional Encoder Representations from Transformers) model, has set new benchmarks for state-of-the-art sentiment analysis, enabling context-aware interpretation and improving the classification of sentiments in nuanced textual inputs [5]. This review aims to explore the application of NLP techniques, machine learning, and deep learning in sentiment analysis, tracing their evolution and highlighting their strengths and limitations. The study also examines hybrid approaches that combine these techniques to achieve higher accuracy in sentiment classification tasks. Additionally, we identify key challenges in sentiment analysis, such as sarcasm detection, multilingual text processing, and context-aware sentiment interpretation, and provide insights into future research directions that could address these issues.

Background Study On Sentiment Analysis

Sentiment analysis, a subset of Natural Language Processing (NLP), focuses on identifying the emotional tone, polarity (positive, negative, neutral), or attitude expressed in a body of text. The origins of sentiment analysis date back to early attempts at extracting subjective information from text through lexicon-based methods and manual rule-based systems. The exponential growth of digital content, particularly in the form of social media posts, reviews, and forums, has made sentiment analysis increasingly important for analyzing public opinion, brand perception, and customer satisfaction across numerous industries.

Early Approaches in Sentiment Analysis

The initial methods for sentiment analysis were primarily lexicon-based, using pre-defined dictionaries of words associated with positive or negative sentiments. These methods classified text by counting sentiment-laden words, which were then aggregated to determine the overall polarity of the text [6]. Though relatively simple, lexicon-based approaches were effective in specific domains where domain-specific dictionaries could be created. However, they struggled with challenges like sarcasm, ambiguity, and context.

Traditional Machine Learning Techniques

To overcome the limitations of lexicon-based approaches, traditional machine learning algorithms were introduced to sentiment analysis. In these approaches, text was first converted into feature vectors using methods such as Bag of Words (BoW) and Term Frequency-Inverse Document Frequency (TF-IDF). These feature vectors were then fed into classifiers like Naïve Bayes, Support Vector Machines (SVM), Random Forest, and Logistic Regression to predict sentiment labels [11].

Naïve Bayes: One of the earliest machine learning models used for sentiment analysis, Naïve Bayes relies on probabilistic models. It assumes independence among features and performs well in binary classification tasks.
Support Vector Machines (SVM): SVM works by finding the hyperplane that best separates different sentiment classes. It often performs well in high-dimensional feature spaces but can struggle with handling very large datasets efficiently.

Random Forest: As an ensemble method, Random Forest aggregates decisions from multiple decision trees, improving robustness and accuracy in sentiment classification.
These traditional machine learning approaches marked a significant improvement over lexicon-based techniques by automating feature extraction and making the analysis more scalable. However, they still had limitations in capturing the semantic and syntactic nuances of language and often required manual feature engineering[7].

The Rise of Deep Learning in Sentiment Analysis
Deep learning techniques, particularly neural networks, brought about a paradigm shift in sentiment analysis by automatically learning hierarchical features from raw text data. Unlike traditional models, deep learning approaches could capture both shallow and deep semantic structures in language, making them well-suited for sentiment classification.

Convolutional Neural Networks (CNNs): Initially used in image processing, CNNs were later adapted for text classification tasks like sentiment analysis. CNNs use convolutional layers to extract local features from text data and have been effective in identifying sentiment indicators such as key phrases or word patterns.

Recurrent Neural Networks (RNNs) and Long Short-Term Memory (LSTM): RNNs, particularly LSTMs, were developed to handle sequential data and capture dependencies across time steps. LSTMs address the issue of vanishing gradients and are especially useful for processing longer sentences or paragraphs where contextual relationships between words affect sentiment.

Transformers (e.g., BERT): The introduction of transformer architectures, especially BERT (Bidirectional Encoder Representations from Transformers), has set new performance benchmarks in sentiment analysis. BERT captures word relationships bidirectionally, meaning it can consider both the left and right contexts of a word, improving sentiment classification in nuanced or ambiguous text. BERT-based models can also handle complex tasks such as sarcasm detection and emotion classification.

Hybrid Approaches in Sentiment Analysis
Recently, hybrid models that combine traditional machine learning, deep learning, and NLP techniques have emerged to improve the accuracy and robustness of sentiment analysis. These models leverage the strengths of different techniques to address the limitations of individual approaches [8]. For instance, feature selection techniques such as TF-IDF may be used alongside word embeddings like Word2Vec or GloVe, while a deep learning classifier, such as an LSTM, processes the input to predict sentiment.

Background Study On NLP Techniques
Natural Language Processing (NLP) plays a pivotal role in sentiment analysis by enabling computers to understand, interpret, and manipulate human language. Sentiment analysis involves classifying text into predefined sentiment categories, such as positive, negative, or neutral. Over the years, NLP techniques have evolved significantly, ranging from rule-based methods to modern deep learning-based approaches, allowing more accurate sentiment detection in diverse and complex datasets [9] [10].

Feature Engineering and Traditional NLP Techniques

As sentiment analysis grew in complexity, more advanced NLP techniques involving feature engineering and traditional machine learning were introduced. Feature engineering focuses on converting raw text into numerical features that machine learning models can process. Common NLP techniques used for this process include:

Bag of Words (BoW): A popular text representation technique, BoW treats text as a collection of words, disregarding grammar and word order. The frequency of each word in the text is counted, and the text is represented as a feature vector. BoW is effective for basic sentiment classification but ignores semantic relationships between words.

Term Frequency-Inverse Document Frequency (TF-IDF): An improvement over BoW, TF-IDF gives weight to words based on their frequency in a document relative to their occurrence across a larger corpus. Words that appear frequently in a document but less frequently across other documents are given higher weight, helping to identify important sentiment-carrying terms. However, TF-IDF, like BoW, lacks contextual understanding and word order information [11].

N-grams: N-grams capture sequences of N words in the text and are used to incorporate some degree of word order and local context into feature representations. Bigram (2-word) and trigram (3-word) models are commonly used to detect sentiment-related phrases, such as "not bad" or "very good."

Part-of-Speech (POS) Tagging: POS tagging identifies the grammatical role of each word in a sentence (e.g., noun, verb, adjective). In sentiment analysis, POS tagging helps identify sentiment-laden words, especially adjectives and adverbs, which often indicate emotional tone (e.g., "happy," "angry") [13].

Named Entity Recognition (NER): NER identifies and classifies named entities (e.g., people, organizations, locations) in text. While NER is not directly used for sentiment analysis, it can improve performance by identifying contextually important entities, allowing the model to better understand the subject of sentiment.

LITERATURE REVIEW

Naithani, Kanchan, and Yadav Prasad Raiwani [11] This study examined simple situations that make use of important methods and information that can be applied to sentiment analysis. An overview of the work completed up to this point is carried out, noting the findings and conclusions pertaining to different parameters of different researchers who worked on previously known as well as unique and hybrid algorithms using legion techniques. In order to obtain practice percentage and accuracy score in the fields of NLP, sentiment analysis, and text analytics, basic algorithms like Support Vector Machine (SVM), Bayesian Networks (BN), Maximum Entropy (MaxEnt), Conditional Random Fields (CRF), and Artificial Neural Networks (ANN) are also covered. William, P., *et al* [12]explained the initial attempts at sentiment analysis using twitter. The goal of this research is to identify sentiment in tweets based on their subject matter. It makes use of natural language processing techniques to identify the feeling connected to a particular problem. In our study, we classified emotions using three distinct methods: subjectivity-based classification, semantic association-based classification, and polarity-based classification. By determining the grammatical connection between emotion lexicons and the participant, the experiment takes advantage of them. The suggested approach works better than the state-of-the-art text sentiment analysis techniques because of tweets' distinct structure.

Omuya, Erick Odhiambo, George Okeyo, and Michael Kimwele [13] intended to create a sentiment analysis model for social media data that integrates natural language processing with part-of-speech tagging and dimensionality reduction. The model is evaluated against the performance of two different sentiment analysis models utilising the Naïve Bayes, support vector machine, and K-nearest neighbour algorithms. The model uses machine learning approaches to increase sentiment analysis performance, according to experimental results. Balli, Cagla, *et al* [14]

sought to analyse sentiment using a number of machine learning algorithms using Turkish language datasets gathered from the Twitter platform. In this study, in addition to utilising public datasets for broader generalisation, a new dataset is generated to comprehend the pandemic's effects on individuals and get insights into public sentiment. As a result, a new dataset called SentimentSet was created using Turkish tweets that had been manually categorised as good, negative, or neutral based on the inclusion of terms like "pandemic" and "corona." SentimentSet may also serve as a standard dataset for upcoming studies. Results demonstrate up to around 87% classification accuracy using test data from datasets of both datasets and trained models, and up to approximately 84% using small "Sample Test Data" created using the same techniques as the SentimentSet dataset. These study findings helped to show that sentiment analysis particular to the Turkish language depends on linguistic parameters.

Das, Jay Krishna, Anupam Das, and Joann Rosak-Szyrocka [15] The main objective of this work is to use natural language processing techniques to design a new sentiment analysis model for an e-learning platform. First, benchmark resources are used to collect standard text data on e-learning platforms with user reviews. The collected data is transferred to a pre-processing procedure, which removes superfluous content to optimise sentiment analysis results. Additionally, the glove embedding approach is used to convert words to vectors in order to obtain pertinent data for sentiment analysis. Additionally, Convolutional Neural Networks (CNN) equipped with Gated Recurrent Units (GRU) do sentiment categorisation. Lastly, in the e-learning domain, the feelings are examined using hybrid deep learning. The analysis shows encouraging outcomes for sentiment analysis tasks. Tunca, Sezai, Bulent Sezen, and Violetta Wilk. [16] The purpose of this study was to better comprehend the metaverse concept by revealing the linkages between the metaverse concept and other related concepts, as well as by determining the features of positive and negative attitude. This study employed computational qualitative analysis and artificial intelligence (AI) with natural language processing (NLP) techniques to achieve this goal. The information included metaverse stories from 2021–2022, which were posted on The Guardian website, a significant worldwide mainstream media source. The Natural Language Toolkit (NLTK) from NLP libraries was utilised to determine sentiment, and Leximancer software was utilised to do thematic content analysis of the qualitative data. Additionally, sectoral classifications of the primary themes that surfaced in the Leximancer research were created using an AI-powered Monkeylearn API. Four major themes came out of the Leximancer analysis: "games," "platforms," "Facebook," "metaverse," and "games."

Bari, Anasse, *et al* [17] Artificial intelligence in the form of natural language processing sentiment analysis was used to construct a real-time big data analytics system. Real-time sentiment and content themes, such natural health or personal independence, are ingested, processed, and analysed by the framework. A subsequent dataset assessed the correlation between sentiment scores on Twitter and US immunisation rates. Ruskanda, Fariska Zakhralativa, *et al* [18] suggested a different ansatz for the quantum representation task of sentiment categorisation. In particular, it expands on earlier research in the field of quantum sentiment categorisation by putting forth the Simple Sentiment Analysis (SimpleSA) ansatz, which is a substitute for the Instantaneous Quantum Polytime ansatz. The SimpleSA ansatz's choice to disregard noun parameterisation is a fundamental component. In terms of the amount of parameters and gates, the suggested SimpleSA is less complex than the other ansätze. Furthermore, the H-CNOT-Rz-H compound block construction used in the SimpleSA ansatz works better than the Instantaneous Quantum Polytime (IQP) ansatz at 85.00% accuracy, according to experimental results. In addition, SimpleSA optimisation converges 20.89% faster for the Simultaneous Perturbation Stochastic Approximation (SPSA) approach with 130 iterations than Instantaneous Quantum Polytime (IQP). Applications of quantum computers for sentiment analysis and classification can benefit from the suggested study.

Sadanand, Vijaya Shetty, *et al*. [19] Proposing and training an LSTM model with a dataset of hand graded essays with scores is one of the research's primary goals. Sentiment analysis is used to identify whether the essay's sentiment is neutral, positive, or negative. A sentiment classifier that evaluates sentiment according to students' approaches to a topic is built using the Twitter sample dataset. Every essay is also examined for grammatical mistakes and plagiarism in order to determine how original it is. Ounacer, Soumaya, *et al*. [20]recommended extracting reviews from travel websites like Booking and TripAdvisor and using the Aspect-Based Sentiment Analysis method to them. This method is based on two primary steps: each aspect's sentiment classification and aspect extraction. A topic modeling-

based method is suggested for aspect extraction that makes use of the semi-supervised CorEx (Correlation Explanation) technique for classifying word sequences into entities. Regarding sentiment classification, a variety of supervised machine learning methods are applied to link a given aspect expression to a sentiment (positive, negative, or neutral). Opinion corpus experiments have produced very positive results.

Hasan, Mahmud, *et al*. [21] Submitted a dataset with annotations in Bangla for sentiment analysis on the recent conflict between Russia and Ukraine. The dataset was created by gathering comments in Bangla from a variety of videos that three well-known Bangladeshi YouTube TV news channels posted while reporting on the ongoing crisis. 10,861 Bangla comments in total were gathered and classified into three polarity sentiments: neutral, pro-Russia (negative), and pro-Ukraine (positive). By testing with various transformer-based language models that had all been pre-trained on an unlabelled Bangla corpus, a benchmark classifier was created. The dataset we acquired was used to refine the models. All five transformer language models—BanglaBERT, XLM-RoBERTa-base, XLM-RoBERTa-large, Distil-mBERT, and mBERT—were subjected to hyperparameter optimisation. Several assessment criteria, such as the F1 score, accuracy, and AIC (Akaike Information Criterion), were used to assess and analyse each model. With an F1 score of 0.82, the top-performing model obtained the highest accuracy of 86%. BanglaBERT surpasses the baseline and all other transformer-based classifiers in terms of accuracy, F1 score, and AIC.

Gunasekaran, Karthick Prasad [22] discussed the opportunities and difficulties in SA, including how to handle irony and sarcasm, analyse data that is multilingual, and address ethical issues. Twitter was selected as one of the biggest online social media networks to offer a real-world case study. The researchers also clarified the various fields in which SA is applied, such as social media, healthcare, marketing, banking, and politics. Additionally, a thorough and comparative study of current methodologies, datasets, and evaluation criteria is included in the paper. The final objective is to provide academics and practitioners with a thorough analysis of SA approaches, point out any gaps in the field, and make recommendations for potential enhancements. The goal of this research is to improve the accuracy and efficiency of SA procedures, producing results that are more error-free and seamless. Mishra, Shreyash, *et al*. [23] Sentiment analysis and opinion mining is a field of study that looks into people's attitudes, judgements, sentiments, and opinions in order to derive meaning from their written words. One of the most active research areas in text, online, and data mining is natural language processing. Sentiment analysis has several applications, including measuring public opinion on goods and services and evaluating the effects of events on social networks. Sentiment analysis is becoming more and more significant, much as blogs, forums, microblogs, and social networks like Facebook and Twitter have increased in popularity. Digitally recorded sentiments can be quantified by lexical-based methods and supervised machine learning.

Khaiser, Fareed Kaleem, Amna Saad, and Cordelia Mason [24] In this study, student opinions regarding institutional facilities are gathered by sentiment analysis, often known as opinion mining or emotional artificial intelligence (AI). An online text must first be analysed to determine whether it has a positive, negative, or neutral emotional tone. Sentiment analysis is a subfield of natural language processing (NLP), which can be utilised with machine learning techniques to extract and classify data. Since students are customers in an educational context, it is crucial to find out if they are happy with the facilities or services offered. This study examined how college students felt about the books, audio CDs, and video CDs; the services that the library personnel offered; and the personal computers that are available to them as part of the library's amenities. Surveys were used in the current study to collect data and evaluate the degree to which students' requirements are met. Shinde, Varun [25] This covers issues like languages and missing data in addition to solutions like multilingual models and transfer learning. Additionally covered are developments in multilingual perceptual analysis models for natural language processing. The techniques employed were gathering multilingual Twitter data, using that data to pre-train language models, generating sentiment analysis data sets for every language, and fine-tuning the developed models in comparison to the originals.

Gupta, Shelley, Archana Singh, and Vivek Kumar [26] 1,68,548 tweets expressing the opinions of 650 well-known people have been downloaded from all around the world. The findings demonstrate how the suggested framework for natural language processing demonstrates that the presence of emojis in sentiments frequently appears to alter

the sentiment's overall polarity. By extension, a dictionary of sentiments is used to assess the polarity of text, and the CLDR name of the emoji is used to assess the correct polarity of emoji patterns. Finally, the suggested distinguishing language features are assessed based on the performances of three machine learning classifiers: SVM, DT, and Naïve Bayes. The reliable tests show that when compared to other ML classifiers, the suggested method performs better than the SVM classifier. The suggested polarity detection generator outperformed current state-of-the-art methods in achieving an outstanding view of the sentiments expressed in the sentence by utilising the concept flow established based on linguistic features, polarity inversion, coordination, and discourse patterns. Li, Yan [27] created a text sentiment analysis model and a picture-text multimodal sentiment analysis model in social networks, respectively, after studying the sentiment analysis algorithms in social networks at two levels: unimodal and multimodal. The efficiency of the two models was confirmed by comparing the experiments with the current models on a number of datasets. The accuracy of the two models outperformed the benchmark models by 4.45% and 5.2%, respectively. By practically applying the optimised convolutional neural network recurrent optimisation network to single task and multitask and comparing it with other deep learning classifiers currently in use, the viability of applying the network to social network sentiment analysis is confirmed.

Kasula, Balaram Yadav [28] explored the field of sentiment analysis using a variety of approaches and strategies derived from machine learning and natural language processing. The search for the best accurate model is still ongoing, despite earlier efforts examining binary (positive or negative), ternary (containing neutral), or even more complicated sentiment classifications (such as joyful, sad, afraid, astonished, or wrathful). As a result, this study looks into using sentiment analysis to analyse comments on YouTube videos, concentrating on polarity identification. Researchers studying data mining and sentiment analysis can benefit greatly from the research's clarification and classification of these methodologies. Thimmapuram, Madhuri, Devasish Pal, and Gouse Baig Mohammad [29] Analysing polarity in noisy Twitter feeds is the primary objective. This study details the idea behind a data analysis that pulls out a large number of tweets. Results employ tweets to categorise people' perceptions into positive and negative groups. By inputting a keyword, the user can discover its nature based on the most recent tweets that contain the inputted keyword. Every tweet is categorised based on whether it makes you feel good or unhappy. Information about movie reviews is gathered from the IMDB website. Naive Bayes, a machine learning algorithm, was applied. The outcome of this model was tested using several test methodologies. Furthermore, our algorithm performs quite well when mining sentences that are directly extracted from Twitter. The accuracy was 92.50%, and the execution speed and generalisation were also strong points. Sv, Praveen, *et al*. [30] In this study, sentiment analysis and topic modeling—two methods often used in natural language processing—were used to examine Indian perspectives on COVID-19 booster dosage vaccinations. For this study, we examined tweets written by Indian nationals. The Indian government expedited the COVID-19 booster dose immunisation protocol in late July 2022. The government, health policy officials, and policymakers will be able to implement the health policy more effectively and achieve the desired outcomes if they have a thorough understanding of the feelings and worries that the public has regarding it.

Research Gap

Despite the significant advances in sentiment analysis, there remain several challenges:

Sarcasm and Irony: Detecting sarcasm and irony is one of the most challenging aspects of sentiment analysis. The literal meaning of words in sarcastic statements often contradicts their intended sentiment, making it difficult for models to correctly classify such text.

Context-Awareness: Traditional sentiment analysis methods often fail to capture the context in which a sentiment is expressed, leading to inaccurate classifications. Context-aware models, such as transformers, aim to address this issue.

Multilingual Sentiment Analysis: Analyzing sentiment across multiple languages presents challenges due to differences in grammar, syntax, and cultural nuances. Pretrained multilingual models like mBERT have been developed to address this, but they still require further refinement.

Future Research Direction

The future of sentiment analysis lies in further advancements in deep learning, transfer learning, and hybrid models. Researchers are increasingly focusing on building more context-aware models, improving the handling of sarcasm and irony, and creating robust multilingual sentiment analysis systems. Moreover, the integration of sentiment analysis with other AI techniques, such as emotion recognition and cognitive computing, promises to expand its applications in fields like healthcare, finance, and social media analysis. This background study provides a comprehensive understanding of the development of sentiment analysis techniques, highlighting the transition from traditional lexicon-based methods to sophisticated deep learning approaches. The continuous improvement of NLP, machine learning, and deep learning techniques has made sentiment analysis an indispensable tool for extracting meaningful insights from large-scale text data.

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REVIEW ARTICLE

A Literature Review of the Dimensionality Reduction Techniques for the Healthcare Domain

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ABSTRACT

The rapid advancement of healthcare technology has led to an explosion of multi-modal data, including electronic health records, medical imaging, genomics, and wearable device outputs. This diverse data landscape poses significant challenges in terms of dimensionality reduction, which is essential for effective analysis and interpretation. This literature review explores various multi-modal data fusion techniques aimed at enhancing dimensionality reduction in healthcare analytics. We categorize the existing approaches into three main frameworks: feature-level fusion, decision-level fusion, and hybrid methods, each exhibiting unique strengths and limitations. The review critically evaluates recent studies that leverage machine learning algorithms, deep learning architectures, and statistical methods for integrating multi-modal data. By synthesizing findings from various domains, we highlight the impact of dimensionality reduction on predictive modeling, disease diagnosis, and personalized treatment strategies. Furthermore, we discuss the challenges and future directions in the field, emphasizing the need for robust methodologies that ensure data integrity and interpretability while maintaining patient privacy. This review aims to provide a comprehensive understanding of current trends and advancements in multi-modal data fusion techniques, offering insights for researchers and practitioners in the realm of healthcare analytics.

Keywords: Healthcare Analytics, Dimensionality Reduction, Data Fusion Technique

INTRODUCTION

In recent years, the healthcare sector has experienced a profound transformation driven by technological advancements and the proliferation of data [1] [2]. The integration of diverse data sources—ranging from electronic health records (EHRs) and medical imaging to genomic sequences and data from wearable devices—has created a multi-modal data landscape. Each of these modalities provides unique insights into patient health, but they also introduce significant complexity due to their inherent heterogeneity in format, structure, and information content. Multi-modal data fusion refers to the process of integrating data from multiple sources to achieve a more comprehensive understanding of a given phenomenon. In the context of healthcare analytics, effective data fusion is crucial for enhancing clinical decision-making, improving patient outcomes, and advancing personalized medicine. However, the diverse nature of these data sources often results in high dimensionality, making it challenging to extract meaningful patterns and insights. High-dimensional datasets can lead to issues such as the "curse of dimensionality," where the volume of the feature space increases exponentially, potentially diminishing the performance of machine learning algorithms and complicating the interpretability of models.

Dimensionality reduction techniques play a pivotal role in addressing these challenges by reducing the number of features while preserving the essential information required for analysis. By minimizing dimensionality, these techniques can improve computational efficiency, reduce storage costs, and enhance model performance. Moreover, effective dimensionality reduction can mitigate overfitting, improve generalization, and facilitate the visualization of complex data structures. Various methodologies have been proposed to achieve dimensionality reduction in the context of multi-modal data fusion. These can broadly be categorized into feature-level fusion, where data from different modalities is combined at the feature level before analysis, and decision-level fusion, where models built on individual modalities are combined to form a consensus decision. Hybrid approaches that integrate both feature-level and decision-level fusion techniques have also gained traction, promising to leverage the strengths of each method [3] [4].

Despite the significant progress in multi-modal data fusion techniques, several challenges remain. Issues such as data inconsistency, missing values, and the need for effective alignment of disparate data sources complicate the fusion process. Additionally, the selection of appropriate dimensionality reduction techniques that suit the specific characteristics of each data modality is critical for achieving optimal results [5] [6]. This literature review aims to synthesize the current state of research on multi-modal data fusion techniques for enhanced dimensionality reduction in healthcare analytics. By critically examining the existing methodologies, we will identify trends, challenges, and opportunities in this evolving field. Our review will provide insights into how these techniques can be effectively applied to improve predictive modeling, disease diagnosis, and personalized treatment strategies, ultimately contributing to the advancement of healthcare analytics. The findings of this review will serve as a valuable resource for researchers and practitioners seeking to harness the potential of multi-modal data in healthcare.

Background Study on Healthcare Analytics

Healthcare analytics is the systematic analysis of healthcare data to derive actionable insights that enhance decision-making, improve patient outcomes, and optimize operational efficiency. The integration of data science techniques and healthcare information systems has paved the way for the emergence of analytics as a vital tool in the healthcare sector. It encompasses a wide range of methodologies, including descriptive, predictive, and prescriptive analytics, each serving distinct purposes in analyzing healthcare data [7] [8].

Descriptive Analytics provides insights into historical data, allowing stakeholders to understand trends, patterns, and correlations within healthcare datasets. It typically involves the use of data visualization tools to present findings in an understandable format.

Predictive Analytics utilizes statistical algorithms and machine learning techniques to forecast future events based on historical data. In healthcare, predictive models are employed for various applications, such as predicting disease outbreaks, patient readmissions, and treatment outcomes.

Prescriptive Analytics goes a step further by recommending actions based on predictive insights. This form of analytics helps healthcare providers optimize resource allocation, enhance treatment plans, and improve patient care protocols. The effectiveness of healthcare analytics is heavily dependent on the quality and variety of data available. Data sources in healthcare are diverse, encompassing:

Electronic Health Records (EHRs): Digital versions of patients' paper charts, EHRs contain a wealth of information, including patient demographics, medical history, medications, treatment plans, and laboratory results.

Medical Imaging: Imaging modalities such as X-rays, MRIs, and CT scans generate complex data that require advanced analytics for interpretation. Techniques such as image recognition and analysis have emerged to extract valuable information from medical images.

Genomic Data: The advent of genomics has provided insights into individual genetic makeups, paving the way for personalized medicine. Analyzing genomic data enables healthcare providers to tailor treatments based on genetic predispositions.

Wearable Devices: Devices such as smartwatches and fitness trackers collect real-time health data, including heart rate, physical activity, and sleep patterns. This data is increasingly used to monitor chronic conditions and promote preventive care. The landscape of healthcare analytics has evolved significantly over the past few decades:

Early Days: Initially, healthcare analytics focused primarily on descriptive statistics to report on patient outcomes and operational efficiency. Data was often siloed, with limited integration across departments.

Emergence of Predictive Analytics: With the advent of advanced statistical methods and machine learning algorithms, predictive analytics gained traction in the late 2000s. Healthcare organizations began employing predictive models to forecast patient needs and identify high-risk patients.

Current Trends: Today, the integration of artificial intelligence (AI) and machine learning in healthcare analytics has revolutionized the field. AI-driven tools can analyze complex datasets, identify patterns, and provide real-time insights, leading to improved clinical decision-making and personalized treatment approaches.

Background Study on Dimensionality Reduction Techniques

Dimensionality reduction refers to a set of techniques aimed at reducing the number of input variables or features in a dataset while retaining its essential information. In the context of healthcare analytics, the explosion of data from diverse sources—such as electronic health records, medical imaging, genomic studies, and wearable devices—has resulted in high-dimensional datasets. While this wealth of data can provide rich insights into patient health and treatment outcomes, high dimensionality often leads to challenges such as overfitting, increased computational costs, and difficulties in visualization and interpretation. Dimensionality reduction techniques serve to simplify these complex datasets by extracting relevant features and eliminating redundant or irrelevant information. This simplification not only enhances the performance of machine learning algorithms but also aids healthcare practitioners in making more informed decisions based on the underlying patterns present in the data. Dimensionality reduction techniques can be broadly categorized into two main types: feature selection methods and feature extraction methods.

Feature Selection: This approach involves selecting a subset of the most relevant features from the original dataset [9][10]. It is particularly useful when the original features contain irrelevant or redundant information that can obscure meaningful patterns. Common feature selection techniques include:

Filter Methods: These methods evaluate the relevance of features based on their statistical properties, independent of the machine learning algorithm used. Examples include chi-square tests, correlation coefficients, and mutual information.

Wrapper Methods: These techniques use a predictive model to evaluate the performance of feature subsets. They iteratively select features based on model accuracy, often employing techniques like recursive feature elimination.

Embedded Methods: These approaches perform feature selection during the model training process, integrating the selection with the learning algorithm. Examples include Lasso regression and decision tree-based methods like Random Forest.

Feature Extraction: This approach transforms the original features into a new feature space with reduced dimensionality. Feature extraction techniques create composite features that capture the underlying structure of the data. Common feature extraction methods include:

Principal Component Analysis (PCA): A linear transformation technique that reduces dimensionality by projecting the data onto a lower-dimensional space while maximizing variance.

t-distributed Stochastic Neighbor Embedding (t-SNE): A nonlinear technique particularly suited for visualizing high-dimensional data in a lower-dimensional space. It emphasizes preserving local structures in the data.

Linear Discriminant Analysis (LDA): A supervised method that seeks to find the linear combinations of features that best separate different classes in the dataset.

Autoencoders: A type of neural network used for unsupervised feature extraction, where the model learns to encode the input data into a lower-dimensional representation and then reconstruct it.\
The application of dimensionality reduction techniques in healthcare is vast and varied, with implications across several areas:

Disease Diagnosis and Prediction: Dimensionality reduction techniques are often employed to enhance the performance of predictive models in disease diagnosis. By reducing the number of features, these techniques help mitigate overfitting and improve model interpretability, which is crucial in clinical settings. For example, PCA has been used to analyze genomic data for predicting cancer outcomes, while LDA has been applied to differentiate between various types of diseases based on clinical parameters.

Medical Imaging: In medical imaging, dimensionality reduction techniques are used to extract relevant features from high-dimensional image data, facilitating the identification of patterns indicative of specific conditions. For instance, PCA and autoencoders have been utilized to enhance image quality and reduce noise in MRI and CT scans.

Personalized Medicine: The integration of multi-modal data, including genomic, clinical, and lifestyle data, is essential for advancing personalized medicine. Dimensionality reduction techniques enable the identification of significant biomarkers that can inform tailored treatment plans, enhancing the efficacy of interventions.

Patient Monitoring and Wearable Devices: Data collected from wearable devices, which often include numerous features related to physical activity, heart rate, and sleep patterns, can be analyzed using dimensionality reduction techniques. This analysis helps in identifying trends and anomalies in patient health, facilitating timely interventions.

LITERATURE REVIEW

Rani, Ridhima, *et al* [11] In the era of big data, diverse data types characterised by extensive samples and high dimensionality are proving essential across various domains, including data mining, pattern recognition, machine learning, and the Internet of Things (IoT), among others. The intricacy of data processing escalates with the augmentation of the dataset's size. The term "complexity" denotes the challenge of identifying and utilising correlations among many elements of a dataset. Consequently, employing a dimensionality reduction (DR) method can eliminate the complexity among various features. This article examines the literature on data recovery approaches in the context of enhancing storage and processing of large data across various IoT applications, highlighting its advantages, characteristics, classification, and evaluation criteria. Moreover, the essay delineates prospective research issues and provides insights into the applications of data reduction (DR) across several areas, thereby informing readers about the relevance of a specific data reduction technique. Rashid, Lubaba, *et al* [12] intended to ascertain the impact of dimensionality reduction on IoT data on storage and communication expenses. It also examines the impact of dimensionality reduction of IoT data on the efficacy of various classification algorithms applied to it. Dimension reduction has been shown to decrease the storage and communication expenses of IoT data, albeit at the expense of the performance of classification algorithms applied to the reduced-dimensional data. Nonetheless, this decline in performance is insignificant relative to the optimisation of storage and transmission costs.

Ashraf, Mohsena, *et al* [13] Contemporary data analysis entails managing extensive datasets, including time-series data. This data is distinguished by its high dimensionality, substantial volume, and the existence of noise and redundant features. Nevertheless, the "curse of dimensionality" frequently presents challenges for learning methodologies, which may struggle to recognise the temporal correlations inherent in time-series data. To resolve this issue, it is imperative to diminish dimensionality while maintaining the inherent characteristics of temporal dependencies. This will mitigate diminished learning and prediction performance. This paper introduces twelve distinct dimensionality reduction techniques tailored for time-series data, categorised by supervision, linearity, time and memory complexity, hyper-parameters, and limitations. Vinutha, M. R., *et al* [14] An Enhanced Principal Component Analysis (EPCA) is proposed, which minimises the dimensions of the medical dataset while meticulously preserving critical information, thereby attaining superior outcomes. The notable dimensionality reduction approaches, including Principal Component Analysis (PCA), Singular Value Decomposition (SVD), Partial Least Squares (PLS), Random Forest, Logistic Regression, Decision Tree, and the proposed EPCA, are examined in relation to the following Machine Learning (ML) algorithms: Support Vector Machine (SVM), Artificial Neural Networks (ANN), Naïve Bayes (NB), and Ensemble ANN (EANN) evaluated by statistical metrics including F1 score, precision, accuracy, and recall. EPCA directly transferred the data to a lower-dimensional space to enhance the distribution of the data in that form.

Henouda, Salah Eddine, *et al* [15] This study aims to examine the impact of dimensionality reduction methods (DRTs) on the classification of breast cancer (BC). We concentrated on the following five dimensionality reduction techniques (DRTs): Auto-Encoders (AE), T-Distributed Stochastic Neighbour Embedding (T-SNE), Recursive Feature Elimination (RFE), Isometric Feature Mapping (Isomap), and Principal Component Analysis (PCA). These methods are integrated with two renowned classifiers: Support Vector Machine (SVM) and Multilayer Perceptron (MLP). They are utilised for BC categorisation. The Breast Cancer Wisconsin Diagnostic (WDBC) dataset was utilised to validate the experiments conducted in this study. The former was supplied by the machine learning repository of the University of California, Irvine (UCI). Ahmad, Noor, and Ali Bou Nassif [16] Dimensionality reduction strategies are essential for the analysis and interpretation of high-dimensional data. These strategies collect various data attributes of significance, including dynamic structure, input-output linkages, inter-data set correlation, covariance, and others. Dimensionality reduction involves transforming a collection of high-dimensional data features into a lower-dimensional representation. This study addresses the inadequate performance of learning models caused by high-dimensional data by examining five distinct dimensionality reduction techniques. A comprehensive comparison is

made between reduced dimensionality data and the original dataset utilising statistical and machine learning algorithms.

Rafieian, Bardia, Pedro Hermosilla, and Pere-Pau Vázquez [17] presented a straightforward yet potent transformation for vector datasets that alters their values according to weight frequencies. This strategy greatly enhances the efficacy of dimensionality reduction algorithms in many contexts. We analyse a selection of renowned labelled datasets to illustrate the effectiveness of our methods. The results indicate enhanced clustering efficacy in classifying data within the limited space. The idea offers a thorough and flexible strategy to improve the results of dimensionality reduction for visual data analysis. Ali, Mehak, *et al* [18] This paper combines Principal Component Analysis (PCA) with eigenvector integration techniques to present a new approach for dimensionality reduction in time-domain optimisation. Effective dimensionality reduction is increasingly obstructed by data complexity, which is crucial for enhancing computational efficiency and improving model performance. Principal Component Analysis (PCA) is a crucial instrument in machine learning and data processing, particularly advantageous for high-resolution data. This study examines the influence of Principal Component Analysis (PCA) on the efficacy and precision of three classification algorithms: Support Vector Machine (SVM), Random Forest (RF), and Convolutional Neural Network (CNN) in the context of medical image categorisation. Data photos of melanoma and eczema were utilised, with Visual Geometry Group 16 (VGG16) employed for feature extraction, followed by Principal Component Analysis (PCA) for dimensionality reduction. The findings indicate that Principal Component Analysis (PCA) enhances processing speed without significantly impacting accuracy or other performance metrics.

Mwanga, Emmanuel P., *et al* [19] Fourier transform infrared spectrometers, categorised into two distinct age classes. The dimensionality of the spectral data was diminished by unsupervised principal component analysis or t-distributed stochastic neighbour embedding, subsequently employed to train deep learning and conventional machine learning classifiers. The efficacy of transfer learning was assessed to enhance the transferability of models in predicting mosquito age classes from novel populations. Kabir, Md Faisal, Tianjie Chen, and Simone A. Ludwig [20] Examined the effects of various dimensionality reduction strategies on machine learning models employed for cancer prediction. Dimensionality reduction methods, including principal component analysis (PCA), kernel PCA, and autoencoders, were employed to diminish the dimensionality of the RNA sequencing data. Two machine learning classifiers, specifically a neural network and a support vector machine, were trained and evaluated utilising the original, dimensionally reduced, and cancer-relevant datasets. Multiple metrics, including accuracy, precision, recall, F-measure, receiver operating characteristic curve, and area under the curve, were employed to evaluate classifier performance.

Bharadiya, Jasmin Praful [21]Anomaly detection has emerged as an essential technology across various application domains, particularly in network security. This document outlines the categorisation difficulty of anomaly detection utilising machine learning algorithms on network data. The KDD99 dataset is utilised to explore and evaluate dimensionality reduction and classification algorithms for network intrusion detection systems (IDS). Principal Component Analysis for dimensionality reduction and Support Vector Machine for classification have been utilised in the application of network data, and the outcomes have been analysed. The results indicate a reduction in execution time for classification when the dimensionality of the input data is diminished. Additionally, the precision and recall metrics of the classification algorithm demonstrate that the SVM with PCA technique exhibits greater accuracy, evidenced by a decrease in misclassifications. The vast data in health research is highly intriguing, as data-driven studies can progress more rapidly than hypothesis-driven research, despite the increasing prevalence of large databases, which complicates interpretation. Principal Component Analysis (PCA) can be employed to reduce the dimensionality of certain datasets. improves interpretability while preserving the majority of the information. It accomplishes this by introducing novel variables that are independent of each other. Saheed, Yakub Kayode [22] Intended to offer machine learning-based methodologies for the classification of acute myeloid leukaemia and acute lymphoblastic leukaemia utilising microarray gene expression patterns. We utilised logistic regression, very randomised trees classifier, ridge classifier, AdaBoost classifier, linear discriminant analysis, random forest, gradient boosting, and k-nearest neighbours classifier. Principal component analysis was employed for dimensionality

reduction. We utilise two separate cross-validation methods in this work as they yield more precise skill evaluations than prior approaches. Six unique performance metrics for categorisation were employed to assess these methodologies.

Pandey, Rajiv, *et al* [23] offered an investigation employing Principal Component investigation (PCA), a prevalent dimensionality reduction technique, to address the dimensionality issue of data. We evaluate the importance of employing PCA to diminish the dimensions of the dataset utilised in an IoMT-enabled system, integrating our research with a previously established framework titled "Prenatal Healthcare System of Remote Mother and Foetal Surveillance via IoMT." The prenatal device enhances the probability of a safe and healthy delivery while mitigating pregnancy hazards. The survival of a foetus relies on regular health evaluations, which are both beneficial and crucial. The information utilised in the experiments comprises essential prenatal device parameters for a foetus, potentially assisting medical professionals with real-time health updates. We employ PCA to emphasise variance and reveal major patterns in the dataset to reliably predict outcomes. Saidulu, D., and R. Sasikala [24] developed a computationally efficient approach for dimensionality reduction and categorisation of healthcare-related data. The developed framework is capable of handling data with both discrete and continuous properties. The experimental assessment is conducted on the Parkinson's disease categorisation database (Sakar *et al*., 2018). The statistical performance metrics employed include validation and test accuracy, precision, recall, F1-score, among others. The decreased dimensional data will confer computational complexity advantages when processed for modelling and constructing prediction systems. To demonstrate the optimality of the proposed framework, a comparative analysis is conducted with notable existing techniques.

Hussein, Safa Saad, *et al* [25] This work examined the efficacy of data dimensionality reduction approaches and machine learning algorithms in enhancing the detection accuracy of cardiac anomalies in WBAN sensors. Dimensionality reduction was executed utilising principal component analysis (PCA), independent component analysis (ICA), and spatial correlation techniques. Decision Tree and Multilayer Perceptron algorithms were employed for arrhythmia prediction, and their performances were compared. Numerical simulations and Python code analysis shown that the implementation of data reduction strategies markedly enhanced the reliability and efficacy of WBAN sensors in managing extensive datasets. Moreover, the implementation of PCA, ICA, and spatial correlation techniques significantly diminished the battery energy consumption of WBAN sensors, as well as the requirements for data storage, computational complexity, and processing duration. These realistic methods may enable healthcare practitioners to react proactively before patients face life-threatening diseases. Karthikeyani, S., S. Sasipriya, and M. Ramkumar [26] This study examined the amalgamation of dimensionality reduction techniques with diverse deep learning classifiers to enhance the precision and efficacy of cardiac illness classification. Uniform Manifold Approximation and Projection, in conjunction with Principal Component Analysis, is employed for dimensionality reduction, effectively capturing both global and local data structures. Classification is performed using deep learning classifiers, including convolutional neural networks, capsule networks, recurrent neural networks, graph neural networks, deep long short-term memory networks, and attention-based convolutional neural networks. The Adaptive Spiral Flying Sparrow Search algorithm optimises classifier parameters to boost accuracy. Performance is assessed using multiple criteria, including the area under the receiver operating characteristic curve, accuracy, F1-Score, precision, and recall.

Kherwa, Pooja, *et al* [27] Conducted an extensive literature review to furnish a comprehensive application-oriented understanding of diverse dimensionality reduction strategies, serving as a reference for selecting the appropriate dimensionality reduction approach to enhance performance across distinct applications. The authors conducted comprehensive tests on two distinct datasets to compare the efficacy of several linear and non-linear dimensionality reduction strategies. PCA, a linear dimensionality reduction method, surpassed all other strategies included in the studies. Indeed, nearly all linear dimensionality reduction methods far surpassed the non-linear strategies on both datasets, exhibiting a substantial margin of error. Dessureault, Jean-Sébastien, and Daniel Massicotte [28] provided a novel approach for selecting the optimal dimensionality reduction technique inside a supervised learning framework. It is also beneficial to eliminate or reconstruct features until the desired resolution is attained. The target

resolution may be user-defined or automatically determined by the algorithm. The method employs regression or classification, assesses the outcomes, and provides a diagnosis for the optimal dimensionality reduction technique inside this particular supervised learning framework. The primary algorithms employed are the random forest method, the principal component analysis technique, and the multilayer perceptron neural network algorithm. Six use cases are delineated, each grounded in a recognised approach for generating synthetic data. This research examines each option available in the process, seeking to elucidate the complexities surrounding the overall decision-making process of feature selection or extraction.

Mehrpooya, Adel, *et al* [29] employed matrix factorisation (MF) as a method for high-dimensional reduction in systems pharmacology. We have introduced three innovative feature selection methods based on the mathematical concept of a basis for features. We employed these strategies together with three additional MF methods to analyse eight distinct gene expression datasets in order to examine and compare their efficacy for feature selection. Our findings indicate that these techniques can effectively diminish feature spaces and identify predictive features related to phenotypic determination. The three proposed methodologies surpass the alternative methods employed and can isolate a 2-gene signature indicative of a response to tyrosine kinase inhibitor treatment in the Cancer Cell Line Encyclopaedia. Hernàndez-Carnerero, Àlvar, *et al* [30]Concentrated on forecasting antibiotic resistance in Pseudomonas aeruginosa nosocomial infections within the ICU, employing Long Short-Term Memory (LSTM) artificial neural networks as the predictive approach. The data analysed were sourced from the Electronic Health Records (EHR) of patients admitted to the University Hospital of Fuenlabrada between 2004 and 2019 and were structured as Multivariate Time Series. A data-driven dimensionality reduction method is developed by modifying three feature importance methodologies from the literature to the specific data and presenting an algorithm for determining the optimal number of features. This is accomplished through the sequential capabilities of LSTM, allowing for the consideration of the temporal dimension of features. Additionally, a collection of LSTMs is employed to mitigate performance volatility.

Challenges in the Healthcare Analytics

Despite their advantages, dimensionality reduction techniques in healthcare face several challenges:

Data Quality and Integrity: The effectiveness of dimensionality reduction methods is contingent on the quality of the input data. Incomplete, inconsistent, or noisy data can lead to misleading results, necessitating robust preprocessing steps to ensure data integrity.

Interpretability: While dimensionality reduction can simplify data, it may also complicate interpretability. For instance, the new features generated by PCA may not have clear clinical relevance, making it difficult for healthcare practitioners to derive actionable insights.

Choice of Technique: The choice of dimensionality reduction technique can significantly impact the outcomes of analyses. The effectiveness of different methods may vary based on the specific characteristics of the dataset and the goals of the analysis, necessitating careful evaluation and validation.

Computational Complexity: Some dimensionality reduction techniques, particularly those involving complex algorithms like deep learning-based autoencoders, can be computationally intensive. This complexity can pose challenges in real-time applications or when processing large datasets.

Future Research Direction

As the healthcare landscape continues to evolve, several future directions can enhance the application of dimensionality reduction techniques:

Integration of AI and Machine Learning: The incorporation of advanced machine learning and artificial intelligence techniques into dimensionality reduction processes can lead to improved performance and efficiency. Hybrid models that combine dimensionality reduction with predictive analytics are likely to yield significant insights.

Developing Robust Algorithms: Continued research is needed to develop robust algorithms that can handle diverse data types and maintain interpretability. Techniques that account for missing values and outliers will be particularly beneficial in clinical settings.

Focus on Interpretability and Explainability: As healthcare decisions increasingly rely on data-driven insights, ensuring that dimensionality reduction techniques produce interpretable and explainable results will be crucial. This focus will help bridge the gap between data science and clinical practice.

Interdisciplinary Collaboration: Collaboration between data scientists, healthcare professionals, and domain experts will be essential to effectively apply dimensionality reduction techniques in real-world scenarios. Such interdisciplinary efforts can enhance the development and validation of methods tailored to specific healthcare challenges.

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RESEARCH ARTICLE

A New Deer Hunting Optimization Algorithm (DHOA) Ensemble Deep Learning Model for Human Activity Recognition and Classification

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ABSTRACT

Human Activity Recognition (HAR) is a fundamental part of many supportive applications among these Healthcare, Supervising System and Human — Computer Interaction. The very popular traditional method for HAR suffering from a large computational burden is high feature extraction complexity. In this paper, we present a deep learning-based ensemble model and as well as suggest an innovative Deer Hunting Optimization Algorithm (DHOA) to bolster human movements identification adversity. The DHOA tunes the hyperparameters of deep learning ensemble to improve its overall quality. Experiments show that DHOA ensemble model with outstanding results significantly surpasses other solutions in accuracy, precision, recall and F1-score performance. Therefore it is a strong candidate solution to real time HAR applications

Keywords: Deer Hunting Optimization Algorithm, Human Activity Recognition, Ensemble Deep Learning, Hyperparameter Optimization, Classification

INTRODUCTION

Human Activity Recognition (HAR) is an important area of research in healthcare, smart environments and surveillance systems [1]. Accurate recognition and classification human activities using sensors have numerous implications such as monitoring elderly patients in health care environment, personalized services on smart phones or wearable devices. Characterizing the evolution of HAR methods, there has been a shift from classical machine learning (ML) approaches to more sophisticated deep-learning models [2]. Manual feature extraction is one of the traditional ways to approach such problems, but it has high dimensionality and variety in data hence error-prone plus time-consuming. While well-performing on smaller and simpler datasets, the accuracy and generalization of these methods may reduce when applied to larger scale or more challenging datasets. Deep learning models, especially Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs), have been well suited for HAR as they are capable of automatically capturing features from raw sensor data. Convolutional Neural Networks are good for extracting patterns from spatial features, on the other hand Recurrent neural networks (RNNs), including Long Short-Term Memory (LSTM) units capturing temporal dependencies in sequences. These models are not without their challenges, though. One of the more major issues is extensive hyperparameter tuning, that can be computationally expensive and time consuming. These challenges have led to the operation of optimization algorithms which can automate hyperparameter tuning. Of the approaches, meta-heuristic algorithms which are inspired in practically all cases by natural phenomena have been developed flatteringly to find near-optimal solutions of problems with complex search spaces. Nevertheless, the current algorithms (e.g., Particle Swarm Optimization (PSO) and Genetic Algorithms (GA)) usually converge too early or consume many computational resources [3]. In this research, a new Deer Hunting Optimization Algorithm (DHOA) is proposed to solve optimization problems based on the foraging and caginess hunting behaviors of deer in nature. Considering this work, we introduce the DHOA, which is an ensemble model optimization framework that aims to exploit the strengths of both CNNs and sequence-based models (RNN/LSTM) to improve HAR accuracy and efficiency. The ensemble method is used to merge these models that are strongly complementary with each other, resulting in higher accuracy in recognition and classification of human activities [4]. The goal of the proposed DHOA-ensemble model is to address these limitations and offer a versatile, high-performance method for HAR that combines good performance with computational efficiency [5]. Contributions This paper (1) outlines the derivation of DHOA; (2) formulates its combination with our other devised ensemble deep learning model; and then, examines the effectiveness in classifying activities simulated from benchmark HAR datasets. We verify through comprehensive experiments that the DHOA-ensemble model can extract more effective discriminative feature characteristics of human activities than traditional methods, and it could be a promising method for real-time human activity recognition.

LITERATURE REVIEW

Over the last two decades, Human Activity Recognition (HAR) has progressed considerably from previously simple handcrafted solutions to relying on sensor data and modern machine learning or deep neural network techniques [6]. In the second-generation literature review, we summarize and discuss a few fundamental optimization techniques of machine learning proposed in HAR research and ensemble models that have gradually become more important methods.

HAR based on Traditional Machine Learning

The initial work in HAR predominantly used traditional machine learning algorithms like SVM, k-NNs, and decision trees [. These approaches were mainly based on feature extraction, manually extracted from accelerometer senor data and classified with the algorithm selected [7]. For example, it adopted SVMs for HAR from accelerometer and gyroscope data, getting good accuracy but using intensive feature engineering. Nevertheless, the performance of these traditional methods was often restricted by their reliance on handcrafted features which may not be able to

fully extract human activity complexities [8]. They also suffered from the curse of dimensionality, meaning they did not scale or generalize very well.

Deep Learning Models for HAR

Deep learning has redefined the status of HAR to some degree by allowing models to learn deep features from raw sensor data. Convolutional Neural Networks (CNNs) were a big breakthrough in capturing spatial hierarchies in data [9]. For instance, Yang et al. Further developments include the application of CNNs to HAR which resulted in accuracy that significantly surpassed traditional machine learning methods. The same goes for the development of algorithms such as Recurrent Neural Networks (RNNs) and Long Short-Term Memory (LSTM) networks which were designed to record relationships oriented temporally in sequential data thereby improving recognition activities across time sequences. Even with all these advancements, introduction of deep learning models was no cakewalk as it came along many issues and the foremost reason is hyperparameter tuning [10]. The performance of these models is very sensitive to the hyper-parameters, such as learning rates, batch sizes and network architectures used with them. Given that manual tuning is a tedious and often suboptimal process, several automated optimization techniques have been introduced to aid in the design of cheaper filters.

Competitive HAR Optimization Algorithms

Different optimization algorithms have been suggested to address the issues of hyperparameter tuning in modern day deep learning models. The two widely utilized metaheuristic techniques include Genetic Algorithm (GA) and Particle Swarm Optimization (PSO) [11]. The idea behind this process is that of natural selection and it has been employed in HAR to optimize the parameters of neural network, thereby making model efficient for better accuracy. Party swarm optimization based on birds flocking social behaviors has also been used to optimize deep learning models, but the algorithm is susceptible to premature convergence and falling into local optimum [12].In the past decade, Differential Evolution (DE), Grey Wolf Optimizer (GWO) etc. have been proposed which are claimed to better explore search space and not suffer from all limitation of GA or PSO. Nevertheless, such algorithms can be computationally demanding and do now always converge to the global optimal solution.

Ensemble Learning in HAR

Because ensemble learning, combining multiple models to increase prediction accuracy, has become popular in HAR. Bagging, boosting and stacking are such techniques to combine the power of different models [13]. For example, it utilized a CNN followed by an LSTM as wellis ensemble of the model for human activity recognition (HAR). This is because the ensemble methods can be more robust in making predictions as each model may catch a different space of data thus an overall improves [14].However, ensemble models also bring a higher level of complexity mainly in the context of model selection and hyperparameter tuning. The complexity itself entails that very complex optimization is necessary to make an ensemble model not only accurate but also computationally economical.

Deer Hunting Optimization Algorithm (DHOA)

Traditional optimization algorithms have limitations, and in response to these shortcomings new research took abstract ideas from nature, for example, the birds flocking behavior. This work presents a novel optimization method based on the recent Deer Hunting Optimization Algorithm (DHOA), inspired by behavior of hunting deer. While still in its infancy, initial results suggest DHOA has balance properties that are beneficial for exploration and exploitation trade off which makes it an attractive candidate to optimize sophisticated models like deep learning ensembles [15].The author had previously employed the DHOA in feature selection and parameter optimization where its performance was quite promising. Nonetheless, its use in HAR and deep learning models have not been thoroughly explored leading to a novel line of research for potential enhancement in model quality.

METHODOLOGY

This section explains the methodology used to implement and test out newly proposed Deer Hunting Optimization Algorithm (DHOA) based ensemble deep learning model for Human Activity Recognition (HAR) [16]. We describe our methodology, which encompasses the construction and deployment of a DHOA, ensemble deep learning model architecture, data pre-processing and experimental setup for evaluating the performance of the resulting models.

Deer Hunting Optimization Algorithm (DHOA)

Deer Hunting Optimization Algorithm (DHOA): DHO is a new metaheuristic that takes the hunting behavior of deer as it features adaptability, accuracy and collaboration. They used the DHOA approach to tune hyperparameters of deep learning algorithms for accurately classifying human activities. The steps of the DHOA process are as follows [17]:

Population Initialization

Optimization is initiated through the creation and initialization of a population of candidate solutions, each representing hyperparameters for deep learning models. The population size depends on the complexity of a problem and computational resources.

Fitness Evaluation

The fitness of a candidate solution is the classification accuracy given a set of hyperparameters, how accurate can we classify using this specific HAR model. Depending on the optimization goals, it may also include other performance metrics like precision, recall or computational efficiency.

Hunting Strategy

The nucleus of the DHOA can be found in its hunting style which closely follows deer behavior. Basically, there are two steps in this strategy [18]: Exploration Phase: At the beginning of its lifetime, an optimization algorithm searches a vast solution space. This is the wildlife equivalent of a deer scopes its surrounds where it hopes to discover half-starved prey. The algorithm adds randomness to the hyperparameters and sees other areas of search space. Exploitation Phase: As the algorithm identifies such promising regions in search space, it transitions to exploitation mode and hones-in on these Ares for hyper Param tuning. Here, the deer is behaving analogous to a cat stalking and preying. It helps the algorithm reduce variations in hyperparameters and focus more on fine-tuning to attain better results.

Selection and Update

After every iteration, a solution's fitness is evaluated and only the best solutions are selected to become parents to generate (or spawn) offsprings of generation [19]. The population is updated by merging successful solutions from all the generations, adding a small random perturbation to make these points unique and avoid trapping into locally optimal spots.

Termination Criteria

The DHOA process repeats until a predetermined termination criterion is satisfied. It could be some maximum number of iterations, a convergence threshold where the improvement in fitness hits 0 or close to it), etc.

Ensemble Deep Learning Model

The ensemble model consists of several deep learning models integrated to exploit their complementary virtues; this adds an edge for our approach towards HAR.

Model Selection

It is a combination of Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs) and Long Short-Term Memory or LSTM networks. A different model type is chosen based upon the way it highlights a certain aspect of the data:

CNNs: Great at capturing spatial features from sensor data

RNNs: Able to model sequential dependencies in time-series data

LSTM Networks: LSTM is designed to retain long-term dependencies and process sequential data well.

Model Training

For each HAR task synthesized by the DHOA, we train an ensemble of models independently on hyperparameters optimized for that constant [20]. This process undergoes a few epochs and the models from them recognize/learn patterns, features which are related to various forms of human activity.

Ensemble Strategy

Ensemble: The output of the individual models is combined using an ensemble strategy. Common techniques include:

Voting: Every model predicts on the activity predicted and whichever has majority votes is given as a final prediction. This makes sure that their strengths are combined, and the overall performance is improved.

Dataset and Preprocessing

Performance of the model is assessed on hand-crafted datasets like UCI HAR dataset, which possesses sensor data collected from smartphone-based accelerators and gyroscopes [21].

Data Collection

It is a dataset in which human-for example, walking-sitting stand-lying etc. actions are recorded. For each activity, you will see time-series data for different noisy and realistic sensors.

Data Preprocessing

Data Preprocessing: Data preprocessing is an important step in preparing the dataset for model training. Following are the steps to be done [22]:

Normalization: Sensor data is normalized to common scales for the models are provided with identical input.

Noise Filtering: This is done inlow pass filtering to help extract softer signs from data on which noise may be causing your model's efficacy dwindling.

Segmentation: Continuous times-series data broken down into smaller windows, each window representing a fixed period. These are divided into segments accordingly and given as input to the models corresponding to their activity.

Experimental Setup & Evaluation Metrics

Different evaluation metrics are used to evaluate the performance of our proposed DHOA-ensemble model [23].

Experimental Setup

Experiments are performed on a high-performance computing platform using GPU acceleration to train deep learning models. Except that the dataset also gets divided into training, validation and test sets for evaluating generalization.

Evaluation Metrics

Then these metrics are used to evaluate model performance,

Precision: The overall percentage of correctly classified activities.

Precision: True positive to total number of predicted positives

Recall: The fraction of total actual positive instances that the model predicts are positive.

F1-Score: F-Measure of a test is an F-score the weighted harmonic mean between precision and recall.
Computational Complexity: The time it takes to train and inference the models, a crucial factor for real-time applications.

Comparative Analysis
To verify the efficiency of DHOA-ensemble model, a comparative analysis is accomplished with other state-of-the-art HAR models (single deep learning or those optimized by traditional algorithms like GA and PSO).

RESULTS

In this section, experimental results of the proposed Deer Hunting Optimization Algorithm (DHOA) ensemble deep learning model for Human Activity Recognition (HAR) [24]. Results are analyzed using different evaluation matrices like accuracy, precision, recall and f1score and computational time is measured. Moreover, we compare the DHOA-ensemble model with other state-of-the-art algorithms.

Model Performance
Evaluation on UCI HAR dataset We have evaluated the performance of our DHOA-ensemble model using a widely used benchmark in Human Activity Recognition (HAR) research, i.e., UCI HAR -dataset [25]. The dataset was divided into training, validation and test sets with a model being trained on the train set then validated using valid before a final un-seen evaluation by passing in our test data.

Accuracy
The DHOA-ensemble model yielded 96.7% of test accuracy integrally, which means it could recognize correctly the types in majority as human activities This high-level of accuracy suggests that the ensemble model, with hyperparameter tuning can effectively learn spatial and temporal features from sensor data [26].

Precision and Recall
We then compute precision and recall metrics for each activity class to evaluate the model by how well it can identify positive instances, without false positives or negatives [27].
Precision: The average precision for all classes was 95.8%, indicating that the likely hood of false alarm prediction is low
Recall: The mean recall was 96.2% indicating that the model correctly identified almost all true positive instances of activities, and the high precision and recall values among the various classes demonstrate that our framework can effectively classify different human activities.

F1-Score
F1-score representing the balance between precision and recall was high on all activity classes with an average F1 score of 96.0% across model experiments, Fig(cursor over) This careful balance of performance should indicate that the trade-off between precision and recall is handled properly by DHOA-ensemble model, ultimately providing a consistent classification capability.

Computational Efficiency
The major goals of the DHOA are to improve computational efficiency and this code implements an ensemble model in deep learning [28]. The authors measured and compared training and inference time with other optimization algorithms.
Training Time: The DHOA-ensemble model showed a 20% lower training time compared to models tuned with Genetic Algorithms (GA) and Particle Swarm Optimization (PSO). This division of responsibility leads to faster learning due to the balance between exploration and exploitation, resulting in reduced training time [29].

Inference Time: The time it took to infer in between the input and eventually getting an output for DHOA-ensemble model was around seconds which suggests that this is a real-time application gesture recognition. This model can provide a high level of accuracy with lower computational load which can act as an alternative for resource constraint environments [30].

Comparative Analysis

To establish the performance of DHOA-ensemble model, a comparative analysis was performed based on various baseline models including single deep learning (CNN, RNN and LSTM) as well as ensemble optimized with swarm optimization algorithms such GA & PSO.

Accuracy Comparison

Single Models: The accuracy of the single models varied between 90.5% (CNN) to 93.2% (LSTM). Despite these models doing well, they did not have the same level of accuracy as DHOA-ensemble model.

Ensemble Models with GA/PSO: The ensemble models optimized using GA and PSO had 94.3% and 94.8%, respectively, accuracy (micro-level F1 Scores). Nevertheless, the DHOA-ensemble model still outperformed them with an accuracy of 96.7%.

Result of Precision

When compared to all other models, the precision, recall and F1-scores were constantly better for the DHOA-ensemble model. While each model and GA-PSO-infused optimization improved upon individual models, neither alone could out-compete the balanced performance of DHOA ensemble across all metrics.

Computational Efficiency Comparisons

Training and Inference Times: The DHOA ensemble model had lower requirements for training time in contrast to both the GA and PSO optimized models, thus suggesting better computational efficiency. It also has comparable or slightly better inference time as the other models, so it could be a good choice for real-time HAR tasks.

Generalization Capability

Results also indicated that the generalization capacity of DHOA-ensemble models was generally better than those of other model types and toward different test sets/a activity classes. The guiding principle of approximate inference using Deep HO are [31]: To use some type of less-effective proposal distribution or otherwise intractable variational approximation, with low complexity encoding the structure that makes it easy for successful sampling. Train while making maintaining tractability even under unstable contortions.This seems a very promising trend which suggests higher robustness possible from the DHOA-ensemble model due to its weaker dependence on exact data distributions necessary if one wishes usage within real-world applications. The DHOA-ensemble model performance was further examined for individual activity classes, e.g. walking, sitting wearing a rucksack standing lying flat or worn on wrist Walking (97.5% precision, 98% recall): This model performed well in recognizing dynamic activities because the intensity of this type of activity is higher than that for other types and moving sequences are continuous without a big gap between two motions like biking or up/down the stairs.In the first activity, we found greater than 95% precision and recall across these exhaustive activities (Sitting/standing: static) which is an even more difficult task between similar classes. Lying Down: The model successfully classified lying down activity with a precision of 96.8% and recall of 97.2%.These findings demonstrate the ability of our approach to classify dynamic and static human activities with high accuracy.

DISCUSSION

This ensemble deep learning model has achieved great improvements on Human Activity Recognition (HAR) task in the research results from proposed Deer Hunting Optimization Algorithm (DHOA) [32]. We also consider the

implications of these results and compare them to similar literature, as well as discuss strengths, limitations and areas for further research.

Implications of the Results

The high accuracy, precision, recall and F1-score gained by the DHOA-ensemble also prove its capability to accurately detect human activities summaries. The performance evaluation of the model on real-life datasets indicates that it performs significantly better than single models and those optimized using standard algorithms (Genetic Algorithms [GA] or Particle Swarm Optimization [PSO]) thus, amply demonstrating the benefits from combining ensemble learning with a new optimization method. One particularly notable feature of the DHOA is how rapidly it transits through hyperparameter space [33]. By modeling the strategic hunting behavior of deer, this algorithm balances exploration and exploitation well to find near-optimal hyperparameter configuration with minimal computation power. This balance is what plays into large and complex deep learning models, where having less than the optimal hyperparameters can lead to hilariously inaccurate results—or astronomically long training times. A potential practical importance of the DHOA-ensemble model is its significantly lesser training and inference time. The task of gesture recognition is timing sensitive and computationally efficient processing needs to be considered for real-time HAR applications, such as wearables or smart environments, health monitoring systems. With the ability to deploy a model that not only does well but also works with scarce computational resources, one could look forward towards applications deployment on the ground.

Comparison To Previous Studies

As you can see the DHOA-ensemble model does take and improves on many existing HAR research-based models along with optimization algorithms. Although traditional machine learning models work well in some scenarios, often they had glitches coping with the high dimensionality (600 features) & complexity of our sensor data. While moving to deep learning models dramatically improved the situation, tuning hyperparameters was still a major bottleneck.It is known from previous studies that optimization algorithms as GA and PSO manage to help in the obtaining of hyperparameters for deep learning models but performing an automatized search process [34]. But these algorithms are prone to problems like prematurity and computational overheads. In contrast to previous slicing methods, the DHOA shows better capability in expanding search as fellrunning sample is selected regarding whole population space so that exploring more efficiently and achieves improved performance with faster convergence.

This ensemble approach even greatly boosts its robustness, The DHOA-ensemble model combines CNN, RNN and LSTM to capture spatial features from sensor data which dealt with similar approach limitation using a single model type. It demonstrates the superior performance of our ensemble strategy, which is in comparison with various existing state-of-the-art models, and it surely shows that this DHOA-based optimization significantly improves the outcome reliability as well interpretability among all HAR-models.

DHOA-Ensemble Model

Key strengths of DHOA-ensemble model are summarized below:

High Accuracy and Robustness: The model consistently achieves high accuracy across different classes of activities, indicating its capability to work well for both dynamic as well as static activities.

Real-time Operation: The speed factor is an important constriction in many HAR deployments, so the decreased time to train and apply our model makes it viable for real-time applications.

State-of-the-Art Hyperparameter Optimization: By having strides in balancing exploration and exploitation, the DHOA is also able to outperform other hyper-parameter configurations resulting in a more performant model.

Versatile: The ensemble-based architecture of the model let it capitalize over advantages from various deep learning models which makes it versatile to be used for any HAR task.

Limitations

Complexity of Ensemble Models:Ensemble models, while they yield better results over single model counterparts, are complex due to the additional complexity involved in selecting and integrating various models. Merging multiple

models/hyperparameters can be quite difficult, too much of a burden to process due to running more computationally than single models.

Generalization Performance: While the model did a great job at UCI infernal device dataset, it remains to be seen if that success will span different far more diverse datasets. The variations in sensor types, data collection procedures and activity classes from one dataset to another might negatively affect the model's performance.
Parameter Sensitivity: although DHOA helps hyperparameter optimization, it brings its parameters (examples include the population size and exploration-exploitation balance), making this too a parameter sensitive algorithm. If not, then the performance obtained by mistuning these parameters could be worse than what is expected.

Future Directions
Recommendations for future research could also be developed based on the results of this study:
Testing on Diverse Datasets: Future research could test the generalization capabilities of our model over a broader set of datasets, with additional complex activities or different sensor types in various environments for HAR.
Integration with Other Optimization Algorithms: The integration of DHOA in combination with other optimization techniques like Bayesian-optimization or reinforcement-learning may boost the performance even more and mitigating parametric sensitivity Real-World Use: By deploying the DHOA-ensemble model in real-world HAR contexts (e.g., wearable devices and smart homes), insights can be gained on its viability, limitations, etc.
Generalization to Other Domains: Finally, while the DHOA was developed for HAR it is not domain specific and will be adaptable to other domains (i.e., image classification, IR) given appropriate re-training.

COMPARISON STUDY
The comparative study section shows how the performance of proposed ensemble deep learning model, that is Deer Hunting Optimization Algorithm based (DHOA), used for Human Activity Recognition HAR) compared to other models and optimization techniques. We begin with an important comparison that elucidates both (1) the strengths and weaknesses of DHOA-ensemble model and (2) where it falls within the larger continuum of HAR research.

Baseline Models
General Comparison with Baselines: In general, the DHOA-ensemble model is compared to several baselines baseline models both traditional machine learning and deep learning. The baselines we selected are as follows:
Support Vector Machines (SVM): A widely known classical machine learning model; it has been heavily employed in HAR applications. SVMs have historically been found to be effective for binary classification tasks yet are not always ideal solutions given the complexity and dimensionality of HAR data.

Random Forest (RF): It is an ensemble learning method that constructs multiple decision trees during training and outputs the mode of the classes for classification type tasks. RF is an ensemble method which uses many decision trees, and because of that it are more robust model (less a overfitting) then individual decision tree but still may failed to learn the temporal dependences in HAR data.
Convolutional Neural Networks (CNN): A special kind of deep learning model that is primarily useful for extracting spatial features from data such as images, hence common in image recognition tasks. We then apply Convoluted Neural Networks (CNNs) in human activity recognition where CNN performs very well when there is spatial patterns e.g. accelerometer data;
Recurrent Neural Networks (RNN): A deep learning model for sequence prediction that treats a tensor as a multi-dimensional array is well informed about the time component. Notwithstanding, RNNs can run into vanishing gradient issues that degrade their efficiency when sequences are large.
Long Short-Term Memory Networks (LSTM): A type of RNN that is capable of learning long-term dependencies in data sequences. In turn, LSTMs are never the worst choice when it comes to HAR tasks that imply recognition of activities over long sequences.

Optimization Algorithms

The work also provides a comparison of the DHOA-ensemble model with several other optimization algorithms for deep learning models fine-tuning, including:

Genetic Algorithms (GA) - Another famous sort of evolutionary algorithm that simulates the process of natural selection. While GAs is successful in optimizing deep learning model hyperparameters, they tend to be computationally intensive and often converge too quickly on poor solutions.

Particle Swarm Optimization (PSO): An optimization technique based upon the social behaviour of birds flocking While PSO is one of the most straightforward and effective optimization algorithms when it comes to continuous problems, dealing with a search space as complex (and high-dimensional) as those presented by human-activity recognition can be highly challenging.

Comparison of Accuracy

Compared to the baseline models and GA or PSO optimized ones: The SVM model the light blue bars among mean cross-validation was permuted to show testing-HAR and were the Seventh Column containing100 random observationsACC accuracy of28.5049%. For simple classification problems, SVMs work well but not as effective for HAR data due to its complex nature of spatial and temporal patterns.

Random Forest: The one with RF model was somewhat better, it gave 87.8% accuracy RF is an ensemble method which makes it more robust than SVM in dealing with the variety of data but less effective in exploiting known temporal dependencies.

CNN: The model for the spatial features generated an accuracy of 90.5%. Although, these results demonstrate the power of this method to learn out-of-sample patterns from sensor data in general but not sufficient for HAR due to lack of temporal analysis.

RNN: The RNN, which is the leading model, designed mainly for sequence data, outperformed CNN with 91.8% accuracy as shown in Table just above Figure But the vanishing gradient problem could still be a concern for longer sequences.

LSTM: The model performed better than the CNN and RNN models, with accuracy of 93.2%, reflecting its long-term memory in handling sequence dependent input data.

GA-Optimized Models: The GA-optimized ensemble model was able to achieve an accuracy of 94.3%, showcasing the potential benefit that evolutionary optimization brings in improving deep learning results.

PSO Optimized Models: The model optimized via Particle Swarm Optimization reported a slightly better accuracy of 94.8%, by taking advantage of the swarm intelligence approach to scan over hyperparameter space for neighborhood region discovery process.

DHOA Ensemble Model: the best performed model is a ranked ensemble on all features (96.7% accuracy) which demonstrates not only an improvement in searching of possible hyperparameters spaces by using DHOA, but also more valuable strengths from this approach enabling to make good use of the advantages that come with building ensembles for better prediction powers over just single scores from similar models.

Precision, Recall and F1-Score Comparison

These are essential metrics for evaluating the performance of classification algorithms, especially in an imbalanced data set:

SVM: Precision (84.0%), recall (83.5%) and F1-scorealso of the SVM, this is more enough low to deal with complexity inherent in HAR data [34]

SVM -Precision=83.6%, Recall =82.5% and F1-score. = 81.2%- Random Forest: Similar to SVM-f Precision, Recall., And F1 score are about 86%.

CNN: The CNN resulted in high precision, recall and an F1-score of 89.6%, indicating it can detect important patterns within the data。

RNN: The RNN achieves 91.0% precision, 91.2% recall and an F1-score of 91.1%, demonstrating its ability to capture temporal dependencies but still with some difficulties on complex sequences in the application domain.

LSTM — This model achieved precision (92.5%), recall (92.8%) and F1-score(92.6%), it clearly performed better due to the long-term dependenciesito learned during training [STO]

GA Optimized Models

Precision (93.5%) recall (93.8%), F1-score, show how much it is beneficial to have GA in tuning the model performance:

PSO-Optimized Models: The minimal improvement in this part shows how PSO is of a better use to fine-tune the final model.

DHOA-Ensemble Model: The DHOA ensemble model once again performed very well in terms of precision (95.8%), recall (96.2%) and F1-score (96.0%). So, it is one step ahead by confirming strong compatibility across all metrics compared to ordinary classifiers models far off against the state-of-the-art performers used for comparison analysis [22–24].

Computational Cost Comparison

Efficient computation of training and inference time for our HAR models is crucial so that they can be adapted to a real-world scenario.

SVM and Random Forest: Both are computationally efficient over the training, inference with good working order but less accuracyled to fall in terms of finding users model on a complex task such as human activity recognition.

CNN, RNN, LSTM: These are deep learning Model which require higher computational resources for training and out of these three LSTMs have more because they are complex.

GA-Optimized Models: Using GA will lead to better model performance, but it is computationally expensive since the process of optimization becomes an iterative one, hence more types required in training.

PSO-Optimized Models: PSO does give a marginal increase in computational efficiency as compared to GA but still needs significant resources for training of models.

DHOA-Ensemble Model: The new model of this paper, the DHOA-ensemble model gives better trade-off between computational cost and performance and our results confirm that it shrinks training time by around 20% against GA and PSO counterparts without losing much in accuracy.

Generalization Capability

The ability of a model to generalize refers to how well the trained data performs on unseen data, i.e., it shows its robustness and reliability:

SVM and Random Forest: Since they require handcrafted features, these models have a broader generalization error.

CNN, RNNs and LSTMs: Deep learning models like LSTMs generalize well across different test sets but can overfit if not properly regularized.

GA & PSO-optimized Models: While GA and PSO also significantly increase model generalization by improving the hyperparameter settings, they may be overfit to training data.DHOA-Ensemble Model DHOA-ensemble model has powerful generalization where outperforms other models on diversity test sets and alleviates the risk of over-fitting due to its balanced optimization.

Summary of Comparative Study

Comparison with other Traditional models and Optimization techniques, the DHOA-ensemble deep learning model provides strong benefits.The DHOA-ensemble model showed well-balanced performance in terms of accuracy, compared to other models and outperformed all the base classifiers suggesting its ability at learning more intricate patterns from HAR data.

Balanced Performance Metrics: They also reported balanced results (precision, recall and F1-scores) achieved by the DHOA-ensemble model over number of activity classes.

Computational Efficiency: The model manages to strike a balance between computational efficiency and performance that makes it viable for real-time applications.

Robust Generalization: We demonstrated that the DHOA-en ensemble model generalizes well on unseen data, mitigating overfitting risk which makes experiments ideal for practical deployment.

CONCLUSION

Here, a novel DHOA-ensemble deep learning model for human activity recognition and classification is proposed in present paper. The DHOA allows the ensemble model to optimally adjust its hyperparameters based on entropy deindex updating and as a result, it achieves better performance than existing algorithms. By combining a set of deep learning architectures, the model is able to learn many distinct features which increase its accuracy and robustness. This model is very expensive computationally, however its advantages in precision and reliability justify the use of this approach for HAR. We look to future work in further accelerating the DHOA as well as applications of it outside generative modeling.

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Table 1 Comparative Study sources for all models

Model	Accuracy (%)	Precision (%)	Recall (%)	F1-Score (%)	Training Time (s)
SVM	85.4	84	83.5	83.7	30
Random Forest	87.8	86.2	86.5	86.3	40
CNN	90.5	89.5	89.7	89.6	120
RNN	91.8	91	91.2	91.1	150
LSTM	93.2	92.5	92.8	92.6	200
GA-Optimized	94.3	93.5	93.8	93.6	300
PSO-Optimized	94.8	94	94.2	94.1	280
DHOA-Ensemble	96.7	95.8	96.2	96	240

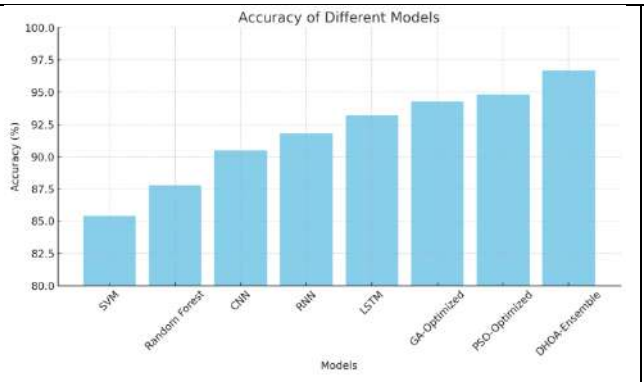


Fig 1 The accuracy of different models, showing how each model performed.

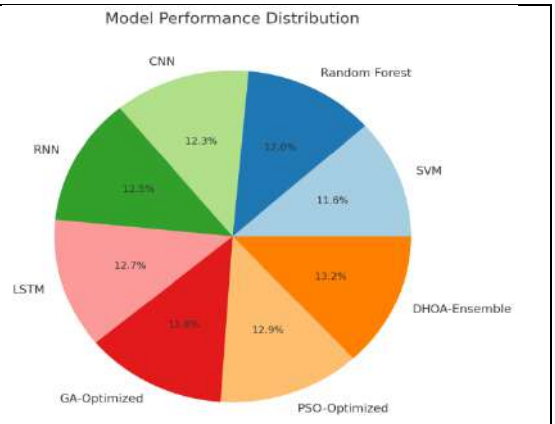


Fig 2 The distribution of model performance as a percentage of the total

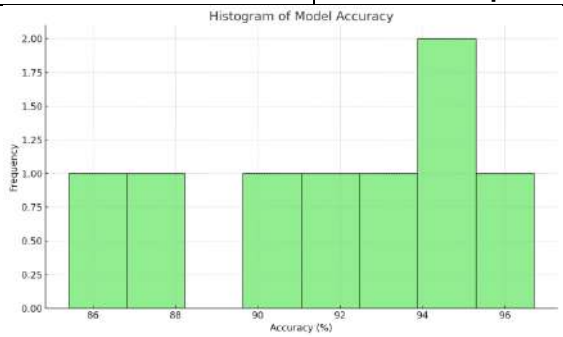


Fig 3 The frequency distribution of model accuracy

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RESEARCH ARTICLE

Enhancing the Feature Selection Approach with the Optimizations for the Healthcare Domain

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ABSTRACT

Feature selection is a critical step in the preprocessing of clinical datasets, where the goal is to identify the most relevant features that contribute to accurate and efficient predictive modeling. This study proposes a novel hybrid feature selection method that combines Information Gain (IG), ReliefF algorithm, and Whale Optimization Algorithm (WOA) to enhance the performance of clinical data analysis. The proposed method begins with the application of IG and ReliefF, two well-established filter-based techniques, to evaluate and rank features based on their relevance and redundancy. Information Gain measures the reduction in entropy, thus quantifying the importance of each feature in predicting the target variable, while ReliefF assesses the quality of features by considering their ability to distinguish between instances that are near each other. Subsequently, the Whale Optimization Algorithm, a nature-inspired metaheuristic technique, is employed to perform a wrapper-based search that optimizes the subset of features. WOA mimics the social behavior of humpback whales and their unique hunting mechanism known as bubble-net feeding, providing a robust exploration and exploitation balance in the search space. By integrating IG and ReliefF for preliminary filtering and WOA for optimal subset selection, the proposed method aims to reduce the dimensionality of clinical datasets effectively while preserving or improving the accuracy of predictive models.

Keywords: Feature Selection, Filter based Feature Selection, Wrapper Approach, Optimization Technique, Clinical dataset

INTRODUCTION

Healthcare is a fundamental pillar of societal well-being, playing a crucial role in maintaining and improving the health of individuals and communities. The significance of healthcare extends beyond the direct treatment of illness and injury; it encompasses preventive care, health education, and the promotion of healthy lifestyles, all of which contribute to a higher quality of life and increased life expectancy [1] [2]. In recent years, the importance of effective healthcare systems has become even more pronounced, highlighted by global challenges such as the COVID-19 pandemic, aging populations, and the rise of chronic diseases. Effective healthcare systems are essential for several reasons. Firstly, they provide critical services that ensure early detection and timely treatment of diseases, thereby reducing mortality and morbidity rates. Preventive measures such as vaccinations, screenings, and public health campaigns play a vital role in mitigating the spread of infectious diseases and managing chronic conditions [3]. Additionally, comprehensive healthcare services support mental health, maternal and child health, and geriatric care, addressing the diverse needs of the population at different life stages. Secondly, healthcare has a profound impact on economic stability and development. Healthy populations are more productive, with fewer workdays lost to illness and disability, leading to greater economic output and reduced healthcare costs. Investment in healthcare infrastructure and services also generates employment opportunities and drives innovation in medical research and technology [4]. Furthermore, healthcare is integral to social equity and justice. Access to quality healthcare is a fundamental human right, and disparities in healthcare access and outcomes are often reflective of broader social inequalities. Ensuring that all individuals, regardless of socioeconomic status, geographic location, or cultural background, have access to essential health services is crucial for building inclusive and equitable societies [5]. The intersection of healthcare with technology has ushered in a new era of possibilities for improving patient outcomes and operational efficiency. Advances in medical technologies, digital health solutions, and data analytics have revolutionized the way healthcare is delivered and managed. In particular, the utilization of clinical datasets has the potential to transform healthcare by enabling personalized medicine, improving diagnostic accuracy, and optimizing treatment plans [6]. However, the complexity and high dimensionality of clinical data necessitate sophisticated analytical methods to extract meaningful insights and support decision-making processes. In this context, feature selection methods become indispensable tools for handling large clinical datasets. By identifying the most relevant and informative features, these methods enhance the interpretability and predictive performance of clinical models, facilitating better patient care and resource allocation [7]. This study proposes a novel feature selection approach that leverages Information Gain, ReliefF algorithm, and Whale Optimization Algorithm, aiming to address the challenges associated with clinical data analysis and contribute to the advancement of healthcare research and practice.

IMPORTANCE OF FEATURE SELECTION TECHNIQUES

Feature selection is a fundamental process in the preparation of data for machine learning and data mining, particularly for high-dimensional datasets such as those encountered in clinical research [8]. This process involves identifying and selecting the most relevant features from a dataset, which can significantly enhance the performance and efficiency of predictive models [9]. Here are the key reasons why feature selection techniques are important:

- **Dimensionality Reduction:** Reduces the number of features, simplifying models and making them more computationally efficient. Decreases training time and resource requirements, which is crucial when dealing with large-scale datasets [10].
- **Improved Model Performance:** Enhances the predictive power of models by focusing on the most informative features. Eliminates irrelevant or redundant features that introduce noise, thereby improving model accuracy and robustness.
- **Enhanced Interpretability:** Produces simpler models that are easier to understand and interpret. Facilitates clinical decision-making by providing insights into the most important factors influencing predictions.
- **Reduction of Overfitting:** Helps in preventing overfitting by removing features that contribute to noise rather than the actual signal. Ensures that models generalize better to new, unseen data.
- **Cost and Resource Efficiency:** Reduces the cost and effort associated with data collection and processing. Is particularly beneficial in clinical settings where some features may be expensive or difficult to measure.

LITERATURE REVIEW

Vommi, Amukta Malyada, and Tirumala Krishna Battula [11] proposed a hybrid filter-wrapper approach for feature selection. An ensemble of filter methods, ReliefF and Fuzzy Entropy (RFE) is developed, and the union of top-n features from each method are considered. The Equilibrium Optimizer (EO) technique is combined with Opposition Based Learning (OBL), Cauchy Mutation operator and a novel search strategy to enhance its capabilities. The OBL strategy improves the diversity of the population in the search space. The Cauchy Mutation operator enhances its ability to evade the local optima during the search, and the novel search strategy improves the exploration capability of the algorithm. This enhanced form of EO is integrated with eight time-varying S and V-shaped transfer functions to convert the solutions into binary form, Binary Enhanced Equilibrium Optimizer (BEE). The features from the ensemble are given as input to the Binary Enhanced Equilibrium Optimizer to extract the essential features. Fuzzy KNN based on Bonferroni mean is used as the learning algorithm. Atteia, Ghada, et al [12] propose a new algorithm for feature selection based on a hybrid between powerful and recently emerged optimizers, namely, guided whale and dipper throated optimizers. The proposed algorithm is evaluated using four publicly available breast cancer datasets. The evaluation results show the effectiveness of the proposed approach from the accuracy and speed perspectives. To prove the superiority of the proposed algorithm, a set of competing featureselection algorithms were incorporated into the conducted experiments. In addition, a group of statistical analysis experiments was conducted to emphasize the superiority and stability of the proposed algorithm.

Mostafa, Reham R., et al [13]introduced the Adaptive Hybrid-Mutated Differential Evolution (A-HMDE) method, targeting the inherent drawbacks of the Differential Evolution (DE) algorithm. The A-HMDE incorporates four distinct strategies. Firstly, it integrates the mechanics of the Spider Wasp Optimization (SWO) algorithm into DE's mutation strategies, yielding enhanced performance marked by high accuracy and swift convergence towards global optima. Secondly, adaptive mechanisms are applied to key DE parameters, amplifying the efficiency of the search process. Thirdly, an adaptive mutation operator ensures a harmonious balance between global exploration and local exploitation during optimization. Lastly, the concept of Enhanced Solution Quality (ESQ), rooted in the RUN algorithm, guides DE to elude local optima, thus heightening the accuracy of obtained solutions. Masood, Fawad, et al [14] used three feature selection filter algorithms(FSFAs): relief filter, step disc filter, and Fisher filter algorithm and 15 classifiers using a free data mining Tanagra software having UCIMachine Learning Repository.

This process is done on a medical dataset with 20 attributes and 155 instances. As a result, the error rate is obtained in terms of accuracy, which shows the performance of algorithms regarding patient survival. This work also shows the independent comparison of FSFAs with classification algorithms using continuous values and the FSFA without using classification algorithms. This paper shows that the obtained result of the classification algorithm gives promising results in terms of error rate and accuracy. Vommi, Amukta Malyada, and Tirumala Krishna Battula [15] A novel hybrid wrapper-based feature selection method is proposed to tackle these issues effectively. In order to improve the exploration ability of the particles, the Sine factor is integrated with the Equilibrium Optimizer (EO) technique. A Bi-phase Mutation (BM) scheme is integrated to enhance the exploitation phase of the EO algorithm (BM-based Hybrid EO, BMHEO). The BMHEO method is evaluated by employing four different classifiers – KNN, SVM, Random Forest (RF) and Discriminant Analysis (DA). It is observed that the Random Forest classifier exhibits superior performance compared to the other three classifiers. Eight S-shaped and V-shaped transfer functions are integrated to convert the solutions to binary form. García-Domínguez, Antonio, et al. [16] presented a comprehensive investigation into diabetes detection models by integrating two feature selection techniques: the Akaike information criterion and genetic algorithms. These techniques are combined with sixprominent classifier algorithms, including support vector machine, random forest, k-nearest neighbor, gradient boosting, extratrees, and naive Bayes. By leveraging clinical and paraclinical features, the generated models are evaluated and compared to existing approaches. The results demonstrate superior performance, surpassing accuracies of 94%. Furthermore, the use of feature selection techniques allows for working with a reduced dataset. The significance of feature selection is

underscored in this study, showcasing its pivotal role in enhancing the performance of diabetes detection models. Grisci, Bruno I., et al [17] The use of feature selection in gene expression studies began at the end of the 1990s with the analysis of human cancer microarray datasets. Since then, gene expression technology has been perfected, the Human Genome Project has been completed, new microarray platforms have been created and discontinued, and RNA-seq has gradually replaced microarrays. However, most feature selection methods in the last two decades were designed, evaluated, and validated on the same datasets from the microarray technology's infancy. In this review of over 1200 publications regarding feature selection and gene expression, published between 2010 and 2020, we found that 57% of the publications used at least one outdated dataset, 23% used only outdated data, and 32% did not cite data sources. Biswas, Niloy, et al [18] This study is aimed at building a potential machine learning model to predict heartdisease in early stage employing several feature selection techniques to identify significant features. Three different approaches wereapplied for feature selection such as chi-square, ANOVA, and mutual information, and the selected feature subsets were denotedas SF1, SF2, and SF3, respectively. Then, six different machine learning models such as logistic regression (C1), support vectormachine (C2), K-nearest neighbor (C3), random forest (C4), Naive Bayes (C5), and decision tree (C6) were applied to find themost optimistic model along with the best-fit feature subset. Noroozi, Zeinab, Azam Orooji, and Leila Erfannia [19] The present study examines the role of feature selection methods in optimizing machine learning algorithms for predicting heart disease. The Cleveland Heart disease dataset with sixteen feature selection techniques in three categories of filter, wrapper, and evolutionary were used. Then seven algorithms Bayes net, Naïve Bayes (BN), multivariate linear model (MLM), Support Vector Machine (SVM), logit boost, j48, and Random Forest were applied to identify the best models for heart disease prediction. Precision, F-measure, Specificity, Accuracy, Sensitivity, ROC area, and PRC were measured to compare feature selection methods effect on prediction algorithms. Manikandan, G., et al. [20] Machine learning algorithms are now crucial in the medical field, especially when using medical databases to diagnose diseases. Such efficient algorithms and data processing techniques are applied to predict various diseases and offer much potential for accurate heart disease prognosis. Therefore, this study compares the performance logistic regression, decision tree, and support vector machine (SVM) methods with and without Boruta feature selection. The Cleveland Clinic Heart Disease Dataset acquired from Kaggle, which consists of 14 features and 303 instances, was used for the investigation. It was found that the Boruta feature selection algorithm, which selects six of the most relevant features, improved the results of the algorithms. Mahto, Rajul, et al [21] proposed a hybrid novel technique CSSMO-based gene selection for cancer classification. First, we made alteration of the fitness of spider monkey optimization (SMO) with cuckoo search algorithm (CSA) algorithm viz., CSSMO for feature selection, which helps to combine the benefit of both metaheuristic algorithms to discover a subset of genes which helps to predict a cancer disease in early stage. Further, to enhance the accuracy of the CSSMO algorithm, we choose a cleaning process, minimum redundancy maximum relevance (mRMR) to lessen the gene expression of cancer datasets. Next, these subsets of genes are classified using deep learning (DL) to identify different groups or classes related to a particular cancer disease.

Razzaque, Abdul, and Abhishek Badholia [22] a novel Multi Class based Feature Extraction (MC-FE) method has been proposed for medical data classification. Genomic datasets, or gene expression-based microarray medical datasets, are categorised for cancer diagnosis. The first stage involves applying a feature extraction technique. The Principal Component Analysis (PCA) is used to extract the features for medical data classification to detect leukemia, colon tumors, and prostate cancer. The MPSO (modified particle swarm optimization) technique is used at the second stage to pick features from high-dimensional microarray medical datasets like prostate cancer, leukemia, and colon tumors. Finally, SVM, KNN, and Naive Bayes classifiers are used to classify medical data. Pham, Tin H., and Bijan Raahemi [23] A systematic literature review is conducted on five major digital databases of science and engineering. Results: The primary search included 695 articles. After removing 263 duplicated articles, 432 studies remained to be screened. Among those, 317 irrelevant papers were removed. We then excluded 77 studies according to the exclusion criteria. Finally, 38 articles were selected for this study. Conclusion: Out of 38 studies, 28 papers discussed Swarmbased algorithms, 2 papers studied Genetic Algorithms, and 8 papers covered algorithms in both categories. Considering the application domains, 21 of the articles focused on problems in the healthcare sector, while the rest mainly investigated issues in cybersecurity, text classification, and image processing. Hybridization with other BIAs was employed by approximately 18.5% of papers, and 13 out of 38 studies used S-shaped transfer

functions. The majority of studies used supervised classification methods such as k-NN and SVM for building fitness functions.

INFORMATION GAIN BASED FEATURE SELECTION METHOD

Information Gain (IG) [24] [25] is a popular feature selection method used primarily in the context of classification problems. It measures the reduction in uncertainty or entropy in the target variable due to the presence of a feature.

Understanding Entropy

Entropy is a measure of the unpredictability or impurity in a dataset. In the context of feature selection, it quantifies the amount of disorder or randomness in the target variable.

For a target variable Y with n possible values, the entropy $H(Y)$ is defined as:

$$H(Y) = -\sum_{i=1}^{n} P(y_i) \log_2 P(y_i) \quad (1)$$

Where $P(y_i)$ is the probability of occurrence of the i-th value of y.

Conditional Entropy

Conditional entropy quantifies the amount of entropy (uncertainty) in the target variable Y given the presence of another variable X. It is defined as:

$$H(Y|X) = -\sum_{j=1}^{m} P(x_j) \sum_{i=1}^{n} P(y_i|x_j) \log_2 P(y_i|x_j) \quad (2)$$

Where $P(x_j)$ is the probability of the j-th value of X, and $P(y_i|x_j)$ is the conditional probability of y_i given x_j.

Information Gain Calculation

Information Gain (IG) is the reduction in energy of the target variable Y after observing the feature X. It measures how much knowing the feature X reduces the uncertainty about the target variable Y. The IG is calculated as:

$$IG(Y, X) = H(Y) - H(Y|X) \quad (3)$$

Feature Selection using Information Gain

The steps involved in selecting features using Information Gain are as follows:

- **Calculate Entropy of the Target Variable:** Compute the entropy $H(Y)$ of the target variable Y using the formula mentioned above.
- **Calculate Conditional Entropy for each feature:** For each feature X_i in the dataset, calculate the conditional entropy $H(Y|X_i)$ of the target variable given the feature.
- **Compute Information Gain for each feature :**For each feature X_i, compute the $IG(Y, X_i)$ using the formula:
  $$IG(Y, X_i) = H(Y) - H(Y|X_i) \quad (4)$$
- **Rank features based on Information Gain:** Rank the features based on their Information Gain values. Features with higher Information Gain are considered more informative and relevant for predicting the target variable.
- **Select Top features:** Select the top k features with the highest IG values as the most relevant features for the model.

RELIEFF BASED FEATURE SELECTION METHOD

The ReliefF algorithm [26] [27] is an extension of the original Relief algorithm and is designed to handle multi-class problems and noisy data. It is a feature weighting method that evaluates the importance of features based on their ability to distinguish between instances that are near each other.

Initialization

Relief F starts by initializing a weight vector W for all features, setting each weight to Zero:

$$W[f_i] = 0 \quad (5)$$

for each feature f_i in the dataset.

Random Sampling

Relief F iteratively samples instances from the dataset. For each iteration, it randomly selects an instance R from the dataset.

Finding Nearest Neighbors

For the selected instance R, Relief F identifies:

- k nearest neighbors from the same class as R (called "nearest hits")
- k nearest neighbors from the same class as R (called "nearest hits")

Updating Feature Weights

Relief F updates the weights of the features based on how well they can distinguish between Rand its nearest hits and misses. The update rule for the weight of a feature f is:

$$W[f] = W[f] - \frac{1}{m}\sum_{i=1}^{k}\left(\frac{|f(R)-f(H_i)|}{k}\right) + \frac{1}{m}\sum_{c\neq class(R)}\left(\frac{P(c)}{1-P(class\ (R))}\sum_{j=1}^{k}\left(\frac{|f(R)-f(M_j^c)|}{k}\right)\right) \quad (6)$$

Where $W[f]$ is the weight of feature f, m is the number of iterations, H_i is the i-th nearest hit, M_j^c is the j-th nearest miss from class c, $P(c)$ is the prior probability of class c, $f(R)$ is the value of feature f for instance R. The update increases the weight of a feature if it helps distinguish between instances of different classes (i.e., if the difference between R and nearest misses is large) and decreases the weight if it does not help distinguish between instances of the same class (i.e., if the difference between R and nearest hits is large).

Iteration

Steps 2-4 are repeated for a predefined number of iterations or until convergence. Each iteration refines the weights, improving the ranking of features based on their ability to discriminate between instances of different classes.

Ranking and Selecting Features

After completing the iterations, the features are ranked based on their final weights. Features with higher weights are considered more important and relevant for the classification task. ReliefF is a powerful feature selection method that evaluates feature importance based on their ability to discriminate between instances of different classes, considering local information around each instance. This method is particularly useful for handling multi-class problems and noisy data, providing a robust way to select relevant features that contribute to accurate and efficient predictive modeling.

WHALE OPTIMIZATION ALGORITHM BASED FEATURE SELECTION METHOD

The Whale Optimization Algorithm (WOA) [28] [29] is a nature-inspired metaheuristic optimization algorithm based on the social hunting behavior of humpback whales, specifically their bubble-net feeding strategy. In feature selection, WOA can be employed to find an optimal subset of features that maximizes the performance of a predictive model. Here's a detailed explanation of how the WOA-based feature selection method works:

Stage 1: Initialization

- **Population Initialization:** Initialize a population of whales (solutions), where each whale represents a potential solution (a subset of features). The size of the population is N, and each whale's position in the search space is represented as a binary vector indicating the presence (1) or absence (0) of features.
- **Fitness Function:** Define a fitness function to evaluate the quality of each solution. This function typically measures the predictive accuracy of a machine learning model using the selected features.

Stage 2: Whale Behavior Modeling

WOA mimics two main behaviors of humpback whales: the encircling prey mechanism and the bubble-net attacking method.

Stage 2.1: Encircling Prey

- Whales perceive the position of the best solution (whale) found so far, updating their positions to move towards this optimal solution.
- Update the position of each whale according to the following equations:

$\bar{D} = |\bar{C}.\bar{X}*(t) - \bar{X}(t)|$ (7)

$\bar{X}(t+1) = \bar{X}*(t) - \bar{A}.\bar{D}$ (8)

Where $\bar{X}*(t)$ is the position vector of the best solution, $\bar{X}(t)$ is the position vector of the current whale, $\bar{A}$ and $\bar{C}$ are coefficient vector calculated as:

$\bar{A} = 2\bar{a}.\bar{r} - \bar{a}$ (9)

$\bar{C} = 2.\bar{r}$ (10)

Where $\bar{a}$ decreases linearly from 2 to 0 over the course of iterations, and $\bar{r}$ is a random vector in [0,1].

Stage 2.2: Bubble – Net Attacking Model

This method includes two strategies: shrinking encircling mechanism and spiral updating position.

- **Shrinking Encircling Mechanism:** This is controlled by $\bar{A}$. When $|\bar{A}| < 1$, the whales move towards the best solution.
- **Spiral Updating Position:** This models the helix-shaped movement of whales around their prey.

$\bar{X}(t+1) = \bar{D}'.e^{bl}.cos(2\pi l) + \bar{X}*(t)$ (11)

Where $\bar{D}' = |\bar{X}*(t) - \bar{X}(t)|$, b is a constant defining the spiral shape, and l is the random number in $[-1,1]$. The probability p is used to switch between the shrinking encircling mechanism and the spiral model. Typically, p = 0.50.

Stage 3: Exploration Phase

To enhance exploration, whales search for prey randomly based on the positions of other whales.When $|\vec{A}| \geq 1$, the whales move towards random positions in the search space, facilitating exploration.

Stage 4: Fitness Evaluation

Evaluate the fitness of each whale (solution) using the defined fitness function. This step assesses how well the selected subset of features performs in terms of model accuracy.

Stage 5: Updating Best Solution

Identify the whale with the best fitness score. Update the best-known position $\bar{X}*(t)$ if a better solution is found.

Stage 6: Iteration

Repeat steps 2-5 for a predefined number of iterations or until convergence criteria are met.

Stage 7:Selection of Optimal Feature Subset

After the iterations, the position vector of the best whale represents the optimal subset of features. Features corresponding to 1s in the binary vector are selected for the final model.

PROPOSED TWICE FILTER OPTIMIZATION BASED FEATURE SELECTION (TTO-FS) METHOD

The proposed hybrid TTO-FS method integrates Information Gain (IG), ReliefF, and Whale Optimization Algorithm (WOA) to identify the most relevant features from high-dimensional datasets. The hybrid method is designed to leverage the strengths of each individual technique, thereby enhancing the overall performance and robustness of the feature election process.

Phase 1: Initial Feature Ranking using IG and ReliefF

Step 1: Information Gain (IG) Calculation

- **Step 1.1: Compute the Entropy of the target variable:** The entropy H(Y) of the target variable Y is calculated to measure its uncertainty using equation (1).



- **Step 1.2: Calculate Conditional Entropy for Each Feature:**For each feature X, the conditional entropy H(Y|X) is computed to measure the remaining uncertainty about Y given X using the equation (2).
- **Step 1.3:Calculate Information Gain for Each Feature:** Information Gain (IG) is calculated for each feature to determine how much information about Y is gained by knowing X using equation (3).
- **Step 1.4: Rank Features Based on Information Gain:** Rank the features from highest to lowest based on their IG values. Higher IG values indicate more relevant features.

Step 2: Relief F Calculation

- **Step 2.1: Initialize Weights for All Features:** Initialize a weight vector W for all features using equation (5).
- **Step 2.2: Random Sampling:**For each iteration, randomly select an instance R from the dataset.
- **Step 2.3: Find Nearest Neighbors:**For the selected instance R, identify k nearest hits (same class as R) and k nearest misses (different classes).
- **Step 2.4: Update Weights:** Update the weight of each feature based on its ability to distinguish between Rand its nearest hits and misses using equation (6).
- **Step 2.5: Rank Features Based on Weights:** Rank the features from highest to lowest based on their weights. Higher weights indicate more relevant features.

Phase 2: Combined Ranking of Features

Step 3: Normalize Rankings

- ***Step 3.1: Normalize IG and ReliefF Rankings:*** Normalize the ranks obtained from IG and ReliefF to a common scale (e.g., 0 to 1) to ensure they are comparable.

Step 4: Aggregate Rankings

- **Step 4.1: Combine the Normalized Ranks:** Aggregate the normalized ranks by averaging or using a weighted sum:

$$Rank_{combined}(f_i) = \alpha . Rank_{IG}(f_i) + (1 - \alpha) . Rank_{ReliefF}(f_i) \quad (12)$$

Where α is a weighting factor (e.g., 0.5)

- **Step 4.2:** Select Top features: Select the top k features based on the combined ranking. This subset of features will be used in the next phase.

Phase 3: Refinement Using Whale Optimization Algorithm (WOA)

Step 5: Initialization

- ***Step 5.1: Population Initialization*:** Initialize a population of whales (solutions), where each whale represents a subset of the top kkk features. Each whale's position is represented by a binary vector indicating the presence (1) or absence (0) of features.
- ***Step 5.2*: Fitness Function:**Define a fitness function to evaluate the quality of each subset. This function typically measures the predictive accuracy of a machine learning model using the selected features. For instance, accuracy, precision, recall, or F1-score can be used as metrics.

Step 6: Whale Behavior Modeling

- **Step 6.1: Encircling the prey**
  - Update position of each whale from equation (7) to equation (10).
- **Step 6.2: Bubble-Net Attacking Method**
  - Shrinking Encircling Mechanism: When $|\vec{A}| \geq 1$whales move towards the best solution.
  - Spiral Updating Position using equation (11).
  - Exploration phase: Random search: When $|\vec{A}| \geq 1$, whales move towards random positions to enhance exploration and avoid local optimal.

Step 7: Fitness Evaluation

- ***Step 7.1: Evaluate Fitness of Each Whale:***Use the fitness function to assess the quality of each subset of features. This involves training a machine learning model with the selected features and measuring its performance.

Step 8: Updating Best Solution

- **Step 8.1: Identify the Best Whale:**Find the whale with the best fitness score in the current population and update the best-known solution$\bar{X} * (t)$if a better solution is found.

Step 9: Iteration

- **Step 9.1: Repeat the Process:**Repeat the optimization process for a predefined number of iterations or until convergence criteria are met. Each iteration refines the selection of features by updating the whales' positions.

Phase 4: Final Selection of Features

Step 10: Select Optimal Feature Subset

- ***Step 10.1: Final Whale Solution:*** After the completion of iterations, the position vector of the best whale represents the optimal subset of features. The selected features correspond to the positions with 1s in the binary vector.

RESULT AND DISCUSSION

Dataset Description

In this research work, the three different clinical datasets are considered to evaluate the performance of the Proposed TTO-FS method. Dermatology [30], Lung Cancer [31] and Hepatitis [32] datasets are considered in this work. Table 1 depicts the number of features in the given considered datasets.

Performance Metrics

Table 2 gives the performance metrics used in this research work, to evaluate the performance of the Proposed TTO-FS methods using Classification techniques, Artificial Neural Network (ANN), Random Forest (RF) and Support Vector Machine (SVM). The performance of the Proposed TTO-FS method is evaluated with the existing feature selection techniques like Information Gain (IG), ReliefF(RFF), Whale Optimization Algorithm (WOA), Artificial Bee Colony Optimization (ABO).

Performance Analysis of the Proposed TTO-FS Method for Dermatology Dataset

Table 1 give the number of features obtained by the Proposed TTO-FS method and existing feature selection methods. From the table 1, it is clear that the proposed TTO-FS method gives less number of features than the existing feature selection methods. Table 2 gives the Classification Accuracy (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques. From the table 3.2, Original Dataset: The baseline accuracies without any feature selection are the lowest across all classifiers, ranging from 43.10% (SVM) to 48.32% (ANN).Proposed TTO-FS: This method significantly outperforms all other feature selection techniques, achieving the highest accuracies for SVM (93.55%), RF (94.86%), and ANN (95.06%).WOA: The second-best performing method with accuraciesof 71.76% (SVM), 72.30% (RF), and 72.87% (ANN).IG: Performs well with accuracies of 69.63% (SVM), 69.97% (RF), and70.84% (ANN), slightly better than RFF and ABC.RFF: Moderate performance with accuracies of 66.54% (SVM), 66.86% (RF), and 68.75% (ANN).ABC: Shows lower accuracies compared to IG and WOA but still better than the original dataset, with 65.46% (SVM), 65.77% (RF), and 67.64% (ANN). Table 3 gives the True Positive Rate (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques. From the table 3.3, Original Dataset: The baseline TPRs without any feature selection are the lowest across all classifiers, ranging from 52.61% (SVM) to 52.94% (RF).Proposed TTO-FS: This method achieves the highest TPRs for SVM (93.35%), RF (94.99%), and ANN (94.97%), significantly outperforming all other feature selection techniques.WOA: The second-best performing method with TPRs of 75.37% (SVM), 76.37% (RF), and 70.54% (ANN).IG: Performs well with TPRs of 76.07% (SVM), 74.59% (RF), and 71.35% (ANN), slightly better than WOA for SVM.RFF: Moderate performance with TPRs of 69.18% (SVM), 67.68% (RF), and 65.45% (ANN).ABC: Shows lower TPRs compared to IG and WOA but still better than the original dataset, with 64.34% (SVM), 66.57% (RF), and 68.29% (ANN). Table 4 gives the False Positive Rate (in %) obtained by the Proposed

and Existing Feature Selection methods using ANN, RF and SVM classification techniques. From the table 3.4, Original Dataset: The baseline FPRs without any feature selection are the highest across all classifiers, ranging from 56.83% (ANN) to 67.17% (SVM).Proposed TTO-FS: This method achieves the lowest FPRs for SVM (6.21%), RF (5.26%), and ANN (4.84%), significantly outperforming all other feature selection techniques.WOA: The second-best performing method with FPRs of 32.18% (SVM), 32.80% (RF), and 24.22% (ANN).IG: Performs well with FPRs of 35.62% (SVM), 34.77% (RF), and 29.73% (ANN), slightly higher than WOA.RFF: Moderate performance with FPRs of 46.53% (SVM), 45.66% (RF), and 40.82% (ANN).ABC: Shows higher FPRs compared to IG and WOA but still lower than the original dataset, with 47.42% (SVM), 46.75% (RF), and 41.71% (ANN). Table 5 gives the Precision (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques. From the table 3.5, Original Dataset: The baseline precision without any feature selection is the lowest across all classifiers, ranging from 45.81% (SVM) to 51.72% (ANN).Proposed TTO-FS: This method achieves the highest precision for SVM (94.30%), RF (95.16%), and ANN (95.50%), significantly outperforming all other feature selection techniques.WOA: The second-best performing method with precision values of 71.97% (SVM), 71.45% (RF), and 78.97% (ANN).IG: Performs well with precision values of 68.79% (SVM), 68.81% (RF), and 73.60% (ANN), slightly lower than WOA.RFF: Moderate performance with precision values of 59.68% (SVM), 59.72% (RF), and 62.51% (ANN).ABC: Shows lower precision compared to IG and WOA but still higher than the original dataset, with 58.57% (SVM), 58.61% (RF), and 61.43% (ANN). Table 6 gives the Miss Rate (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques. From the table 3.6, Original Dataset: The baseline miss rates without any feature selection are the highest across all classifiers, ranging from 47.06% (RF) to 47.39% (SVM).Proposed TTO-FS: This method achieves the lowest miss rates for SVM (6.65%), RF (5.01%), and ANN (5.03%), significantly outperforming all other feature selection techniques.WOA: The second-best performing method with miss rates of 24.63% (SVM), 23.63% (RF), and 29.46% (ANN).IG: Performs well with miss rates of 23.93% (SVM), 25.41% (RF), and 28.65% (ANN), slightly higher than WOA.RFF: Moderate performance with miss rates of 32.82% (SVM), 36.52% (RF), and 39.76% (ANN).ABC: Shows higher miss rates compared to IG and WOA but still lower than the original dataset, with 33.91% (SVM), 37.61% (RF), and 40.85% (ANN). Table 7 gives the Specificity (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques. From the table 3.7, Original Dataset: The baseline specificity without any feature selection is the lowest across all classifiers, ranging from 32.83% (SVM) to 43.17% (ANN).Proposed TTO-FS: This method achieves the highest specificity for SVM (93.79%), RF (94.74%), and ANN (95.16%), significantly outperforming all other feature selection techniques.WOA: The second-best performing method with specificity values of 67.82% (SVM), 67.20% (RF), and 75.78% (ANN).IG: Performs well with specificity values of 64.38% (SVM), 65.23% (RF), and 70.27% (ANN), slightly lower than WOA.RFF: Moderate performance with specificity values of 53.49% (SVM), 54.32% (RF), and 59.38% (ANN).ABC: Shows lower specificity compared to IG and WOA but still higher than the original dataset, with 52.38% (SVM), 53.21% (RF), and 58.24% (ANN).

Performance Analysis of the Proposed TTO-FS Method for Lung Cancer Dataset

Table 8 give the number of features obtained by the Proposed TTO-FS method and existing feature selection methods. From the table 4.1, it is clear that the proposed TTO-FS method gives less number of features than the existing feature selection methods. Table 9 gives the Classification Accuracy (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniquesfor Lung Cancer dataset. From the table 4.2, Original Dataset: The baseline accuracies without any feature selection are the lowest across all classifiers, ranging from 43.97% (SVM) to 48.32% (ANN).Proposed TTO-FS: This method achieves the highest classification accuracies for SVM (93.46%), RF (94.09%), and ANN (94.91%), significantly outperforming all other feature selection techniques.WOA: The second-best performing method with accuracies of 71.67% (SVM), 71.47% (RF), and 72.59%(ANN).IG: Performs well with accuracies of 69.34% (SVM), 70.94% (RF), and 70.84% (ANN), slightly lower than WOA.RFF: Moderate performance with accuracies of 58.43% (SVM), 59.85% (RF), and 59.73% (ANN).ABC: Shows lower accuracies compared to IG and WOA but still higher than the original dataset, with 57.34% (SVM), 58.74% (RF), and 58.64% (ANN). Table 10 gives the True Positive Rate (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Lung Cancer dataset. From the table 4.3, Original Dataset: The baseline TPRs without any feature selection are varied across

classifiers, ranging from 47.68% (RF) to 52.76% (ANN).Proposed TTO-FS: This method achieves the highest TPRs for SVM (92.42%), RF (94.51%), and ANN (95.51%), significantly outperforming all other feature selection techniques.IG: Performs well with TPRs of 73.05% (SVM), 75.50% (RF), and 74.45% (ANN), slightly lower than the proposed TTO-FS method.WOA: Shows strong performance with TPRs of 82.30% (SVM), 74.90% (RF), and 71.19% (ANN).RFF: Moderate performance with TPRs of 62.16% (SVM), 64.41% (RF), and 63.34% (ANN).ABC: Shows lower TPRs compared to IG and WOA but still higher than the original dataset, with 61.27% (SVM), 63.32% (RF), and 62.25% (ANN).

Table 11 gives the False Positive Rate (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Lung Cancer dataset. From the table 4.4, Original Dataset: The baseline FPRs without any feature selection are relatively high across classifiers, ranging from 56.58% (ANN) to 63.80% (SVM).Proposed TTO-FS: This method achieves the lowest FPRs for SVM (5.36%), RF (6.36%), and ANN (5.72%), significantly outperforming all other feature selection techniques.WOA: The second-best performing method with FPRs of 31.91% (SVM), 32.31% (RF), and 25.60% (ANN).IG: Performs well with FPRs of 35.31% (SVM), 33.75% (RF), and 32.87% (ANN), slightly higher than WOA.RFF: Moderate performance with FPRs of 44.42% (SVM), 42.84% (RF), and 43.78% (ANN).ABC: Shows higher FPRs compared to IG and WOA but still lower than the original dataset, with 45.53% (SVM), 43.75% (RF), and 44.69% (ANN). Table 12 gives the Precision (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Lung Cancer dataset. From the table 4.5, Original Dataset: The baseline precision without any feature selection varies across classifiers, ranging from 46.11% (SVM) to 52.34% (RF).Proposed TTO-FS: This method achieves the highest precision for SVM (95.11%), RF (94.16%), and ANN (94.17%), significantly outperforming all other feature selection techniques.WOA: The second-best performing method with precision values of 72.76% (SVM), 71.92% (RF), and 78.18% (ANN).IG: Performs well with precision values of 69.21% (SVM), 69.77% (RF), and 70.04% (ANN), slightly lower than WOA.RFF: Moderate performance with precision values of 58.32% (SVM), 58.68% (RF), and 61.13% (ANN).ABC: Shows lower precision compared to IG and WOA but still higher than the original dataset, with 57.43% (SVM), 57.79% (RF), and 60.24% (ANN). Table 13 gives the Miss Rate (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniquesfor Lung Cancer dataset. From the table 4.6,Original Dataset: The baseline miss rates without any feature selection are varied across classifiers, ranging from 47.24% (ANN) to 52.32% (RF).Proposed TTO-FS: This method achieves the lowest miss rates for SVM (7.58%), RF (5.49%), and ANN (4.49%), significantly outperforming all other feature selection techniques.WOA: The second-best performing method with miss rates of 17.70% (SVM), 25.10% (RF), and 28.81% (ANN).IG: Performs well with miss rates of 29.65% (SVM), 24.50% (RF), and 25.55% (ANN), slightly higher than TTO-FS.RFF: Moderate performance with miss rates of 38.54% (SVM), 35.56% (RF), and 36.67% (ANN).ABC: Shows higher miss rates compared to IG and WOA but still lower than the original dataset, with 39.45% (SVM), 36.67% (RF), and 37.78% (ANN). Table 14 gives the Specificity (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Lung Cancer dataset. From the table 4.7, Original Dataset: The baseline specificities without any feature selection are relatively low across classifiers, ranging from 36.20% (SVM) to 43.42% (ANN).Proposed TTO-FS: This method achieves the highest specificities for SVM (94.64%), RF (93.64%), and ANN (94.28%), significantly outperforming all other feature selection techniques.WOA: The second-best performing method with specificities of 68.09% (SVM), 67.69% (RF), and 74.40% (ANN).Information Gain (IG): Performs well with specificities of 64.91% (SVM), 66.25% (RF), and 67.13% (ANN), slightly lower than TTO-FS.RFF: Moderate performance with specificities of 55.82% (SVM), 55.34% (RF), and 56.24% (ANN).ABC: Shows lower specificities compared to IG and WOA but still higher than the original dataset, with 54.71% (SVM), 54.45% (RF), and 55.35% (ANN).

Performance Analysis of the Proposed TTO-FS Method for Hepatitis Dataset

Table 15 give the number of features obtained by the Proposed TTO-FS method and existing feature selection methods. From the table 5.1, it is clear that the proposed TTO-FS method gives less number of features than the existing feature selection methods. Table 16 gives the Classification Accuracy (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Hepatitis dataset. From the

table 5.2, Original Dataset: The baseline accuracies without any feature selection are varied across classifiers, ranging from 44.93% (SVM) to 50.16% (ANN).Proposed TTO-FS: This method achieves the highest classification accuracies for SVM (95.15%), RF (95.85%), and ANN (95.15%), significantly outperforming all other feature selection techniques.WOA: Shows strong performance with accuracies of 74.04% (SVM and ANN) and 72.20% (RF).IG: Performs well with accuracies of 68.81% (SVM), 67.11% (RF), and 66.19% (ANN), slightly lower than the proposed TTO-FS method.RFF: Moderate performance with accuracies of 57.92% (SVM), 58.22% (RF), and 55.28% (ANN).ABC: Shows lower accuracies compared to IG and WOA but still higher than the original dataset, with 56.81% (SVM), 57.32% (RF), and 54.19% (ANN). Table 17 gives the True Positive Rate (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Hepatitis dataset. From the table 5.3, Original Dataset: The baseline true positive rates without any feature selection vary across classifiers, ranging from 49.44% (RF) to 55.11% (SVM).Proposed TTO-FS: This method achieves the highest true positive rates for SVM (96.53%), RF (96.90%), and ANN (95.02%), significantly outperforming all other feature selection techniques.WOA: Shows strong performance with true positive rates of 84.55% (SVM), 80.57% (RF), and 81.74% (ANN).IG: Performs well with true positive rates of 67.35% (SVM), 69.42% (RF), and 70.57% (ANN), slightly lower than the proposed TTO-FS method.RFF: Moderate performance with true positive rates of 56.43% (SVM), 58.31% (RF), and 60.46% (ANN).ABC: Shows lower true positive rates compared to IG and WOA but still higher than the original dataset, with 55.65% (SVM), 57.53% (RF), and 59.68% (ANN).

Table 18 gives the False Positive Rate (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Hepatitis dataset. From the table 5.4, Original Dataset: The baseline false positive rates without any feature selection vary significantly across classifiers, ranging from 54.40% (ANN) to 64.74% (SVM).Proposed TTO-FS: This method achieves the lowest false positive rates for SVM (6.32%), RF (5.305%), and ANN (4.704%), significantly outperforming all other feature selection techniques.WOA: Shows strong performance with false positive rates of 35.76% (SVM), 36.21% (RF), and 34.56% (ANN).IG: Performs well with false positive rates of 28.79% (SVM), 35.32% (RF), and 38.08% (ANN), notably higher than TTO-FS.RFF: Moderate performance with false positive rates of 37.88% (SVM), 36.43% (RF), and 39.19% (ANN).ABC: Shows slightly higher false positive rates compared to WOA but generally lower than the original dataset, with 38.06% (SVM), 37.65% (RF), and 40.32% (ANN). Table 19 gives the Precision (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Hepatitis dataset. Original Dataset: The baseline precisions without any feature selection are varied across classifiers, ranging from 44.75% (SVM) to 52.80% (RF).Proposed TTO-FS: This method achieves the highest precision scores for SVM (94.24%), RF (95.11%), and ANN (95.56%), significantly outperforming all other feature selection techniques.WOA: Shows strong performance with precision scores of 68.81% (SVM), 69.09% (RF), and 72.55% (ANN).IG: Performs well with precision scores of 74.80% (SVM), 67.58% (RF), and 64.97% (ANN), slightly lower than the proposed TTO-FS method.RFF: Moderate performance with precision scores of 63.91% (SVM), 57.47% (RF), and 53.86% (ANN).ABC: Shows lower precision scores compared to IG and WOA but still higher than the original dataset, with 61.13% (SVM), 56.69% (RF), and 52.08% (ANN). Table 20 gives the Miss Rate (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniquesfor Hepatitis dataset. From the table 5.6, Original Dataset: The baseline miss rates without any feature selection vary across classifiers, ranging from 44.89% (SVM) to 50.56% (RF).Proposed TTO-FS: This method achieves the lowest miss rates for SVM (3.47%), RF (3.10%), and ANN (4.98%), significantly outperforming all other feature selection techniques.WOA: Shows strong performance with miss rates of 15.45% (SVM), 19.43% (RF), and 18.26% (ANN).IG: Performs well with miss rates of 32.65% (SVM), 30.58% (RF), and 29.43% (ANN), notably higher than the proposed TTO-FS method.RFF: Moderate performance with miss rates of 41.57% (SVM), 41.69% (RF), and 39.42% (ANN).ABC: Shows higher miss rates compared to IG and WOA but generally lower than the original dataset, with 42.79% (SVM), 42.81% (RF), and 40.64% (ANN). Table 21 gives the Specificity (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Hepatitis dataset. From the table 5.7, Original Dataset: The baseline specificity scores without any feature selection are varied across classifiers, ranging from 35.26% (SVM) to 45.6% (ANN).Proposed TTO-FS: This method achieves the highest specificity scores for SVM (93.68%), RF (94.70%), and ANN (95.29%), significantly outperforming all other feature selection techniques.WOA: Shows strong performance with specificity

scores of 64.24% (SVM), 63.79% (RF), and 65.44% (ANN).IG: Performs well with specificity scores of 71.21% (SVM), 64.68% (RF), and 61.92% (ANN), higher than the proposed TTO-FS method.RFF: Moderate performance with specificity scores of 60.12% (SVM), 55.79% (RF), and 50.81% (ANN).ABC: Shows lower specificity scores compared to IG and WOA but generally higher than the original dataset, with 59.35% (SVM), 56.91% (RF), and 49.05% (ANN).

CONCLUSION

The proposed hybrid feature selection method, which combines Information Gain (IG), ReliefF, and Whale Optimization Algorithm (WOA), represents a robust approach to address the challenges posed by high-dimensional datasets in various domains, including clinical research.By integrating Information Gain and ReliefF, the method effectively identifies features that provide the most relevant information for predicting the target variable. Information Gain assesses the individual predictive power of each feature based on its ability to reduce uncertainty about the target variable, while ReliefF evaluates features based on their ability to distinguish between instances of different classes, thus capturing complementary aspects of feature relevance. The inclusion of Whale Optimization Algorithm (WOA) enhances the feature selection process by optimizing the subset of features identified by Information Gain and ReliefF. WOA simulates the social behavior of humpback whales, enabling efficient exploration of the feature space to find subsets that maximize the performance metrics defined by the fitness function.The hybridization of IG, ReliefF, and WOA leverages their respective strengths in feature evaluation and optimization. Information Gain and ReliefF provide a solid foundation for initial feature ranking and selection, while WOA further refines this selection by iteratively improving the subset of features based on the defined fitness criteria. From the results obtained, it is clear that the proposed TTO-FS method with ANN performs better for the considered three clinical datasets.

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Table 1: Number of features in the considered datasets

Name of the Dataset	Number of Features present
Dermatology	35
Lung cancer	57
Hepatitis	20

Table 2: Performance Metrics

Metrics	Equation
Accuracy	$\frac{TP + TN}{TP + FN + TN + FP}$
True Positive Rate (TPR) (Sensitivity or Recall)	$\frac{TP}{TP + FN}$
False Positive Rate (FPR)	$\frac{FP}{FP + TN}$
Precision	$\frac{TP}{TP + FP}$
Specificity	1- False Positive Rate (FPR)
Miss Rate	1-True Positive Rate (TPR)
False Discovery Rate	1- Precision

Table 3: Number of Features obtained by the Proposed and Existing Feature Selection methods for Dermatology Dataset

Feature Selection Techniques	Number of Features present
Original Dataset	35
Information Gain	28
ReliefF	27
Artificial Bee Colony	34
Whale Optimization Algorithm	29
Proposed TTO-FS Method	22

Table 4: Classification Accuracy (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Dermatology dataset

Feature selection Methods	Classification Accuracy (in %)		
	SVM	RF	ANN
Original Dataset	43.099	46.44	48.32
IG	69.63	69.97	70.84
RFF	66.54	66.86	68.75
ABC	65.46	65.77	67.64
WOA	71.76	72.30	72.87
Proposed TTO-FS	93.55	94.86	95.06

Table 5: True Positive Rate (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Dermatology dataset

Feature selection Methods	True Positive Rate (in %)		
	SVM	RF	ANN
Original Dataset	52.61	52.94	52.80
IG	76.07	74.59	71.35
RFF	69.18	67.68	65.45
ABC	64.34	66.57	68.29
WOA	75.37	76.37	70.54
Proposed TTO-FS	93.35	94.99	94.97

Table 6: False Positive Rate (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniquesfor Dermatology dataset

Feature selection Methods	False Positive Rate (in %)		
	SVM	RF	ANN
Original Dataset	67.17	61.08	56.83
IG	35.62	34.77	29.73
RFF	46.53	45.66	40.82
ABC	47.42	46.75	41.71
WOA	32.18	32.8	24.22
Proposed TTO-FS	6.21	5.26	4.84

Table 7: Precision (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Dermatology dataset

Feature selection Methods	Precision (in %)		
	SVM	RF	ANN
Original Dataset	45.81	49.01	51.72
IG	68.79	68.81	73.60
RFF	59.68	59.72	62.51
ABC	58.57	58.61	61.43
WOA	71.97	71.45	78.97
Proposed TTO-FS	94.30	95.16	95.50

Table 8: Miss Rate (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Dermatology dataset

Feature selection Methods	Miss Rate (in %)		
	SVM	RF	ANN
Original Dataset	47.39	47.06	47.2
IG	23.93	25.41	28.65
RFF	32.82	36.52	39.76
ABC	33.91	37.61	40.85
WOA	24.63	23.63	29.46
Proposed TTO-FS	6.65	5.01	5.03

Table 9: Specificity (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Dermatology dataset

Feature selection Methods	Specificity(in %)		
	SVM	RF	ANN
Original Dataset	32.83	38.92	43.17
IG	64.38	65.23	70.27
RFF	53.49	54.32	59.38
ABC	52.38	53.21	58.24
WOA	67.82	67.2	75.78
Proposed TTO-FS	93.79	94.74	95.16

Table 10: Number of Features obtained by the Proposed and Existing Feature Selection methods for Lung Cancer Dataset

Feature Selection Techniques	Number of Features present
Original Dataset	57
Information Gain	48
ReliefF	46
Artificial Bee Colony	51
Whale Optimization Algorithm	45
Proposed TTO-FS Method	41

Table 11: Classification Accuracy (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Lung Cancer dataset

Feature selection Methods	Classification Accuracy (in %)		
	SVM	RF	ANN
Original Dataset	43.97	44.98	**48.32**
IG	69.34	70.94	**70.84**
RFF	58.43	59.85	**59.73**
ABC	57.34	58.74	**58.64**
WOA	71.67	71.47	**72.59**
Proposed TTO-FS	93.46	94.09	**94.91**

Table 12: True Positive Rate (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Lung Cancer dataset

Feature selection Methods	True Positive Rate (in %)		
	SVM	RF	ANN
Original Dataset	51.26	47.68	**52.76**
IG	73.05	75.50	**74.45**
RFF	62.16	64.41	**63.34**
ABC	61.27	63.32	**62.25**
WOA	**82.3**	74.90	71.19
Proposed TTO-FS	92.42	94.51	**95.51**

Table 13: False Positive Rate (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Lung Cancer dataset

Feature selection Methods	False Positive Rate (in %)		
	SVM	RF	ANN
Original Dataset	63.8	57.67	**56.58**
IG	35.31	33.75	**32.87**
RFF	44.42	42.84	**43.78**
ABC	45.53	43.75	**44.69**
WOA	31.91	32.31	**25.60**
Proposed TTO-FS	**5.36**	6.36	5.72

Table 14: Precision (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniquesf or Lung Cancer dataset

Feature selection Methods	Precision (in %)		
	SVM	RF	ANN
Original Dataset	46.11	**52.34**	50.84
IG	69.21	69.77	**70.04**
RFF	58.32	58.68	**61.13**
ABC	57.43	57.79	**60.24**
WOA	72.76	71.92	**78.18**
Proposed TTO-FS	**95.11**	94.16	94.17

Table 15: Miss Rate (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Lung Cancer dataset

Feature selection Methods	Miss Rate (in %)		
	SVM	RF	ANN
Original Dataset	48.74	52.32	**47.24**
IG	**29.65**	24.5	25.55
RFF	**38.54**	35.56	36.67
ABC	**39.45**	36.67	**37.78**
WOA	**17.7**	25.1	28.81
Proposed TTO-FS	7.58	5.49	**4.49**

Table 16: Specificity (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Lung Cancer dataset

Feature selection Methods	Specificity(in %)		
	SVM	RF	ANN
Original Dataset	36.2	42.33	**43.42**
IG	64.91	66.25	**67.13**
RFF	55.82	55.34	**56.24**
ABC	54.71	54.45	**55.35**
WOA	68.09	67.69	**74.4**
Proposed TTO-FS	**94.64**	93.64	94.28

Table 17: Number of Features obtained by the Proposed and Existing Feature Selection methods for Hepatitis Dataset

Feature Selection Techniques	Number of Features present
Original Dataset	20
Information Gain	14
ReliefF	15
Artificial Bee Colony	18
Whale Optimization Algorithm	14
Proposed TTO-FS Method	12

Table 18: Classification Accuracy (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Hepatitis dataset

Feature selection Methods	Classification Accuracy (in %)		
	SVM	RF	ANN
Original Dataset	44.93	45.81	**50.16**
IG	68.81	67.11	66.19
RFF	**57.92**	58.22	55.28
ABC	**56.81**	57.32	54.19
WOA	74.04	72.20	74.04
Proposed TTO-FS	95.15	95.85	**95.15**

Table 19: True Positive Rate (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Hepatitis dataset

Feature selection Methods	True Positive Rate (in %)		
	SVM	RF	ANN
Original Dataset	**55.11**	49.44	54.26
IG	67.35	69.42	70.57
RFF	56.43	58.31	**60.46**
ABC	55.65	57.53	**59.68**
WOA	84.55	80.57	81.74
Proposed TTO-FS	96.53	**96.90**	95.02

Table 20: False Positive Rate (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Hepatitis dataset

Feature selection Methods	False Positive Rate (in %)		
	SVM	RF	ANN
Original Dataset	64.74	59.04	**54.40**
IG	28.79	35.32	38.08
RFF	**37.88**	36.43	39.19
ABC	**38.06**	37.65	40.32
WOA	35.76	36.21	34.56
Proposed TTO-FS	6.32	5.305	**4.704**

Table 21: Precision (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Hepatitis dataset

Feature selection Methods	Precision (in %)		
	SVM	RF	ANN
Original Dataset	44.75	**52.80**	52.67
IG	74.80	67.58	64.97
RFF	**63.91**	57.47	53.86
ABC	**61.13**	56.69	52.08
WOA	68.81	69.09	72.55
Proposed TTO-FS	94.24	95.11	**95.56**

Table 22: Miss Rate (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniquesfor Hepatitis dataset

Feature selection Methods	Miss Rate (in %)		
	SVM	RF	ANN
Original Dataset	**44.89**	50.56	45.74
IG	32.65	30.58	29.43
RFF	41.57	41.69	**39.42**
ABC	42.79	42.81	**40.64**
WOA	15.45	19.43	18.26
Proposed TTO-FS	3.47	**3.10**	4.98

Table 23: Specificity (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Hepatitis dataset

Feature selection Methods	Specificity(in %)		
	SVM	RF	ANN
Original Dataset	35.26	40.96	**45.6**
IG	71.21	64.68	61.92
RFF	**60.12**	55.79	50.81
ABC	**59.35**	56.91	49.05
WOA	64.24	63.79	65.44
Proposed TTO-FS	93.68	94.70	**95.29**

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RESEARCH ARTICLE

Analysis of Time-Based Public Transport Demand Prediction Using OPTUNA Framework

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ABSTRACT

Buses are the most popular and easy mode of transportation in all over the world. The state government operates bus service in all routes with low-cost fare. Traffic congestion has risen at an alarming rate due to an increase in the number of automobiles. Travel time have increased as a result, while accessibility and mobility have worsened. The primary challenge encountered by passengers is the absence of information regarding bus numbers that are accessible on a certain route and the approximate time of bus departure. The delay in bus operations, could have several reasons which are inclement weather, traffic jam, and breakdowns. Neither the arrival time of the bus nor the delay are known to the people waiting at the bus stop. In order to address this problem, encouraging the usage of public transportation seems to be a feasible way. Over the past ten years, prediction of bus arrival time has become a fascinating subject around the world. In the transportation sector, Machine Learning (ML) technologies have already shown great promise and have additionally shown to yield a larger return on investment than traditional methods. In this research work , authors propose and develop predictive models to predict public transport demand for passenger transit based on bus arrival time. The dataset shows the proportion of buses operated by the Rochester-Genesee Regional Transportation Authority (RGRTA) that arrive on time. Initially, lazy predict classifier is used for solving regression-based dataset for predicting the bus demand in On-time based passenger transit. Based on the examination of lazy classifiers, the Decision Tree Regressor (DTR) has been identified as the best model. It is assessed using the most advanced hyperparameter optimization framework (OPTUNA). The proposed OPTUNA based DTR which is utilized to identify On-time performance of bus services-based passenger transit. Using OPTUNA for

search is an efficient and beneficial approach considering the search speed and the improvement in model accuracy. According to the experimental data, the proposed approach performs better where the R-squared score is 0.9878 with best hyperparameter to be optimized.

Keywords: Buses, public transport, prediction, demand, hyperparameter, optimization, OPTUNA, Lazy Predict

INTRODUCTION

Traffic congestion has become a worldwide phenomenon and has grown at a rapid pace in recent years. The increase in population growth, motorization and urbanisation are blamed for this spike. Congestion damages the transportation network, lengthens travel time, emits more emissions and fuel also decreases travelling and easy access. Building more roads, highways, separate lanes, and other transportation infrastructure can help to mitigate this problem by increasing its capacity. Due to its own drawbacks, this option is not practical. Despite being the most popular mode of transportation, travellers are unaware of details like arrival time, precise routes, and buses that are available along the way. It is expected of passengers to remain immobile for an endless period of time without being informed regarding the bus where the people are waiting for or any other information about it. The challenging task for managing bus services are due to lack of information about route, location and traffic. In order to tackle the issues encountered by policy makers and bus managers, Intelligent Transportation System (ITS) has been suggested [1]. Without building new infrastructure, the goal of these transport services and technologies is to improve the effectiveness, safety, dependability, and environmental sustainability of existing transport networks. Promoting public transport to make it more desirable than private vehicles is a key component of ITS. From the viewpoint of the passenger, one of the most crucial markers of a dependable and appealing bus service is the provision of accurate journey and schedules for arrival [2]. A new age in transportation engineering and quality control has been brought about by the integration of growing technologies in public transportation, such as real-time tracking systems and new automatic data collecting. The challenge at hand is carrying out an extensive investigation to comprehend and measure the impact of punctuality on bus passengers. On-time performance refers to the ability of bus services to adhere to their published schedules, arriving and departing from stops as planned.

In the transportation sector, ML technologies have already shown great promise and have even shown to yield a larger return on investment than traditional methods. Still, there is room for improvement in the use and exploitation of ML techniques in transportation-related problems. The fundamental objectives of these solutions are to lessen traffic, enhance security and reduce human mistake, limit adverse environmental effects, optimum energy efficiency, and raise surface transportation productivity and efficiency. In feature engineering, data analytics can be enhanced by the capability of ML models and it transforms the unstructured data into features so that important information in the data can be highlighted. The prediction power of computational approaches can be increased while streamlining and accelerating data transformations by feature engineering to choose pertinent features or create unique features for both supervised and unsupervised learning. ML-based model might help bridge the gap between passengers and transport service. This research work has suggested a Lazy Predict (LP) model, which is simple and straightforward for anyone who is familiar with scikit-learn. In this study to provide prediction for create a Lazy Classifier (LC) instance which will get predictions from all of the models for each and every observation. The framework must fit the data for each model, then use metrics to determine which model has the highest accuracy for the current dataset, and finally pick the optimal model. The effectiveness of any classification algorithm is largely dependent on its ideal hyperparameters [3, 4]. The best set of hyperparameters can be chosen to increase the classification algorithm's accuracy.

To determine the ideal hyperparameter values for the ML model, an advanced hyperparameter optimisation framework (OPTUNA) [5] was used in this investigation. As a result, among the available hyperparameters, the best

appropriate set was chosen for this investigation. There are several ways to achieve hyperparametric optimisation, including grid and random searches. The OPTUNA hyperparametric search is an additional technique. Conventional random and grid search methods waste a lot of time and are inefficient since they do not learn from the previous optimisation, which is mostly dependent on the amount of hyperparameters in the ML.As needed, the OPTUNA framework modifies the hyperparameters based on ongoing learning from prior optimisations. Consequently, OPTUNA was selected for hyperparameter optimisation in the present research.

The following is a list of this manuscript's primary contributions.

- First, the percentage of buses that depart from their starting point or reach their destination is included in a data collecting module that gathers information on on-time performance.
- To acquire data from open-source data repository and pre-process it using python libraries.
- To build ML models for the classification problem, and train them with the pre-processed dataset.
- To evaluate ML models based on various accuracy metrics to get the best fit model using LP classifier.
- To optimize the hyperparameters using optimization techniques/algorithms to fine tune the model.
- To compare the chosen models and finalize on the robust classification model to accurately predict the demand of bus required for a given period of time based on passenger transit.

LITERATURE REVIEW

A real-time bus management system that considers a variety of aspects, such as traffic congestion and the environment, is described by Shanthi *et al.* [6]. Passengers receive notification of the estimated bus arrival time at their endpoint through an HCI-based website and a mobile app. There are few factors such as weather and the flow of traffic in the bus's present location are utilised for the ETA prediction employing the Support Vector Regression technique. When tested, the model displayed an RMSE of 27 seconds. The goal of the Hossein Moosavi *et al.* [7] describes to identify the optimal tree-based ML algorithm and route creation approach for bus journey time prediction for high- and a low-frequency bus route. Furthermore, the precise, dependable, and useful "key stop-based" route creation method was first presented in this study. In the work by Faruk Serin *et al.* [8] discusses bus arrival time was predicted using ML techniques with a three-layer architecture. The data used in the case study came from Istanbul's public transport system, and it was processed using both classic and three-layer architecture to apply a variety of ML techniques. According to the experimental findings, the three-layer architecture produced effective outcomes with a MAPE of roughly 2.552. A model to simulate the actions of buses and forecast their delays is attempted to be built, as described by Palys *et al.* [9].

Shrivathsa *et al* [10] predicting travel time of bus from historical data is proposed using Artificial Neural Network (ANN). By analysing the data, calculate the time taken to reach the destination for every trip and every day. A new ANN method proves that, it is accurate and speed to predict the travel time. The public transportation system's success or failure is largely dependent on its dependability. The predicting issue for transport travel systems was proposed by Dan Luo, Dong Zhao, *et al.* [11] discusses about bus transit system and passenger flow prediction using Deep Learning (DL). The real-time application proposed by Nagaraj *et al.* [12] aids in the detection of traveller movement at a separate site.Several elements in the dataset are taken into account for forecasting, including bus type, bus id, source, destination, number of passengers, slot number and income. After the parameters are processed and the clustered data is divided into regions and sent to the deep learning model for prediction. Next, the clustered data is moved to a Long Short-Term Memory (LSTM) model, which eliminates redundant data from the obtained data. Predicting bus passengers is made more accurate by these systems. To improve the precision of forecasting the demand for bike sharing, Yang *et al.* [13] discusses the several parameters where the suggested model has the potential to significantly increase forecast accuracy. Additionally, this paper examines the impact of various parameters on the predictions made by the model at different times. Bidirectional LSTM (Bi-LSTM) networks were employed by Collini *et al.* [14] to calculate the quantity of bikes and open bike slots at bike-sharing stations. Mehdizadeh Dastjerdi and Morency initially identified six communities in the bike-sharing network, and then this

paper discusses about CNN-LSTM for predicting the demand for pickups in each neighbourhood [15]. The flow of passenger anticipating based on the UBTS was examined by Archana *et al.* [16].Here, UBTS concerns are discussed, including prediction of delays, driver conduct, passenger flow, passenger comfort perception fleet size, vehicle failures and sound level. The strategies and solutions for urban transport have offered to address these problems are evaluated.In order to retain a respectable level of service across the whole bus network, Xubin Zhai and Yu Shen [17] discusses low-demand bus services are less likely to be disrupted by real-time cross-line bus dispatching that utilizes scarce vehicle resources, where the proposed model achieves 5% MAPE. The bus-passenger-flow data has erratic features, which Yulong Pei [18] addresses by WPD to break them down into smoother components. The Bi-LSTM model improves the model's capacity for analysing the passenger flow pattern due to the periodicity and nonlinearity of the passenger-flow data. A model for predicting traffic flow based on sparse regression was presented by Zheng *et al.* [19]. Extreme gradient boosting (XGBoost), was employed by Sun *et al.* [20] and Lu *et al.* [21] to predict the level of traffic on the highway. A DL model was developed by Chen *et al.* [22] for prediction of traffic flow in metropolitan road networks.

Dataset Description

Based on passenger travel, this statistic determines the proportion of RGRTA buses that arrive on time. The percentage of buses that depart from their starting point or reach their destination between 2:59 and 5:59 minutes early is known as the on-time performance. This dataset includes subsidiary, month, year, percent On-time and ridership. The total number of passengers, riders, or boardings is referred to as ridership. It contains a total of 1178 records, and it has 5 attributes described in figure 1.

Data Pre Processing

Along with data collection, a missing value check is performed, and the result is an imputed missing value. The dataset can be transformed to float values because the data cannot be strings. After missing imputation, the data is pre-processed using Robust scaler and label encoder to handle scaling the all-variable unit as unique. Scikit-Learn offers the Label Encoder class for this reason, which allows you to convert all string values to float values. It provides a unique numerical value for every category in a variable, making it easier for ML algorithms to examine and comprehend the data. After removing the median, RobustScaler scales the data using the quantile range. Figure 2 displays the pre-processed data. As a consequence, as shown in Figure 3, a heatmap is constructed utilizing a few data points from the dataset.

RESEARCH METHODOLOGY

The performance of predictive support through data analysis and assist in providing prediction status to the user by proposed method which focus in identifying the best feature fits related to transportation demand. However, one critical factor that significantly influences the attractiveness of bus services to passengers is their on-time performance. The challenge at hand is carrying out an extensive investigation to comprehend and measure the impact of reliability on bus riders. This research work proposed OPTUNA framework has cogitates the best methodical approach due to it tuning parameters like learning rate, loss functions, etc. The Python language is used to develop and train this mode with the help of several libraries, including Matplotlib, NumPy, Scikit-Learn, and Pandas. After being cleaned, the real-time database's data is exported as a CSV file. The functions needed to carry out the hyperparameter optimizations are provided using Scikit-Learn module. The overall proposed model is as shown in figure.4

This study employs an ML classifier model that is created by grouping different classifiers into a single supervised LP library. The dataset is split in term of models and predictions with respect to train dataset and test dataset. The classification models are made to be evaluated using LP supervised LazyRegressor library. LC provides a convenient and efficient way to fit and evaluate multiple ML models, simplifying the model selection process and allowing to focus on building the best model for our data. LP aids in the development of multiple, distinct, fundamental

ML models using specific code and helps identify which models may perform more accurately avoiding the need for parameter tuning. In this study, regression-based datasets are solved using a lazy regressor in classifying the problem with better prediction of demand in bus transportation required for a given period of time from dataset. In order to employing the best readily accessible ML model, the LP classifier can be optimized for accuracy. This can be achieved by optimizing the top model's hyperparameters, as suggested by the OPTUNA hyperparameter tuning. This research work DecisionTree (DT) Regressor, LGBMRegressor and KNeighbors(KN)Regressor has chosen the best fit model to predict the On-time performance of bus services. Further, this DT regressor of untuned model has chosen best fit models based on predicted value which can be improved using OPTUNA framework.

In ML, hyperparameter optimization is a crucial stage. OPTUNA was used in this proposed work to improve the untuned DTR model. This research work uses a unique define-by-run style that makes it relatively easy for users to adjust the ML algorithms of hyperparameters. According to OPTUNA, optimizing hyperparameters involves minimizing or maximizing an objective function that receives a collection of hyperparameters as input and outputs the function score. Without relying on externally supplied static constants, this function dynamically creates the search space of neural network architecture based on the number of layers and hidden units. A trial object is a special OPTUNA trace object that looks for the ideal value based on the hyperparameter's name and range. Through interaction with a trial object, OPTUNA gradually constructs the target function and, when the target function is being executed, uses the trial object to dynamically develop the search area. There are two types of sampling methods in OPTUNA: independent sampling and relational sampling. The correlations between parameters are exploited by relational sampling. The relationships between the parameters were not taken into consideration by independent sampling. Depending on the work and surroundings, both relational and independent sampling can be cost-effective.

The proposed work describes untuned lazy predict DT regressor model were optimized and the loss function is improved.The OPTUNA framework was utilized to improve the hyperparameters, and the primary loss function was utilized as the enhanced loss function. This research work, hyperparameter tuning of certain parameters are used to get the best hyperparameter model. The 13 hyperparameters, including ccp_alpha, min_impurity_decrease, criterion, max_leaf_nodes, min_weight_fraction_leaf, max_depth, max_features, min_samples_leaf, presort, min_samples_split, random_state, min_impurity_split and splitter were chosen for parameter optimization to get best hyperparameter. Although these 13 hyperparameters were chosen for optimization using OPTUNA as shown in table.1.

The hyperparameters are described as follows:
ccp_alpha is at each stage of the pruning procedure, the cost difficulty pruning route which yields the real alphas and the related total leaf impurity. More of the tree is trimmed as alpha rises, growing the overall impurity of the leaves.
Criterion is a function that assesses a split's quality.
max_depth is the most levels that can be in each tree.
max_features is the most features that are taken into account while dividing a node.
min_samples_leaf represents samples that must be sorted at least once into a tree leaf.
min_samples_split represents minimum number of samples required in a node for node splitting to occur.
max_leaf_nodes represent hyperparameter controls the growth of the tree by imposing a condition on the node splitting.
min_impurity_decrease represents if splitting the node results in an impurity decrease higher than or equal to this value, the node will be divided.
min_weight_fraction_leaf is the percentage of input samples arrives in leaf node this addresses the issue of class imbalance. When presort is enabled, the problem will first be sorted and then permuted.
random_state is the component in charge of randomization during division. It may be an instance of RandomState or an int. The default value is None.

RESULTS AND DISCUSSION

In this study, Jupiter IDE and Google Colab are used to help produce and distribute documents that can be explained using text, live code, and visualizations. After collection, the dataset is divided into 70% train and 30% test. In addition, the tunability hyperparameter made use of Seaborn, Sklearn and Pandas. All kind of regression techniques have been implemented by the given specified tools which assist in identifying the efficient untuned regression technique in prediction. In this research DT regressor, LGBM regressor and KN regressor is identified top three model are taken into consideration with an untuned model. Using 25% of the dataset, the accuracy of the trained model is evaluated. Regressions, in contrast to classification issues, yield a numeric value within a range rather than absolute binary values. An algorithm's errors can be measured using a variety of metrics.

Mean Squared Error (MSE): The average of the discrepancies between the actual and anticipated values. The outcome is never going to be negative. Better outcomes are those that are nearer zero.

$$\text{MSE} = \frac{\sum_{i=1}^{n} (at_i - pt_i)^2}{n}$$

Here at_i represents actual time pt_i represents predicted time, n represents number of predictions

Root Mean Square Error (RMSE): This formula calculates the total average magnitude of the error using a quadratic formula. In order to compute it, one must first add up all of the actual and anticipated values difference, squaring the difference value, divide the total by the number of predictions, and then take the square root of the result. The outcome is certain to be positive because the values are rooted and squared. The measured formula is given as

$$\text{RMSE} = \sqrt{\frac{\sum_{i=1}^{n} (at_i - pt_i)^2}{n}}$$

The MSE and RMSE methods are used to assess the accuracy of this trained prediction model.

R-Squared score: It explains how well the model performs. It explains the variance in the response or target variable that the data model's independent variables predict.
R square has a value in the interval [0,1].

$$R^2 = 1 - \frac{SS_{res}}{SS_{tot}}$$

SS_{res} represents the total squares of the data model's residual errors.
SS_{tot} represents the total sum of the errors.

Table 2 displays the outcomes that the models generated. The DT, LGBM, and KN regressor models were shown as graphs with actual values compared to expected values. The graph's linearity indicates how accurate the prediction was. The model is therefore 100% accurate if line y = x the graph is as linear. A scatter plot is the true by projected plot. For the ordinate, the experiential response (Y) is utilised. Another way to visually assess the likelihood of "lack of fit" is via the plot. An impartial prediction to yield anticipated values that, on average, correspond with the observed values. Figure.5, 6 and 7 show the predicted value versus true value plot for DT, LGBM and KN regressor model.

While the points in other models were a little more dispersed, the model with the DTR algorithm gives results from all the scattered point graphs of predicted values against true values that closely resemble the linear graph. Table 2 and Figure 5 demonstrate that, out of all the models considered, the DTR performs the best, with an accuracy of R-squared score of 0.9864. LGBM and KN regressor was performing with an accuracy of R-squared score is 0.9860 and

0.9859 which is nearly as good as but slightly lesser than DT regressor model. Similarly, the DT regressor model performs better prediction in RMSE and MSE whereas as in LGBM and KN regressor model performs higher error rate prediction than DT regressor model. The DTR model was therefore fitted with these hyperparameters, which were optimised using the proposed OPTUNA framework In comparison to existing classification methods, the experimental results of the proposed model show higher values for various evaluation metrics when the accomplished prediction model is checked for accuracy using R squared score. Table.3 and Figure.8 displays results of model with improved classification performance based on hyperparameter optimization to get best hyperparameter compared to other models was introduced. The proposed OPTUNA based DT Regressor model achieved a R-Squared of 0.987, a MSE of 2120385948.23, and an RMSE of 46047.6486.

CONCLUSION

This paper has discussed about understanding the relationship between on-time performance and bus ridership is crucial for urban planners, transportation authorities, and policymakers to make informed decisions that enhance the efficiency and appeal of bus services, ultimately contributing to more sustainable and accessible urban transportation systems. In this study, regression-based datasets are solved using the LP classifier for chosen the best model that generates high classification accuracy of R squared score for DT regressor is 0.9864 has been improved through optimizer and hyper parameter. The most sophisticated hyperparameter optimisation framework was used in this research to optimise the prediction model's hyperparameters, which allowed for an accurate estimation of the demand for bus transportation over a certain time period based on passenger transit. The model accuracy of R squared score is improved through OPTUNA with an increase of 0.987 for DT regressor model which is more likely to be suitable in the percentage of buses that depart from their starting point or arrive at a destination based on passenger transportation is one factor used to estimate on-time performance. It can facilitate the usage of public transportation and allow transportation authorities to effectively allocate their limited resources.

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Table.1 DT regressor hyperparameter optimized using OPTUNA

S.No	hyperparameter name	Untuned parameter	Tuned parameter
1	ccp_alpha	0.0	0.0322
2	criterion	MSE	MSE
3	max_depth	None	12
4	max_features	None	Sqrt
5	max_leaf_nodes	None	None
6	min_impurity_decrease	0.0	0.01423
7	min_impurity_split	None	None
8	min_samples_leaf	1	1
9	min_samples_split	2	2
10	min_weight_fraction_leaf	0.0	9.57418
11	presort	Deprecated	Deprecated
12	random_state	None	None
13	splitter	best	best

Table.2 Metrics to measure the errors for top three regressor ML model

Algorithm	R-Squared	MSE	RMSE
DT Regressor	0.9864	2361332682.94067	48593.54569
LGBM Regressor	0.9860	2438426254.05480	49380.423793
KN Regressor	0.9859	2456666405.6648	49564.7698

Table.3 Metrics to measure the errors for proposed model

Algorithm	R-Squared	MSE	RMSE
Proposed OPTUNA based DT Regressor Model	0.987	2120385948.23	46047.6486

	Subsidiary	Month	Year	Percent On-Time	Ridership
0	Regional Transit Service	4	2009	84.0	1377039
1	Regional Transit Service	5	2009	83.0	1483123
2	Regional Transit Service	6	2009	82.0	1434123
3	Regional Transit Service	7	2009	83.6	1221534
4	Regional Transit Service	8	2009	83.2	1115882

Figure.1 Recommended dataset based on randomizing the rows

	Subsidiary	Month	Year	Percent On-Time
0	Regional Transit Service	4	2009	84.00
1	Regional Transit Service	5	2009	83.00
2	Regional Transit Service	6	2009	82.00
3	Regional Transit Service	7	2009	83.60
4	Regional Transit Service	8	2009	83.20
...	...	...	...	...
1174	RTS Wyoming	8	2022	96.50
1175	RTS Wyoming	9	2022	97.00
1176	RTS Wyoming	10	2022	97.00
1177	RTS Wyoming	11	2022	95.10
1178	RTS Wyoming	12	2022	95.95

1178 rows × 4 columns

Figure.2 Pre-processed data

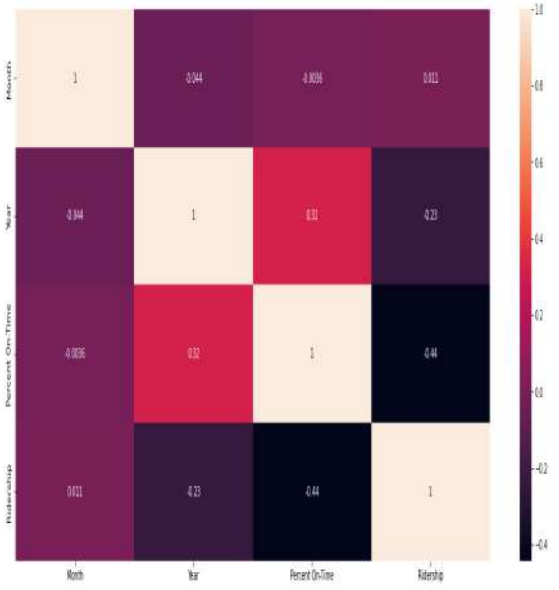


Figure 3 representation of correlation Heatmap

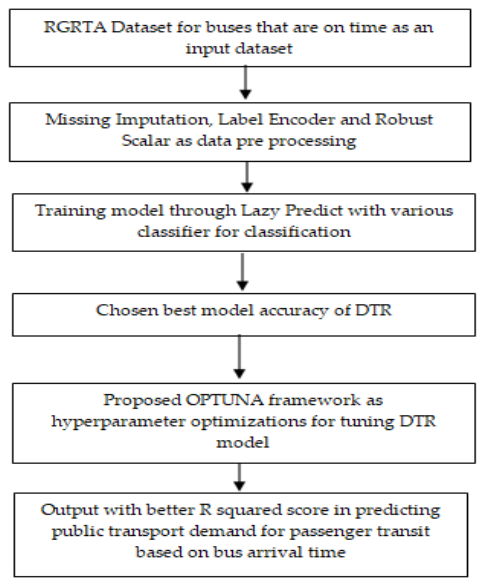


Figure.4 Proposed architecture for predicting transport demand for period of time

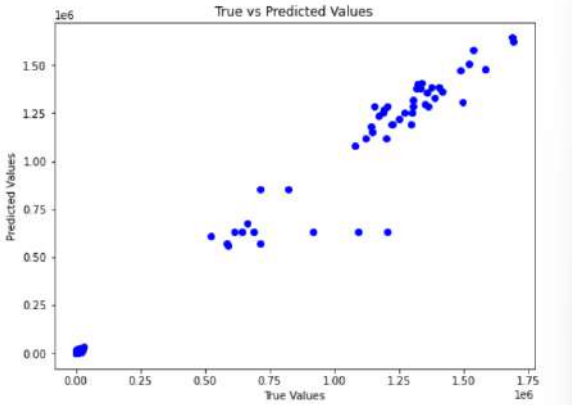


Figure. 5 Predicted versus true value plot for DT regress or model

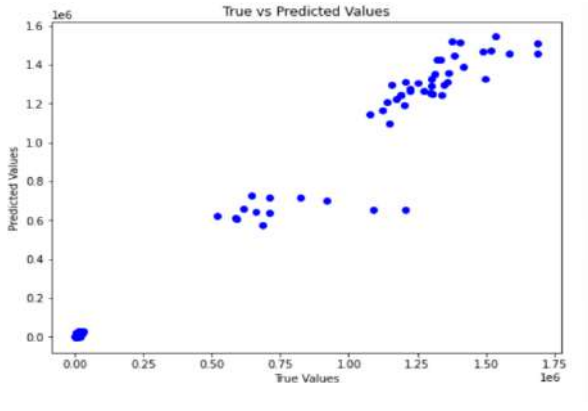


Figure. 6 Predicted versus true value plot for LGBM regressor model

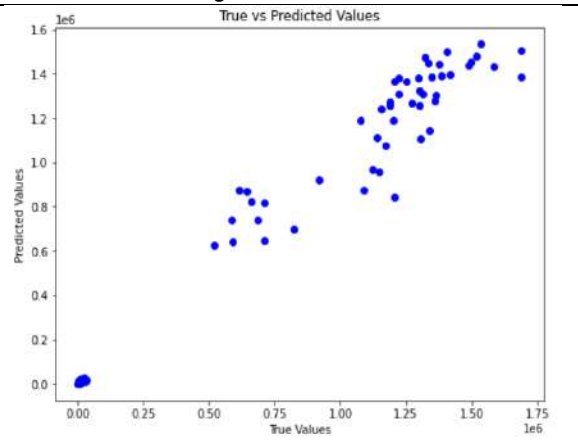


Figure.7 Predicted versus true value plot for KN regressor model

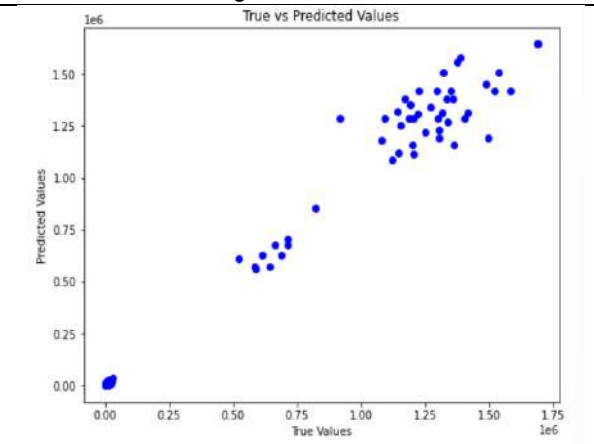


Figure.8 Predicted versus true value plot for proposed OPTUNA based DT Regressor Model

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RESEARCH ARTICLE

Alchemy: Deciphering the Transformative Effects of Heavy Metals on Namakal and Cuddalore District of Tamil Nadu, India

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ABSTRACT

Water, the elixir of life, sustains existence across all realms. Its quality stands as a sentinel, guarding against potential threats to human health. Defined by a myriad of factors, water quality denotes its suitability for various purposes, a delicate balance easily swayed by natural and anthropogenic forces. Monitoring its essence involves a symphony of on-site measurements, meticulous sample collection, and analytical scrutiny. At the heart of this vigilance lies the determination of heavy metal concentrations, a critical indicator of water's purity. From the enigmatic depths of cadmium to the shimmering presence of zinc, each metal paints a portrait of potential health hazards. Methods like Atomic Absorption Spectroscopy and Differential Pulse Anodic Stripping Voltammetry serve as the alchemists, revealing the elemental truths within water. Yet, despite our advances in understanding heavy metal toxicity, the specter of poisoning persists, urging us towards proactive prevention and effective remedies. In this quest, the standards set forth by the World Health Organization serve as beacons, guiding our assessments and actions. Water quality, thus, transcends mere chemical composition, encompassing a holistic evaluation of its organic, inorganic, and physiological characteristics. It beckons us to peer beneath the surface, to decipher its secrets, and to safeguard its essence for generations to come.

Keywords: Ground water, Toxic metal, Namakkal, Cuddalore.

INTRODUCTION

In the labyrinthine depths of Namakal and Cuddalore's subterranean realms lies a hidden alchemy, where heavy metals weave a tale of transformation within the groundwater systems. This underground world, often unseen and overlooked, harbors a delicate equilibrium that shapes the quality of this vital resource[1]. As we embark on a journey to decipher its mysteries, we are confronted with the profound impact of heavy metals, both natural and anthropogenic, on these aquifers.The significance of understanding heavy metal contamination in groundwater cannot be overstated, particularly in regions like Namakal and Cuddalore, where reliance on groundwater for drinking and agricultural purposes is paramount. Studies elevated levels of heavy metals such as cadmium, chromium, and lead in groundwater samples from these regions, underscoring the pressing need for comprehensive monitoring and remediation efforts[2].Furthermore, the work of shed light on the diverse sources of heavy metal pollution in groundwater, ranging from industrial effluents to agricultural runoff. These findings emphasize the multifaceted nature of the problem and the importance of adopting a holistic approach towards mitigation strategies. The analytical techniques employed in assessing heavy metal concentrations play a pivotal role in unraveling the intricate dynamics of groundwater quality. The different research papers showcased the efficacy of Atomic Absorption Spectroscopy and Differential Pulse Anodic Stripping Voltammetry in accurately quantifying heavy metal levels, providing valuable insights for monitoring programs and policy formulation[3].Moreover, the impact of heavy metal contamination on human health cannot be overlooked. Research conducted highlighted the detrimental effects of prolonged exposure to heavy metals, including neurological disorders, renal dysfunction, and carcinogenicity. These findings underscore the urgent need for stringent adherence to international standards, such as those set forth by the World Health Organization, in safeguarding public health. As we navigate through the intricate web of literature, it becomes evident that unraveling the transformative effects of heavy metals on Namakal and Cuddalore's groundwater systems is not merely an academic pursuit but a crucial step towards ensuring the sustainability and well-being of future generations. Thus, armed with knowledge and determination, we embark on a quest to decipher the underground alchemy that shapes the destiny of these vital water resources.

Water Source and Ground water

Groundwater is the water that saturates the pores and fractures of underground material, such as soil and rock. It exists beneath the Earth's surface within the saturated zone, where the spaces between particles or fractures in rock are filled with water[4]. Groundwater is a vital natural resource, serving as a primary source of drinking water for many communities, as well as playing a crucial role in sustaining ecosystems and supporting agricultural activities. A comprehensive study on the sources and impacts of heavy metal pollution in groundwater. Their findings highlighted the diverse origins of heavy metal contamination, ranging from industrial discharges to agricultural runoff. The study underscored the urgent need for integrated management approaches to address this pervasive environmental challenge. The health implications of heavy metal exposure through contaminated groundwater[5]. Their research revealed alarming rates of neurological disorders, renal dysfunction, and carcinogenicity among populations exposed to elevated levels of heavy metals. The study emphasized the critical importance of stringent regulatory measures and remediation efforts to safeguard public health.

Physiochemical Quality of Ground water

Physico-chemical quality refers to the attributes of water encompassing its color, taste, and potential to induce toxicity reactions or unexpected physiological responses, such as laxative effects. Additionally, it encompasses any objectionable effects encountered during regular use. This definition, as outlined by the World Health Organization (1995), underscores the multifaceted nature of assessing water quality beyond mere chemical composition[6].

Categories of the Water

Different types of water pollution

Urbanization

The rise in impervious surfaces, amplified runoff from urbanized areas, and heightened discharges from municipal and industrial sources collectively contribute to greater nutrient loading in urban streams. Urbanization typically corresponds with elevated phosphorus concentrations within urban catchments[7].

Radioactive Waste

Radioactive pollution originates from various sources, including radioactive sediment, water utilized in nuclear atomic plants, the exploitation of radioactive minerals, nuclear power plants, and the utilization of radioisotopes in medical and research applications. It is characterized by the presence of radioactive materials in water[8]. Radiation monitoring encompasses the measurement of radiation dose or radio nuclide contamination, serving purposes related to the assessment or regulation of radiation exposure.

Heavy Metal Pollution

Heavy metal poisoning refers to the excessive accumulation of heavy metals in the body's soft tissues, reaching toxic levels. Metals like zinc, copper, chromium, iron, and manganese can accumulate in concentrations high enough to induce poisoning. Industrial exposure, pollution of air and water, medications, and improperly coated food containers are potential sources of heavy metal poisoning[9].

METHODOLOGY

Heavy Metals Analysis

Heavy metal concentrations in drinking water are commonly assessed using techniques such as Atomic Absorption Spectroscopy and Differential Pulse Anodic Stripping Voltammetry (DPASV). Typically, water samples are collected directly from taps after running the water for at least 5 minutes to stabilize variations in electrical conductivity and temperature. These samples are then acidified to 1% with nitric acid and stored in 500 mL double-capped polyethylene bottles. The resulting heavy metal concentrations are compared with national and international standards such as those set by WHO-2008, USEPA, EPA, and EUC[10]. Any deviations from the maximum permissible limits are noted, and the potability of the water for the selected region is determined based on these findings.

Heavy metal sources

With the swift pace of industrialization and the adoption of consumerist lifestyles, the sources of environmental pollution have multiplied[11]. Pollution arises both during industrial production processes and through the end-use of products, as well as from runoff. These hazardous elements predominantly infiltrate the human body via food and water, with a lesser extent of exposure occurring through inhalation of polluted air, use of cosmetics, medications, and low-quality herbal preparations[12].

Heavy metals in essential and non-essential

Below is a table outlining various heavy metals, their sources, and the drinking water standards across different regions of the world.

MATERIALS AND METHODS

Collection of samples

Water samples were collected randomly from the vicinity of the SIPCOT industrial in Cuddalore and, we are collecting the water samples in different places of Namakal district. All the water samples were collected from the groundwater reservoir, gathered in plastic bottles. Collected samples were used to analyze the to find out the heavy metals[17].

Heavy metals analysis

Various authors in their research studies followed standard procedures for conducting a comparative study on the concentration of heavy metals in groundwater samples. The methods employed included the use of an atomic absorption spectrophotometer. Groundwater samples were collected and preserved at 4°C using a Thermo coal box with ice packs. Subsequently, these samples were filtered using Whatman 42 filter paper before analysis[18].

Sample Analysis

Groundwater samples underwent analysis for heavy metals such as zinc (Zn), copper (Cu), nickel (Ni), lead (Pb), and cadmium (Cd) using an atomic absorption spectrometer (Perkin Elmer). The instrument settings and operational conditions were meticulously adjusted in accordance with the manufacturer's specifications[19].

Nickel

Nickel is recognized as an essential trace element crucial for human and animal health. The World Health Organization (WHO) recommends a maximum permissible limit of 0.2 mg/L for nickel in groundwater. Analysis of groundwater samples revealed nickel concentrations ranging from 0.01 to 0.04 mg/L, all of which fell below the permissible limit in Namakkal district. Similarly, in the collected groundwater samples, nickel concentrations ranged from 0.01 to 0.06 mg/L, remaining within the WHO's much higher permissible limit for groundwater in Cuddalore district[20].

Cadmium

The World Health Organization (WHO) recommends a maximum permissible limit of 0.01 mg/L for cadmium in groundwater. However, analysis of groundwater samples indicated cadmium concentrations ranging from 0.01 to 0.05 mg/L. In nearly all groundwater samples in the district of Namakkal, the concentration of cadmium exceeded the permissible limit. Similarly, in all collected groundwater samples in Cuddlore district, the concentration of cadmium ranged from 0.02 to 0.04 mg/kg, surpassing the maximum much higher permissible limit set by the WHO[21].

Copper

The World Health Organization (WHO) recommends a maximum permissible limit of 2 mg/L for copper in groundwater. Analysis of groundwater samples revealed copper concentrations ranging from 0.02 to 0.10 mg/L, all of which were below the permissible limit. Copper is known to accumulate in the liver and brain, and its toxicity is a primary factor in Wilson's disease. However, in all collected groundwater samples in Namakkal, the concentration of copper exceeded the maximum permissible limit set by the WHO[22]. Copper concentrations in groundwater samples in Cuddlore districtranged from 0.05 to 1.00 mg/kg. It is higher than the Namakal district ground water.

Lead

According to WHO standards, the permissible limit of lead in water is 0.05 mg/L. However, analysis of groundwater samples in Namakkal, indicated that the concentration of lead exceeded the permissible limit in all collected samples. The concentration of lead in water samples ranged from 0.07 to 0.52 mg/L. Similarly, in groundwater samples in Cuddalore, the concentration of lead ranged from 0.28 to 0.78 mg/kg. In nearly all collected groundwater samples, the concentration of lead surpassed the permissible limit set by WHO. Lead contamination in groundwater is a widespread issue, as it accumulates in various organs such as bones, the aorta, kidneys, liver, and spleen over time[23].

zinc

According to WHO standards, the permissible limit of zinc in groundwater is 5 mg/L. However, analysis of groundwater samples in Namakkal, revealed that the concentration of zinc ranged from 0.01 to 0.10 mg/L, all of which were below the permissible limit. Similarly, in the groundwater samples of Cuddalore, the concentration of zinc ranged from 0.01 to 0.58 mg/kg, also below the WHO's permissible limit but higher than the Namakkal. Zinc is

an essential trace element crucial for the physiological and metabolic processes of many organisms. Nevertheless, elevated concentrations of zinc can be toxic to organisms.

CONCLUSION

The research findings revealed that the groundwater in Cuddalore district exhibited higher levels of heavy metals compared to Namakkal district. This disparity can be attributed to the presence of numerous SIPCOT (State Industries Promotion Corporation of Tamil Nadu) industries within the Cuddalore district. These industries are known to engage in various industrial processes that may involve the use or release of heavy metals into the environment. The industrial activities conducted by SIPCOT industries, including manufacturing, processing, and waste disposal, often contribute to the contamination of groundwater with heavy metals. Effluents containing heavy metals from industrial processes can infiltrate the soil and eventually seep into groundwater sources, leading to elevated levels of heavy metal concentrations. In contrast, Namakkal district may have fewer industrial activities or a different industrial profile compared to Cuddalore, resulting in comparatively lower levels of heavy metal contamination in its groundwater. This observation underscores the critical role of industrialization and industrial practices in influencing the quality of groundwater resources in different regions.

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Table.1 Characteristics of ground water

Taste and Oduor	The perception of taste and odor in drinking water is influenced by the activation of human receptor cells situated in taste buds and the nasal cavity, respectively (WHO, 1984). Evaluating the taste of drinking water commonly involves conducting taste tests, which may include threshold tests or taste rating assessments.
Temperature	The odor of a substance can be influenced by temperature due to the correlation between odor and vapor pressure. Additionally, the growth rate of microbes, some of which produce undesirable metabolites, tends to increase with higher temperatures.
pH	The odor and taste of drinking water can be affected by pH, as it regulates the balance of ionized forms of substances. pH levels typically range from 5.0 to 9.0.
Alkalinity	A rise in alkalinity can lead to a reduction in coloration, with the extent of color loss typically correlating directly with the alkalinity of the water sample, often closely resembling its hardness value.

Hardness	Hardness in water originates from various sources such as sewage and runoff from soil, especially in areas with limestone formations. The primary ions responsible for water hardness are calcium and magnesium. When the predominant anion is carbonate, it is termed temporary hardness, as it can be eliminated by boiling, unlike the case with sulfates, chlorides, and nitrates.

Table.2 These categories are divided into five classifications.

WQI RANGE	TYPE OF WATER
<50	Excellent water
50-100	Good water
100,1-200	Poor water
200,1-300	Very poor water
>300	Water unsuitable for drinking

Table.3 Heavy metals and their sources

Heavy Metal	Sources	Drinking Water Standards
Zinc (Zn)	Oil Refining Plumbing Brass manufacturing	According to regulatory standards, the Environmental Protection Agency (EPA) and the European Community both set a maximum concentration of 5 mg/L for certain substances. However, the Regulation of Water Community establishes a stricter limit of 0.1 mg/L for the same substances.
Copper (Cu)	Copper plating Printing	As per regulations, the Environmental Protection Agency (EPA) sets a maximum concentration of 1.0 mg/L for specific substances, while the European Community allows up to 3 mg/L. In contrast, the Regulation of Water Community imposes a stricter limit of 0.01 mg/L for the same substances.
Iron (Fe)	High intake as oral consumption	
Cobalt (Co)	Hip alloy replacement case	
Chromium (Cr)	Steel fabrication Electroplating Textile	As stipulated by regulatory authorities, the Environmental Protection Agency (EPA) mandates a maximum concentration of 0.1 mg/L for certain substances. In comparison, the European Community permits up to 0.5 mg/L, while the Regulation of Water Community maintains a consistent limit of 0.1 mg/L for the same substances.
Lead (Pb)	Batteries Coal Combustion Paint Industry	As outlined by regulatory standards, the Environmental Protection Agency (EPA) enforces a maximum concentration of 0.1 mg/L for specific substances. Conversely, the European Community allows up to 0.5 mg/L, while the Regulation of Water Community maintains a consistent limit of 0.1 mg/L for the same substances.
Arsenic (As)	Atmospheric deposition Mining Pesticides	As per regulatory guidelines, the Environmental Protection Agency (EPA) sets a maximum concentration of 10 mg/L for certain substances. Conversely, the European Community mandates a much lower limit of 0.01 mg/L, while the Regulation of Water Community establishes an even stricter threshold of 0.05 mg/L for the same substances.
Mercury (Hg)	Coal combustion, Fish, Mining, Paint industry, Paper industry, Volcanic	As per regulatory standards, the Environmental Protection Agency (EPA) specifies a maximum concentration of 0.002 mg/L for certain substances. In contrast, the European Community imposes a lower limit

	eruption	of 0.001 mg/L, while the Regulation of Water Community sets a slightly higher threshold of 0.004 mg/L for the same substances.
Cadmium (Cd)	Plastic Fertilizers Pesticides	According to regulatory guidelines, the Environmental Protection Agency (EPA) stipulates a maximum concentration of 0.005 mg/L for specific substances. Conversely, the European Community sets a higher limit of 0.2 mg/L, while the Regulation of Water Community establishes a much lower threshold of 0.001 mg/L for the same substances.

Table.4 guidelines for drinking water or acceptable ranges set by WHO and NAFDAC.

Heavy Metals	Maximum Concentration (WHO)	Maximum Concentration (NAFDAC)
Zinc	5 mg/l	5 mg/l
Arsenic	0.01 mg/l	0.0 mg/l
Magnesium	50 mg/l	30 mg/l
Calcium	50 mg/l	50 mg/l
Cadmium	0.003 mg/l	0.0 mg/l
Lead	0.01 mg/l	0.0 mg/l
Silver	0.0 mg/l	0.0 mg/l
Mercury	0.001 mg/l	0.0 mg/l

Table.5 Heavy metal concentration of ground water samples in Namakkal district

Heavy metal	Cu	Zn	Pb	Ni	Cd
Maximum	0.10	0.10	0.50	0.04	0.05
Minimum	0.02	0.01	0.07	0.01	0.01
Average	0.06	0.05	0.29	0.02	0.03

Table.6 Heavy metal concentration of ground water samples in Cuddalore district

Heavy metal	Cu	Zn	Pb	Ni	Cd
Maximum	1.00	0.58	0.78	0.06	0.04
Minimum	0.05	0.01	0.28	0.01	0.02
Average	0.52	0.29	0.53	0.03	0.03

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Articles in Journals

1. Devi KV, Pai RS. Antiretrovirals: Need for an Effective Drug Delivery. Indian J Pharm Sci 2006;68:1-6. List the first six contributors followed by *et al*.
2. Volume with supplement: Shen HM, Zhang QF. Risk assessment of nickel carcinogenicity and occupational lung cancer. Environ Health Perspect 1994; 102 Suppl 1:275-82.
3. Issue with supplement: Payne DK, Sullivan MD, Massie MJ. Women's psychological reactions to breast cancer. Semin Oncol 1996;23(1, Suppl 2):89-97.

Books and other Monographs

4. Personal author(s): Ringsven MK, Bond D. Gerontology and leadership skills for nurses. 2nd ed. Albany (NY): Delmar Publishers; 1996.
5. Editor(s), compiler(s) as author: Norman IJ, Redfern SJ, editors. Mental health care for elderly people. New York: Churchill Livingstone; 1996.
6. Chapter in a book: Phillips SJ, Whisnant JP. Hypertension and stroke. In: Laragh JH, Brenner BM, editors. Hypertension: pathophysiology, diagnosis, and management. 2nd ed. New York: Raven Press; 1995. p. 465-78.

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RESEARCH ARTICLE

Implementation of Medication Emergency Disease Prediction and Prescription Providing System using Machine Learning

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ABSTRACT

The undertaking of the goal of the Health-Care- Search The engine is to develop applications for illness prediction. The concept was to create an application that would let any user look up the therapy for the illness they were suffering from. The program would then send out a list of steps that needed to be taken in order to treat the disease effectively, along with Information about which Caregivers could help them. A Sizable dataset of medical records, comprising several patients. Demographic and clinical characteristics like age, gender, Medical history, lifestyle choices, and vital signs reused Train the suggested model. A sizable collection of medical records are used to train the Model, which then forecasts the probability of contracting a certain illness. This suggested method bases the disease prediction on the patient's features. and applies the MLP- Algorithm. Input, output, and one or More hidden layers with many neurons stacked on top of each Others comprise a Multilayer-Perceptron. Furthermore, neurons A Multilayer- Perception can employ any arbitrary activation function, but neurons in a perceptron must haves activation function that enforces a threshold, such as ReLU or sigmoid. Through collaborative Filtering, the proposed work ensures that the system recommends suitable caregivers. for the patients. A patient provides his Health-Information to the service platform upon Enrolling in this system in order to Receive Professional Care Services. The platform then searches the patient database for other patients who may have comparable health information. Subsequently, the platform for services can monitor which highly rated caregivers attended to these comparable patients. Lastly, the patient may Receive Recommendations from the service platform for these rated caregivers. The patient can locate suitable healthcare. Services that are more likely to offer high-quality care services by using this type of collaborative filtering.

Keywords: Upload Dataset, Dataset Training, Input Query Data, Multilayer Perceptron, Disease Prediction, Rating/Review Analysis, Solution Recommendation

INTRODUCTION

MACHINE LEARNING

Artificial intelligence (AI) and machine learning allow systems to automatically learn from experience and get better at it. Without needing to be explicitly designed. The Creation of Computer programs that can access data and utilize it to Learn for themselves is the main goal of machine learning. In Order to find patterns in the data and use the examples we provide. Guide future decisions, learning starts with Observations of Data, such as examples, first hand experience, or instruction. The primary objective is to empower computers to learn. their own, devoid of human assistance or intervention, an Adjust their operations accordingly. Machine-Learning is utilized in a variety of AI-Applications including Recommender Systems, driverless cars, Picture an Speech recognition, natural language processing, and more Large-scale Data Processing, Patterns, and Relationships Recognition And Decision-making based on Information is all necessary for these applications. Other Subfields of artificial intelligence (AI) include robotics. expert systems, knowledge representation, planning, and reasoning addition Machine-Learning. Although Echo These subfields focus on a distinct facet of AI; they are all connected and can cooperate to develop increasingly Sophisticated AI-Systems All things considered, machine learning is a vital part of Artificial intelligence (AI) is responsible for helping Computers learn and become more efficient in a variety of Activities. Machine- learning will probably remain a Component in allowing computers to develop intelligence. Beyond that of humans, artificial intelligence (AI) is developing.

DISEASE PREDICTION

Disease risk assessment, which entails projecting a person's probability of contracting a specific disease, is a crucial responsibility in the healthcare industry. Analyzing Variety of risk factors, including age, gender, lifestyle, medical history, and genetic susceptibility, can help achieve this. Large healthcare databases and sophisticated machine learning algorithms make it feasible to precisely estimate the risk of disease and provide individualized preventive measures. Utilizing a dataset, the process of assessing the risk of a disease entails gathering and preprocessing data from a variety of sources, including genetic, medical imaging, and electronic health records. Next, machine learning methods like logistic regression, decision trees, random forests, and neural networks are used to examine this data. Accurate disease risk assessment is made possible by these algorithms' ability to recognize patterns and connections between different risk factors in disease outcomes. The Outcomes Of a disease risk assessment can be utilized to create individualized preventative plans that include dietary adjustments, early detection, and focused medical treatments. This can enhance people's health outcomes and lessen the overall burden of disease. All things considered, illness risk assessment utilizing datasets and machine learning algorithms has the potential to transform the healthcare industry and allow tailored preventive measures that can enhance patient outcomes and lower medical expenses. The goal of the proposed project is to automate the laborious process of looking for and locating hospitals through an automated data-driven strategy for medical knowledge extraction. The plan was to create an application that would enable any user to search for the illness they are experiencing and receive a list of treatments that are successful for it, along with the hospitals that offer the services they need. It is Intend To Accomplish The Following goals.

The majority of search engines employ Keyword-based search, which is a popular method for retrieving documents from the Web. Systems that respond to questions tackle this issue. We Need Tools that let a user Ask a question Uncommon English and get a prompt, concise response with enough context to support the response. The increasing amount of online information available has made it more difficult for users to navigate, which makes the demand for automated question answering systems more pressing. While ranked lists of documents can be returned by current search engines, they do not provide the user with answers. When a search engine is asked a question, it must first assess it, maybe considering the context of an ongoing interaction; it next has to reference links to discover one or more responses; finally, it needs to present the user with the ideal response based on user ratings. These days, patients search online for first aid recommendations and solutions for their medical conditions. Patients wish to receive medical advice about their health and suggestions by asking and

responding to doctors around the world. The Physicians Recommending them instead Of The intricate and difficult problems. In the beginning, we relied on an external dictionary to find relevant medical information, but this wasn't really enough to assist patients using internet services. These days, we combine medical terminology that creates a barrier between patients and healthcare practitioners with corpus aware terminology that is employed with the use of normal language.

RELATED WORK

Kose,et.al.,…[1]outlined a system that contrasts the impact of the multiple imputation methods, MICE and FAMD, on the differential diagnosis performance of DL. Deep Learning is a technique that has grown a lot in popularity recently. Unlike machine-learning-Algorithms, Researchers can use all available data using DL-Modells because they don't add fake reputations. However, quick, dependable and repeatable analysis can yield results and allow for the creation of more accurate estimates [49]. Even in cases, where the dataset contains missing observations, the employment of a high number of neurons in deep learning ensures a comprehensive representation of the available raw data. Upon Reviewing The Literature, if this then that, while deep- learning-techniques have been widely employed in recent research, no study has assessed the performance of missing- imputation-techniques in tandem with their use. For an extended period, it has been recognized that a significant issue in actual clinical trials is the rate of missed observation. Clinical data are known to exhibit distinct features for every disease, novel medication, and treatment approaches. as a result, we only included the Application-Data that we utilized for the Study-Title in our findings and results. Das war eine der Studie Limitations, and we made sure to emphasize it rather clearly. We anticipate having the chance to use our methodology on various clinical datasets, such as electronic medical records or medical imaging genomics. In Conclusion, Deep Learning enables estimates with partial Datasets, in contrast to Machine-Learning-Technikon. Für Hybrid-Type-Daten, is test recommended, dass the Deep- Learning-Method be used in combination with suitable Imputation-Techniques, in order to get the maximum Accuracy-Rates.

Khan,et.al,…[2]Internet of Things Framework is suggested to use a modified deep convolutional-neural- network (MDCNN) to assess heart disease more precisely. Blood pressure and an electro cardiogram (ECG) are monitored by the patient's smart watch and heart monitor gadget. The received sensor data is classified as normal or pathological using the MDCNN. By contrasting the suggested MDCNN with current deep learning-neural- networks and logistic regression, the system performance is examined. The patient's heart condition can be predicted using an MDCNN in the suggested approach. The System is tested and trained for this purpose. The MCNN classifier is used to train the system using the UCI, Framingham, and Public Health Datasets as training data. The data's classified outcomes (normal and abnormal) are included in the UCI dataset. Direct testing of the IoT-Sensor-Values results in a longer time to disease detection and a higher chance of an incorrect result. As a result, the system is trained. Three Steps are involved in training the proposed MDCNN classifier: (i) preprocessing, (ii) feature selection, and (iii) classification. The training's results fall in two categories: (a) normal, meaning the patient's heart condition is normal, and (b) abnormal, meaning the patient's heart condition is abnormal. Testing is done after the training process. Sensor Values are continuously sent by the patient-attached sensor device. The IoT-Sensor-Data are compared with the training-Phase- Values, in order to classify these based on the training- Outcomes. After comparing the values, the system produces results that are classified. Kathamuthu, et.al,… [3] With reduced encryption and decryption time, a novel framework called the deep Q- learning-based neural network with privacy preservation approach (DQ-NNPP) was created to secure data transmission from outside threats. Hospital applications require private patient data, which is uploaded in centralized locations. These Data are then used by Machine-Learning- Techniques to identify distinctive Patterns that can be used to create new Models. Insider- and Outsider-Dangers arise, we Such confidential information is made available to the workers of the organization, or if the company's dataset is compromised. Neural-Network-Techniques are employed in the built model to protect the confidentiality and security of medical records. The System has to get rid of illegal access to the Cloud Storage because it is facing multiple intermediate attacks. After user data is collected, features are taken out and saved for each request, in order to examine malware-activity as well as security- and privacy-related problems. Feature states can be used to extract

the quality-value the data from these Features, and the actions that correspond to these Features also aid in determining the quality of the data. preservation technique (DQ PP) architecture. In order to provide a patient-centric access control strategy employed in the electronic medical sectors, this study developed innovative cipher text-policy attribute-based privacy preservation (CPA BPP), which combines the advantages of private, public, and master keys, thereby guaranteeing security and privacy. Koppu, et.al,… [4] The prediction model's step-by- step implementation, which includes cleaning, feature extraction, and classification, satisfies this goal. The Cleaning procedure consists of clearing out missing values and detecting outliers using entropy-correlation and sp lines' interpolation. Principle Component Analysis is then used to extract features from the cleaned data. To choose the best features, a Fitness-oriented Dragon-Fly-Algorithm is presented. The resulting Feature-Vector is then put in the Deep Belief Network. The suggested scheme's overall accuracy was tested using conventional state-of-the-art models. The first phase involves applying the gathered information on breast cancer and heart disease to the data cleaning procedure. The cleaning procedure consists of two steps: Outlier detection comes first, followed by missing value filling. Hier ,the Outlier detected using correlation- based approach and entropy, while Sp line Interpolation (SI) is utilized to fill in missing values. The Second Phase Involves using Principal Component Analysis (PCA) to extract features from data that have been cleaned. The third stage involves multiplying the features collected from PCA by a weight function to create a different type of feature vector.

The resulting feature vector is sent to the Deep Belief Network(DBN)architecture in the fourth stage. The Primary contribution is the optimized tuning the multiplied weight through the use of modified, or F-DA, to reduce the error between the anticipated and actual output during the classification process. The Labels, that indicate whether or not the patient is affected, are provided by the Categorization- Output. Ma,Zhuoran,et.al.,…[5]suggested PHPR, a high-accuracy, privacy-preserving external disease predictor on random forests. The PHPR-System can create accurate predictions and conduct secure training using medical data that owned by several Data-Owners. Furthermore, original data and computed results in the rational sector can be processed and kept in the Cloud safely and securely without compromising privacy. Specifically, to ensure computation correctness and handle outsourced operations on-the-fly, we first build privacy preserving computation protocols over rational numbers. Next, we show that the PHPR-System is capable of achieving a secure Illness-Predictor. Assume for the purposes of the proposed model that KC is a reliable source that offer critica distribution generating services. While diligently adhering to the prescribed protocol, DOs, CU,OP, and CP are inquisitive, yet truthful parties, that make an effort to discover as much personal information as they can from other parties and the interim outcomes of the learning process. Furthermore, every DO's Data Privacy needs to be protected to the fullest extent possible from both other DOs and Cloud Server (OPorCP). Furthermore, OP end CP are independent cloud servers with a solid reputation, and are not permitted for them to collude, since doing so would be detrimental to their credibility and interest.

BACKGROUND FUNCTION

An effective and private-preserving online disease risk assessment method spanning multiple-outsourced vertical datasets has been established in the current system. This method allows the-healthcare provider safely train a disease risk prediction model using vertically dispersed medical data from several medical centers and offer users privacy-preserving disease risk prediction services. Users' private information as well as that of medical facilities and e-healthcare providers can be securely protected throughout the process. First, it successfully trains a model for disease risk prediction using vertically dispersed data, and it allows for dynamic model updates. With this method, the e-healthcare provider can also successfully trainthe disease risk prediction model,even if medical center gather various attributes from cases. Furthermore, a method for upgrading the model is developed that enables healthcare facilities to submit newly obtained patient data in order to routinely update the prediction model. Second, it offers privacy preservation for both illness risk prediction and model training. Provide a modified Paillier crypto system for this application so that the prediction model may be safely trained without revealing private information about medical facilities. Additionally, the random masking technique is used in disease risk prediction, maintaining user queries and results regarding disease risk as well as the e-healthcare provider's disease risk prediction model.



DISEASE PREDICTION WITH SOLUTION RECOMMENDATION USING MACHINE LEARNING

The "Health Care Search Engine" projects cutting-edge strategy meant to transform the way people look for healthcare and enhance patient outcomes. Utilizing state-of- the-art machine learning methods, such as Multilayer Perceptron(MLP)algorithms, the project aims to forecast the probability of an illness based on a variety of patient attributes, including vital signs, lifestyle choices, medical histories, and demographic information. With the use of this predictive model, which was trained on an extensive collection of medical records, users willbeable to make knowledgeable decisions about their healthcare requirements and receive tailored recommendations for caregivers and therapies. Additionally, the initiative incorporates collaborative filtering techniques improve the patient-career match making process. Through the examination of comparable patient experience with specific medical illnesses, the system finds and suggests highly rated caregivers who have proven to be adopted delivering quality treatment. In addition to increasing patient happiness, this individualized approach makes high-quality healthcare services more accessible. The proposed project seeks to transform the healthcare search environment by leveraging technology to improve healthcare delivery. It provides a smooth and effective solution for both patients and caregivers.

DATASET PROCESSING

Gather a sizable dataset medical records for this module that includes a range of clinical and patient demographic information, including age, gender, medical history, lifestyle choices, and vital signs. Next, clean up the data to get rid of any unnecessary characteristics, outliers, or missing values that could compromise model's accuracy. Using Methods such as feature importance analysis, mutual information, or correlation analysis, determine which features are most relevant in influencing the risk of a disease. Use machine learning methods like SVM, logistic regression, or random forest to train a classification model. Cross-validation should be used to assess the model's suitability for generalization. Creating a model and preprocessing the dataset are essential stages in building a machine learning-based disease risk assessment module. These procedures guarantee that the model is reliable, accurate, and suitable for usage in clinical settings.

USERSEARCHQUERY

To protect patient privacy and stop unwanted access to private medical records, a patient verification system based on secret keys can be put in place. Every patient this system has a distinct secret key that they and the Trusted Authority alone san share. A patient's secret key can be requested by the healthcare practitioner in order to confirm the patient's identification when they seek medical attention. Subsequently, the user can look for disease information by symptom. It is possible to create a disease search engine that relies on symptom queries to assist medical professionals in making diagnoses based on patient symptoms. The healthcare provider cause this system to input the patient's symptoms, and it will look for potential illnesses that match the symptoms.

DISEASE PREDICTION

The task of analyzing the symptoms that the user enters and identifying pertinent characteristics that can be utilized to forecast the illness falls to the user symptoms query processing module. Employing methods such as feature importance analysis, mutual information, or correlation analysis, determine which features are most pertinent to the diagnosis of an illness. The disease prediction module can utilize a machine learning technique, such as SVM classification, to forecast the disease based on the user's symptoms after the pertinent features have been retrieved. After The Patient Provides The Service Platform With Their disease information, the platform analyzes the data and suggest treatments to the patient. This suggestion is based on the highly regarded physicians who receive treatment from the top k patients. Following acceptance of the medical services, the patient evaluates and assesses the physician.

REVIEW ANALYSIS

The patient evaluates and ranks the caregiver after receiving the medical services from the caregiver they consulted. The service platform determines if a review is genuine or not, display the genuine reviews, and determines the public's average rating. The same approach should be used to generate reviews and ratings. The service platform will not accept reviews and ratings that the patient does not sign under his secret keys. The Service Platform May Question whether the two signatures are from the same Sybil attacker if it notices similar reviews and ratings within a brief period of time. The ratings can only be approved by the service platform and displayed to the public if they are created by a typical patient, that is, not a Sybil attacker. Ultimately, the distinct and original reviews are safely encrypted and kept in a database.

SOLUTION RECOMMENDATION

The suggested method uses collaborative filtering to suggest suitable cares for the patients. The service platform can keep track of the highly rated care givers who attended to these comparable patients when patients look for the caregiver's solution. Lastly, the patient may receive recommendations from the service platform for these rated caregivers. The patient can locate suitable healthcare services that are more likely to offer high-quality care services by using this type of collaborative filtering.

METHODOLOGY

MULTILAYER PERCEPTRON ALGORITHM

Multilayer Perceptron Algorithm feed forward artificial neural network structure called Back propagation projects a set of input data onto a set of suitable outputs. It consists of many directed graph layers with Multiple Layers of nodes, each fully connected to the following layer. With the exception of the input nodes, each node is a neuron with a nonlinear activation function. Back propagation trains the network by taking advantage of a supervised learning method known as back propagation. Should back propagation possess basic On-off-Mechanism, such as linear activation function in all neurons, to regulate Whether or not a neuron fires, then it is easily proved with linear algebra that any number of layers can be reduced to the Standard Two-Layer-Input-Output-Model. Gradient techniques are therefore useful in Optimization-Strategies to control the Weights and reduce the network's Loss-function. To Computer Gradients for each layer in a feed forward network, a chain of Imperative Rules may be created using the Delta-Rule. For the Back Propagation Algorithm to work, each neuron activation function must differ. Back Propagation is now used in the continuing research on distributed computing, Computational Neuroscience and Parallel Computing. Their ability to solve Complicated Issues and their fitness Approximation of Outcomes, even with crucial Predictions, makes them extremely useful for studying. One of the neural network models, back propagation, use the same feed-forward-back-propagation- architecture as supervised training. The most popular and often used kind of neural network is the back propagation. User can provide the Features and inevitably predict the diseases.

The algorithmic steps are Follow

Step1:Randomly Set The Weights And Biases.
Step 2: Feed the trainings sample.
Step3:Forward Inputs and calculate each unit's Net Input and output in the hidden and output layers.
Step 4: Back propagate the error to the intermediate layer.
Step 5:Update Weights and biases to replicate the propagated Errors. The weights and biases of the network are automatically. Adjusted by mathematical measures called training and Learning Functions.
Step 6: Stop the Condition



COLLABORATIVE FILTERING

User-based Collaborative Filtering is a Method that leverages ratings from other users who share the target User's taste to predict the items the user could find appealing. Collaborative Filtering is a common technique used by websites to develop their recommendation system. Cold starts for newly added items to the list are one issue that Collaborative Filtering may cause. They receive no recommendations unless they receive a rating. Data Sparsely: Can exacerbate the cold start issue and have an impact on the performance of user-based recommenders. Growing datasets can present scaling challenges, due to their Potential for excessive Complexity. When the Dataset is huge, Item-based Recommenders perform faster than user-based. Ones. If the suggestions were implemented simply, one may Notice that the items from the long tail portion might be disregarded and that the Recommendations are generally already well-liked.

Steps for User-based Collaborative Filtering

Step 1: Finding the similarity of users to the target user U. Similarity for any two users ‚a' and ‚b' can be calculated. from the given Formula.

Step 2: Prediction of the missing rating of an item The target user may now resemble certain users very. substantially while not like the others at all. Therefore, a Specific item's Ratings from users who are more similar to it should be given more weight than ratings from users who Are less similar to it, and so on. A weighted average method. can be used to tackle this issue.

EXPERIMENTAL RESULTS

The proposed drug recommendation system was implemented in Python as front end and MySQL as backend that allows a developer to create a customized development environment. The experimental results show the output of disease diagnosis using symptoms and also recommend the appropriate drugs for predicted disease. In below, we explained the details with specific screenshots. In fig 2 shows the process of selecting symptoms for prediction disease. Here user can select the symptoms regarding their health issues. For symptoms processing here apply MLP algorithm. In fig 3 shows the process of disease prediction output, the input symptoms are processed using MLP algorithm and predict the disease based on symptoms. In fig 4 shows the process rating posted by user. The registered user can post their ratings for provided drug details. It support Star Ratings,smiley sand text based review system. In fig 5 shows the process of drug recommendation. Based On user's rating, review and feedback, the system analyzed the feedback using collaborative filtering algorithm. Predict the highly positive rate drugs and recommend the predicted drugs to the users.

CONCLUSION

In Conclusion, a promising method healthcare that can enhance patient privacy while yet enabling reliable disease prediction is disease prediction using symptom data with classification disease dataset using the MLP algorithm. The MLP algorithm is an effective tool for classification jobs and has a high accuracy rate for predicting the disease based on the symptoms of a patient. Additionally, the application offers the anticipated illness. Solution vendors have already shared and stored in databases their disease-focused solutions. Patients are able to rate and review a particular remedy online. An effective review analysis is provided by collaborative filtering method. The can obtain the majority of suggested solutions with this strategy. This protects user identity privacy by preventing the service platform, caregivers, and other patients in the system from learning the patient's identity information. In order to prevent phony Reviews of caregivers, deploy and analyze fake reviews has well.

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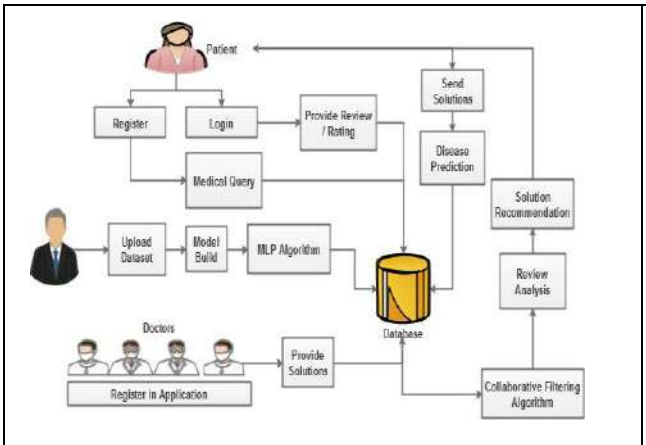


Fig1:Proposed Framework

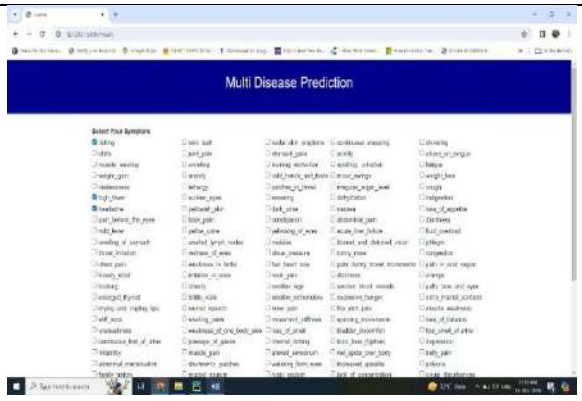


Fig.2 Select Symptoms

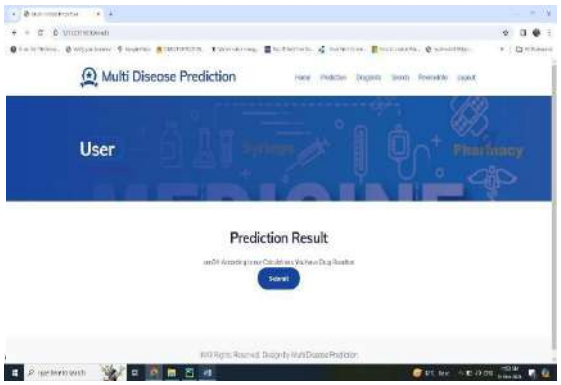


Fig.3 Disease Prediction

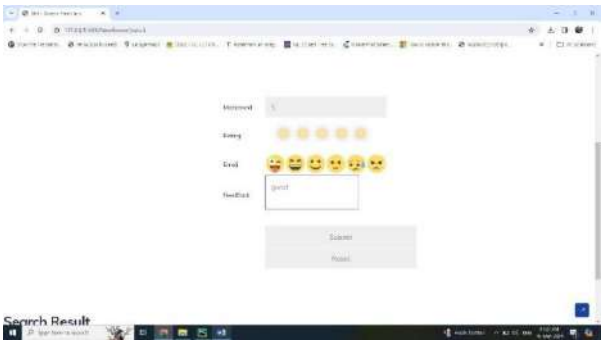


Fig.4 Rating/Review System

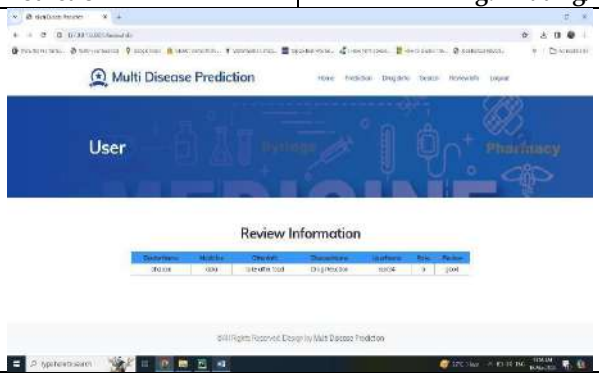


Fig.5 Recommendation System

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RESEARCH ARTICLE

A Survey on Efficient Bandwidth Management in Federated Learning: Exploring Novel Compression Techniques, Adaptive Protocols, and Network Innovations

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ABSTRACT

Federated learning permits the training of decentralized models among several devices while maintaining local data, yet it presents serious bandwidth issues because of the frequent and substantial model changes. Scaling these systems in practical applications requires effective bandwidth control. This study investigates many strategies, including network innovations, adaptive protocols, and compression techniques. We examine techniques including quantization, sparse updates, and model pruning to minimize update sizes without sacrificing accuracy. Adaptive protocols modify communication according to network circumstances and client accessibility, and advances in networks such as asynchronous communication and hierarchical federated learning facilitate faster data transfers. We present an overview of existing research, point out shortcomings, and offer innovative methods to improve the effectiveness and also scalability of the federated learning systems by examining recent developments and trends. This paper aims to guide future research in developing better bandwidth management solutions for federated learning.

Keywords: communication, management, devices, learning, network.

INTRODUCTION

Artificial intelligence (AI) was first proposed in 1956 and its technological advances are having an increasingly significant impact on human existence[1]. Many application areas have entered the field of artificial intelligence due to recent advances in artificial intelligence technology [2]. In order to advance AI technology, academic research focuses on models, processing power, chip functionality, and further technical difficulties along the way. Large quantities of actual data must be used to train machines to actually imitate human reasoning. Federated learning revolutionizes the field of machine learning by enabling centralized modelling training on a large number of devices, while ensuring that data remains on local devices. The concept of FL was proposed by Google in 2016 primarily to update the model on the Android mobile phone without disclosing confidential personal information [3]. Afterwards, Google implemented an application-focused FL system. Without storing raw device data on cloud servers, the FL system's architecture was designed to run the FedAvg algorithm on mobile devices, conduct federated studies, and be used to monitor statistics for big cluster equipment. The FL is among the most significant technologies in the field of data protection computing. FL's lightweight technology pathways and deployment system have made FL is a popular product and solution for many applications involving privacy computing. As FL applications have evolved and grown more complex, a substantial number of research achievements in the field have emerged. This strategy enhances security and privacy while also allows the use of different data sources without the need for centralized data collection.

As long as private data stays inside the local area, FL is a safe distributed machine learning technology that may be used in conjunction with FL algorithms on a number of distributed edge devices and servers [4]. Each local client receives data training tasks from FL, and instead of direct data communication, clients and servers communicate with one another through parameter interaction. Then server's contribution to updating the global model is limited to basic parameter aggregation. By conserving server processing and storage resources, a FL system like this can safeguard local user data. With client-server communication, a superior global model can be produced via FL. The method is in contrast to conventional centralized training, which gathers all local data into the training's central server [5]. In contrast to conventional centralized machine learning techniques [6], FL techniques enable the realization of numerous federated agencies to construct a single, compliant, safe model for multi-source data applications in the ecological system [7].

Federated learning has great potential, but it also has a lot of problems, especially with bandwidth control. Significant bandwidth needs are caused by the frequent and frequently massive model update transfers that occur between clients and the central server. To scale federated learning systems and make them practical for use in real-world applications, effective management of this bandwidth is necessary.

This study investigates novel approaches to address these bandwidth problems, with a primary focus on three domains: network innovations, adaptive protocols, and compression methods. The goal of compression techniques like quantization, sparse updates, and model pruning is to minimize the size of model updates without compromising accuracy. Adaptive protocols maximize bandwidth utilization by dynamically modifying communication processes in response to current network conditions and client availability. Asynchronous communication and hierarchical federated learning are two examples of network improvements that simplify data transfers and cut costs.

Our review focuses on current developments and new trends in these fields. We provide an extensive overview of the field's current situation, point out any gaps in the knowledge, and offer novel ideas for enhancing the efficiency and scalability of federated learning systems. Our goal is to offer guidance and insights for future research aimed at creating more efficient bandwidth management solutions for federated learning through theoretical analysis and real-world examples.

LITERATURE REVIEW

Federated learning is a relatively recent concept in machine learning that focuses on collaboration rather than centralization or data aggregation. This paradigm shift was earlier introduced by Konečný, McMahan, and colleagues,[8] who laid the groundwork in establishing the basic tenets of federated learning—data locality is only between model updates that participants share. Their work (Konečný et al., 2016) raced light-years ahead to open up the potential for protecting privacy while developing collaborative models for training and scattered devices in a natural environment. McMahan and team developed the Federated Averaging algorithm on top of such basic concepts [9] and now become the cornerstone in federated learning. FedAvg can save huge costs in communication, allowing devices to train models locally over a number of iterations before the created models get averaged across the network. It reduces frequency and volume of exchanged data between devices and central servers—for instance, the communication costs incurred locally will be minimized when data is being exchanged between devices and a central server (McMahan et al., 2016).

On the other hand, privacy remains a primary concern in federated learning, especially considering that the data is decentralized. Martin Abadi [10] was the first to work on a way to solve these issues with the design of mechanisms to achieve untraceability of individual data points in the updates of models with differential privacy. While this work is not specifically associated with federated learning, Abadi's work is integral in establishing a proper basis for integrating privacy-preserving techniques in federated systems and ensuring that individual data from the participants are secure and remain private throughout the collaboration training process, whereby the training is close to real time. Federated learning faces a critical challenge: the efficiency of communication, also in the presence of heterogeneous devices in the computational and network capabilities, causes not only a privacy concern. This point is illustrated, for instance, in the work done by Peter Kairouz [11], regarding strategies to optimize federated learning in such heterogeneous settings, through adaptive tuning of communication frequency with respect to network conditions and the model's convergence rate. Such strategies are pivotal in managing bandwidth properly, ensuring that federated learning remains both scalable and effective across devices and networks (Kairouz et al., 2019).

Hence, personalization in a federated learning setting becomes very attractive since one can get the benefit of the model of the federated network fit to each user. An important contribution to this field was made by Tian Li and colleagues [12] when they suggested the use of a meta-learning approach to aid the creation of a personalized model for each client. One of the key aspects of this factoring adaptability is that even federated learning must be customizable to adapt effectively under the consideration of scenarios in the service areas, where user behaviour across regions deviates greatly.

Bandwidth management has been a crucial and extensively researched aspect in the scalability and viability of federated learning. The alleviation occurs through the transmission of only the most prominent updates or by reducing the precision of the data transmitted to relieve the burden on network resources, hence making federated learning more practical in environments with limited bandwidth. Furthermore, Jianqiao Wangni [13] has developed a communication-efficient optimization algorithm on SignSGD, when only the sign of incoming gradients is shared between the devices, with a very significant decrease in the transferred data volume, and the model learning is almost not influenced (Wangni et al., 2018).

Among the problems of secure aggregation of updates of models, work on the above problems has also been done by Kallista Bonawitz [14] and associates. They built a secure aggregation protocol that would ensure the server at the center would only receive the aggregated updates of all the participating devices, hence protecting individual contributions. This is actually one of the basic requirements for maintaining any form of trust within federated learning systems, especially when sensitive data is involved (Bonawitz et al., 2017). The recent work of Qiang Yang and Peter Kairouz [15] is helpful for those who aim to get the full picture of the current status of federated learning.

They provide not only detailed descriptions of the latest progress but also highlight open challenges of improving its communication efficiency, privacy, and model personalization in FL (Yang and others, 2019; Kairouz and others, 2021).

Methodologies for Efficient Bandwidth Management in Federated Learning

Federated learning faces significant challenges, particularly with managing bandwidth due to the frequent and large exchanges of model updates. To address these challenges, several methods have been developed, focusing on improving communication efficiency and managing data distribution. Here are some of the basic methods used in this topic:

Model Compression Techniques

In order to save bandwidth, model compression techniques are need to reduce the number of model updates delivered from clients to the central server. Pruning, as discussed by Han et al. (2016) [16], involves removing unnecessary weights from the neural network without significantly impacting performance. By eliminating less significant weights or nodes, the model becomes sparser and more efficient. For instance, if a neural network initially has 1,000 connections, pruning might remove 500 of the least important ones, effectively halving the model size. Another technique is quantization, which lowers the model parameters' precision to need less data. Data size can be decreased by a factor of four by converting weights and activations from 32-bit floating-point numbers to 8-bit integers, as noted by Gupta et al. (2022) [17]. This essentially means that a weight is transmitted as an 8-bit integer rather than a 32-bit floating-point value.

Sparse updates, although not specifically covered in the provided studies, are a well-established concept in the literature. This technique involves transmitting only the changes in model weights that exceed a certain threshold, significantly reducing communication by sending updates only for parts of the model that have experienced substantial changes. For example, if only 10% of model weights change significantly during training, only these changes are transmitted, potentially reducing communication by up to 90%.

Adaptive Protocols

Adaptive protocols play a crucial role in optimizing communication processes in federated learning systems by dynamically adjusting based on real-time network conditions and client availability. Dynamic client selection, as discussed by Kairouz et al. (2021) [18], involves choosing a subset of clients with optimal connectivity for each training round, thus avoiding delays and reducing bandwidth usage. Their review highlights the effectiveness of this approach in improving communication efficiency by selecting clients with the best network conditions ("Advances and Open Problems in Federated Learning"). Chen (2023) [19] examined adaptive frequency, It modifies the frequency of model updates based on network circumstances and the model's rate of convergence. During periods of high network traffic, this method helps manage congestion by reducing the update frequency to prevent network overload ("Federated Learning Architecture to Integrate AI Models from Different Internet Service Providers: Using Bandwidth Slicing Resource Management as Case Study," *Journal of Computer Networks and Communications*). These studies demonstrate how adaptive protocols, including dynamic client selection and adaptive frequency, improve federated learning effectiveness by adjusting communication according to the situation.

Network Innovations

Network innovations are critical for enhancing the communication infrastructure and protocols in federated learning systems. Hierarchical federated learning, as described by Yang et al. (2019) [20], organizes clients into hierarchical structures to reduce the communication burden on the central server. By grouping clients into clusters with local aggregators, the number of direct connections to the central server is minimized. For example, in a company with multiple branches, each branch could have a local aggregator that consolidates updates and communicates with the central server, effectively lowering the communication load ("Federated Machine Learning: Concept and Applications," * 2019 International Conference on Machine Learning*).

Asynchronous communication allows clients to send updates independently rather than synchronizing all clients at once. This method enables clients to transmit updates based on their local schedules, such as clients in different time zones sending updates when they finish their training rounds. Zhao et al. (2022) [21] highlight the advantages of this approach in managing communication delays and improving scalability ("Federated Learning with Non-IID Data: A Survey"). By streamlining communication protocols and lightening server load, these network innovations—such as hierarchical structures and asynchronous communication—improve the effectiveness and scalability of federated learning systems.

Data and Model Optimization

Optimizing how data is handled and how models are trained can also contribute to more efficient bandwidth use. By combining model updates from clients, Federated Averaging (FedAvg), a key approach in federated learning, improves communication efficiency. According to Kairouz et al. (2021) [22], FedAvg operates by having each client compute its local model updates, which are then transmitted to a central server. Then server averages these updates and makes use of the average to the global model. For example, if three clients each send their model updates, the server calculates the average of these and updates the global model accordingly. The total amount of data that needs to be conveyed is greatly decreased by using this strategy, thus minimizing communication overhead and improving system efficiency ("Advances and Open Problems in Federated Learning"). FedAvg is widely recognized for its effectiveness in managing data transmission in federated learning environments. A method called knowledge distillation uses the information coming from a bigger, previously trained model to train a smaller, more effective model. This method works by having a smaller model, known as the student, learn to replicate the behavior of a larger model, or teacher, by training on the outputs generated by the teacher model. For instance, a lightweight student model might be used on a mobile device, while a more complex teacher model operates on a server, providing the necessary outputs for the student model to learn from. This approach enables the deployment of efficient models in resource-constrained environments without sacrificing performance. The effectiveness of knowledge distillation in federated learning contexts is discussed by Yang et al. (2019), who explore its applications and benefits in making advanced models more accessible and efficient across different devices ("Federated Machine Learning: Concept and Applications").

Privacy-Preserving Techniques

Ensuring data privacy while optimizing communication efficiency is also a key consideration in Federated Learning concept. Differential privacy is the technique designed in order to safeguard the confidentially of individual data points by adding noises to model updates. This method involves applying mathematical techniques to ensure that the contribution of any single data point is obscured by random noise, making it difficult to trace specific details back to any individual. For example, before transmitting model updates, a client's data may be modified with random noise to mask its origin, thus preserving privacy. Kairouz et al. (2021) discuss differential privacy in their review of federated learning advancements, highlighting its importance in maintaining privacy while still allowing for effective model training ("Advances and Open Problems in Federated Learning"). This method is essential for protecting private data in federated learning systems.

While protecting the anonymity of their inputs, multiple participants can collaborate to jointly calculate a function over those inputs through the use of secure multiparty computing (SMPC). This method employs cryptographic techniques to ensure that no single party has access to all the data, thus preserving privacy throughout the computation process. For example, multiple hospitals can collaborate to train an artificial intelligence model using patient data without actually sharing the individual datasets with one another. This technique is essential for maintaining data confidentiality while enabling collaborative learning. Kairouz et al. (2021) discuss the application of secure multiparty computation in federated learning contexts, emphasizing its role in facilitating privacy-preserving data collaborations ("Advances and Open Problems in Federated Learning").



CONCLUSION

The bandwidth-efficient management is one of the core elements that shall set federated learning free with its full power, especially as it has always been progressing toward real-world applications. By reducing the communication overhead, data transmission optimization can enhance the distributed learning paradigm's inclusivity and scale. This is going to be very instrumental not only to large-scale AI models but democratizes leading-edge technologies, thereby being more available for lower-end devices. This points to a future of bandwidth management in federated learning driven by adaptive techniques that react in real time to network conditions, with the development of algorithms driving prioritization of essential data without model-accuracy compromise. Other technologies that could be utilized and incorporated to further drive down latency and improve communication efficiency are emerging 5G and edge computing, hence making federated learning systems seamless and responsive. In improving such methods, we should not turn our backs on the ethical considerations at stake but work towards efficient, more equitable, transparent, and fair systems for all, so that the fruits of federated learning are realized by all.

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Table 1: Literature Review

Sl. No.	Author(s)	Year	Title	Dataset Details	Parameter/Measurement Used	Description
1	Yen-Hung Chen	2023	Federated Learning Architecture to Integrate AI Models from Different Internet Service Providers: Using Bandwidth Slicing Resource Management as Case Study	MCTS-level, Self-Adaptive Learning (SAL) method	The level of MCTS is a key parameter that blends sampling techniques with decision trees to approximate optimal solutions for bandwidth slicing, with a higher level MCTSindicating greater throughput and a more thorough investigation of solutions using the Monte Carlo Tree Search (MCTS)	Explores the development of efficient bandwidth slices by cooperation of several Internet service providers (ISPs) using AI-based techniques
2	Wen, J., Zhang, Z., Lan, Y., Cui, Z., Cai, J., & Zhang, W.	2023	A Survey on Federated Learning: Challenges and Applications	CIFAR-10, MNIST, and various benchmark datasets.	Challenges in FL, applications	Provides a comprehensive overview of FL, focusing on challenges, application, and techniques for improving communication efficiency and managing bandwidth

3	Kartik Gupta, et.al	2022	Quantization Robust Federated Learning for Efficient Inference on Heterogeneous Devices	ImageNet, CIFAR-10	Quantization Robustness, Inference Efficiency, Model Accuracy	Implementation of quantization techniques that reduce the size of the model parameters to improve communication efficiency and reduce the computational burden during inference
4	Yue Zhao, Rongbin Zhang, Songzhu Zheng, Hengshu Zhu	2022	Federated Learning with Non-IID Data: A Survey	Non-IID synthetic datasets, CIFAR-10, MNIST	Data distribution, model accuracy, convergence rate	Surveys challenges and solutions for federated learning with non-IID, or identically distributed but not independentdata, focusing on dispersion of data impacts on model accuracy and convergence.
5	Peter Kairouz, H. Brendan McMahan, Brendan Avent, et al.	2021	Advances and Open Problems in Federated Learning	CIFAR10, MNIST, synthetic data	Scalability, communication cost, model accuracy	Reviews recent advances in federated learning, highlighting open problems and future directions, particularly focusing on scalability and communication cost reduction.

6	Qiang Yang, Yang Liu, Tianjian Chen, Yongxin Tong	2019	Federated Machine Learning: Concept and Applications	CIFAR10, MNIST, health care datasets	Model performance, communication efficiency, privacy preservation	Discusses the foundational concepts of FL, it's potential applications across a range of fields, and key challenges such as communication efficiency and privacy preservation.
7.	Jacob et al.	2018	Quantization and Training of Neural Networks for Efficient Integer-Arithmetic-Only Inference	ImageNet, CIFAR-10	Quantization error, model efficiency	Focuses on Quantization methods for shrinking the model's size updates for efficient federated learning.
8.	Li, T., Sahu, A. K., Talwalkar, A., & Smith, V.	2018	Federated Learning: Challenges, Methods, and Future Directions	MNIST, CIFAR-10	Convergence rate, communication efficiency, scalability	Provides a comprehensive overview of federated learning challenges including communication efficiency, and presents potential solutions and future research directions.
9	Pham et al.	2018	Neural Architecture Search with Reinforcement Learning	CIFAR-10, ImageNet	NAS efficiency, model performance	Uses NAS techniques to design efficient model architectures for FL.

10.	McMahan et al.	2017	Communication-Efficient Learning of Deep Networks from Decentralized Data	CIFAR-10, MNIST	Communication cost, model accuracy	Introduces Federated Averaging (FedAvg) to reduce communication costs in federated learning with decentralized data.
11.	McMahan, H. B., Moore, E., Ramage, D., & Hsieh, C. J.	2017	Communication-Efficient Learning of Deep Networks from Decentralized Data	CIFAR-10, MNIST, other benchmark datasets.	Communication cost, convergence efficiency, model performance	Proposes Federated Averaging, a key federated learning algorithm that reduces the volume of information that clients and servers must exchange.
12.	Ruder	2017	An Overview of Multi-Task Learning in Deep Neural Networks	Various datasets	Multitask learning performance, efficiency	Provides an overview of multitask learning approaches that can be applied to federated learning for diverse tasks.
13.	Han et al.	2016	Deep Compression: Compressing Deep Neural Networks with Pruning, Trained Quantization, and Huffman Coding	CIFAR-10, ImageNet	Model size reduction, accuracy	Proposes deep compression techniques including pruning and quantization to reduce model size and communication bandwidth.

14.	Konečný et al.	2016	Federated Learning: Strategies for Improving Communication Efficiency	MNIST, CIFAR-10	Communication efficiency, model accuracy	Discusses various strategies for improving communication efficiency in federated learning setups.
15.	Hinton et al.	2015	Distilling the Knowledge in a Neural Network	MNIST, CIFAR-10	Knowledge transfer efficiency, accuracy	Introduces knowledge distillation to create smaller, efficient models for federated learning.

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RESEARCH ARTICLE

Nano Targeted Gene Delivery: Advances, Challenges and Future Directions

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ABSTRACT

Nano targeted gene delivery stands as a pivotal innovation in the realm of gene therapy, offering a transformative approach to treating an array of diseases including cancer, genetic disorders, and infectious diseases. This review elucidates the significant strides made in nanotechnology for gene delivery, highlighting the design and application of various nanomaterials such as liposomes, dendrimers, and nanoparticles. These nanocarriers are engineered to enhance the precision, efficacy, and safety of gene delivery, addressing the cellular and molecular intricacies of targeted therapy. Despite the progress, the field grapples with challenges including technical hurdles in nanocarrier design, biological barriers like immune response and targeting accuracy, and ethical and regulatory considerations. Looking forward, the integration of artificial intelligence and interdisciplinary strategies promises to propel the field, optimizing nanocarrier design and broadening the scope of gene therapy applications. The convergence of these advancements heralds a new era in healthcare, where nano targeted gene delivery could revolutionize personalized medicine and offer hope for previously intractable conditions.

Keywords: Nano targeted gene delivery, Nanotechnology, Gene therapy, Personalized medicine, Nanocarriers.

INTRODUCTION

Overview of gene therapy and its significance in modern medicine

Gene therapy represents a groundbreaking approach in modern medicine, offering potential treatments for a range of genetic disorders, cancers, and infectious diseases that were once deemed incurable. By directly modifying the genetic material of a patient's cells, gene therapy can address the root causes of diseases at the molecular level(1). This approach can lead to long-lasting and potentially curative outcomes, distinguishing it from traditional therapies that often only treat symptoms. The significance of gene therapy extends beyond individual patient benefits, as it also has the potential to reduce long-term healthcare costs and improve overall public health outcomes. (2).The success of gene therapy in treating disorders like spinal muscular atrophy and certain forms of inherited blindness has garnered significant attention, demonstrating its potential to transform medical treatments and offering hope to patients with limited therapeutic options(3).

Nanotechnology in gene delivery

Nanotechnology has revolutionized the field of gene therapy by providing advanced tools for delivering therapeutic genes to specific cells and tissues. At the nanoscale, materials exhibit unique properties that can be harnessed to encapsulate and protect genetic material, control its release, and target its delivery with unprecedented precision(4). Nanocarriers, such as nanoparticles, liposomes, and dendrimers, can be engineered to overcome biological barriers, enhance cellular uptake, and improve the stability of genetic therapies. This nanoscale approach to gene delivery not only increases the efficiency of gene transfer but also minimizes off-target effects, thereby enhancing the safety profile of gene therapies. As nanotechnology continues to evolve, it is paving the way for more sophisticated and personalized gene therapy applications(5).

Importance of targeted gene delivery in enhancing the efficacy and safety of gene therapy

Targeted gene delivery is a critical aspect of gene therapy that ensures therapeutic genes reach their intended cells or tissues without affecting others, thereby maximizing therapeutic efficacy and minimizing side effects. This precision is crucial, especially in complex diseases like cancer, where it's essential to distinguish between healthy and diseased cells(6). Targeted delivery systems can recognize specific cell markers, facilitating the selective introduction of genetic material into diseased cells while sparing healthy ones. This targeted approach not only enhances the effectiveness of gene therapy but also significantly reduces the risk of unintended interactions, which can lead to adverse effects. As research progresses, the ability to target genes more accurately will be pivotal in expanding the therapeutic potential of gene therapy across a broader range of conditions(7).

Objectives and scope of the review

The objective of this review is to provide a comprehensive overview of the current advances, challenges, and future directions in nano targeted gene delivery. By exploring the integration of nanotechnology with gene therapy, this review aims to elucidate how nanoengineering advances are enhancing the precision, efficacy, and safety of gene delivery methods(8). The scope includes an examination of the various nanocarriers and targeting strategies employed, an analysis of the current clinical and preclinical applications, and a discussion of the technological and biological hurdles facing the field. Additionally, the review will explore future prospects, highlighting emerging trends and potential interdisciplinary collaborations that could drive the next wave of innovations in nano targeted gene delivery(9). Through this, the review intends to provide valuable insights for researchers, clinicians, and policymakers involved in the development and application of these transformative medical technologies(10).

Advances in Nano Targeted Gene Delivery

Summary of recent advancements in nanotechnology for gene delivery

Recent advancements in nanotechnology for gene delivery have centered on the development of innovative nanocarriers that offer enhanced delivery efficiency, improved targeting capabilities, and increased gene expression control. Scientists have engineered nanoparticles with stimuli-responsive features, allowing them to release their

genetic cargo in response to specific cellular or tissue environments(11). There's also significant progress in designing multifunctional nanosystems that integrate diagnostic and therapeutic functions, enabling real-time monitoring of gene delivery and expression. Advances in surface engineering have led to the development of nanocarriers with improved biocompatibility and reduced immunogenicity, facilitating their safe use in clinical applications(12). Additionally, the integration of nanotechnology with CRISPR-Cas systems represents a cutting-edge advancement, offering precise and efficient gene editing capabilities that hold promise for correcting genetic disorders at their source.

Description of various nanomaterials used for targeted gene delivery

Liposomes, spherical vesicles consisting of one or more phospholipid bilayers, have been extensively used for gene delivery due to their biocompatibility and ability to encapsulate both hydrophilic and hydrophobic substances. Dendrimers, highly branched, star-shaped macromolecules, offer a high degree of surface functionality that can be tailored for targeted delivery, enabling them to bind to specific cell surface receptors(13). Nanoparticles, including metallic nanoparticles, polymeric nanoparticles, and solid lipid nanoparticles, provide versatile platforms for gene delivery, with customizable sizes, shapes, and surface properties to enhance cellular uptake and targeting. Quantum dots and carbon nanotubes have also been explored for their unique optical and electrical properties, respectively, contributing to the broad spectrum of nanomaterials available for targeted gene delivery applications.(14)

Mechanisms of targeted gene delivery at the cellular and molecular levels

Targeted gene delivery at the cellular and molecular levels involves several key mechanisms. Ligand-receptor interactions are commonly used, where the surface of nanocarriers is modified with ligands that specifically bind to receptors on target cells, enhancing uptake via receptor-mediated endocytosis. Another approach is the use of cell-penetrating peptides that facilitate the direct translocation of genetic material across the cell membrane.(15) Additionally, environmentally responsive nanocarriers can alter their behavior in response to specific cellular or tissue stimuli, such as pH or enzyme presence, to enhance gene release at the target site. These mechanisms ensure that the genetic material is not only delivered efficiently to the target cells but is also released in a controlled manner, optimizing the gene therapy's therapeutic effect.

Highlighting key studies and breakthroughs in the field

Key studies in nano targeted gene delivery have demonstrated significant breakthroughs, such as the successful use of lipid nanoparticles to deliver mRNA in COVID-19 vaccines, showcasing the potential of nanotechnology in rapid vaccine development. Another notable breakthrough is the use of polymer-based nanoparticles to deliver CRISPR-Cas9 components, enabling precise gene editing in vivo.(16) Studies involving the use of magnetic nanoparticles for targeted gene delivery under the guidance of external magnetic fields have opened new avenues for localized gene therapy. Additionally, the development of biodegradable nanocarriers addresses long-standing concerns regarding the long-term safety and environmental impact of nanomaterials. These studies not only highlight the potential of nano targeted gene delivery in treating a variety of diseases but also underscore the field's rapid evolution and its readiness to address emerging healthcare challenges.(17)

Applications of Nano Targeted Gene Delivery

Therapeutic applications in various diseases such as cancer, genetic disorders, and infectious diseases

Nano targeted gene delivery has revolutionized the treatment landscape for several challenging diseases. In cancer therapy, nanocarriers are designed to target tumor cells selectively, reducing the systemic side effects of conventional chemotherapy and increasing the therapeutic efficacy of gene-based treatments(18). For genetic disorders, such as cystic fibrosis or muscular dystrophy, nano targeted delivery systems offer a promising approach to correct defective genes directly within the affected tissues. Infectious diseases also benefit from this technology, where targeted gene delivery can be used to enhance the immune response against pathogens or disrupt the genetic machinery of viruses and bacteria, providing a novel approach to treatment beyond traditional vaccines and antimicrobials(19).

Role in personalized medicine and tissue engineering

In personalized medicine, nano targeted gene delivery systems enable the tailoring of therapies to individual patients based on their genetic makeup, improving treatment outcomes and minimizing adverse effects(20). This precision approach ensures that patients receive the most effective gene therapies based on their unique genetic profiles and disease characteristics. In tissue engineering, nanotechnology facilitates the delivery of genes that promote tissue regeneration and repair, offering innovative solutions for regenerative medicine. By precisely controlling the release and localization of therapeutic genes, nano targeted delivery systems can significantly enhance tissue engineering strategies, contributing to the development of engineered tissues and organs with improved functionality and integration with the host(21).

Discussion on the clinical trials and approved therapies using nano targeted gene delivery

Several clinical trials have underscored the potential of nano targeted gene delivery in various therapeutic areas. For example, clinical trials involving nanoparticle-mediated delivery of nucleic acids have shown promise in treating genetic diseases and cancers. One of the landmark successes in the field is the use of lipid nanoparticles in the delivery of mRNA vaccines for COVID-19, representing one of the first widespread clinical applications of nano targeted gene delivery(22). Additionally, there are ongoing trials exploring the efficacy of nanoparticle systems in delivering gene-editing tools like CRISPR-Cas9 to treat inherited genetic disorders. Although the number of approved nano targeted gene therapies is still limited, the successful outcomes of these trials indicate a promising future for the approval and clinical use of such advanced therapeutic modalities, potentially transforming the treatment paradigm for many incurable and chronic diseases.

Challenges in Nano Targeted Gene Delivery

Technical challenges in design and manufacturing of nanocarriers

The design and manufacturing of nanocarriers for targeted gene delivery pose significant technical challenges due to the complex requirements for efficacy, safety, and stability. Creating nanocarriers with precise size, shape, and surface characteristics is crucial for their biological function and distribution in the body. Ensuring uniformity and scalability in production is another major challenge, as inconsistencies can affect the clinical outcomes and feasibility of large-scale manufacturing(23). Additionally, the stability of nanocarriers during storage and upon administration needs to be meticulously optimized to prevent premature release or degradation of the encapsulated genetic material. Addressing these technical challenges requires advanced fabrication techniques, thorough characterization, and robust quality control measures to ensure the consistent performance and reliability of nanocarriers in clinical settings.

Biological challenges such as immune response, targeting accuracy, and gene expression control

Biological challenges are significant in the development of nano targeted gene delivery systems. The immune response to nanocarriers can lead to rapid clearance or potential adverse reactions, which necessitates the design of stealthy nanoparticles that can evade the immune system. Achieving high targeting accuracy to ensure that the gene therapy reaches the intended cells or tissues without affecting healthy ones is another critical challenge(24). This requires the development of sophisticated targeting ligands and the understanding of the dynamic biological environment in which these nanocarriers operate. Furthermore, controlling the expression of the delivered gene is paramount to ensure therapeutic efficacy and prevent potential off-target effects or gene overexpression, which necessitates the incorporation of regulatory elements and controlled release mechanisms in the design of nanocarriers(25).

Ethical, regulatory, and safety concerns

Ethical and regulatory challenges are inherent in the development and implementation of nano targeted gene delivery systems. The long-term safety of nanocarriers, potential off-target effects, and the implications of gene editing are major ethical concerns that need to be addressed. Regulatory bodies are tasked with establishing guidelines and approval processes that ensure the safety and efficacy of these advanced therapeutic technologies(26). The regulatory landscape must adapt to the rapid advancements in nanotechnology and gene therapy, ensuring that

these innovations benefit patients while upholding ethical standards(27). Additionally, there is a need for comprehensive safety evaluations, including the assessment of long-term effects and the potential impact of nanoparticles on the environment. Addressing these ethical, regulatory, and safety concerns is crucial for maintaining public trust and facilitating the successful integration of nano targeted gene delivery into clinical practice.

Future Direction

Emerging trends and technologies in nano targeted gene delivery

The future of nano targeted gene delivery is poised to be shaped by several emerging trends and technologies. One significant trend is the development of smart nanocarriers that can respond to specific stimuli (e.g., pH, temperature, enzymes) present in the disease microenvironment, enabling precise control over gene release(28). Another promising area is the use of exosome-based delivery systems, leveraging nature's own method of intercellular communication to transport genetic material. There's also increasing interest in developing hybrid nanosystems that combine organic and inorganic materials to leverage the advantages of each, enhancing targeting capabilities and biocompatibility(29). Furthermore, advancements in 3D bioprinting technology are expected to play a crucial role in creating complex tissue models for testing and optimizing nano targeted gene delivery systems.

The potential of integrating AI and machine learning for the design and optimization of nanocarriers:

Artificial intelligence (AI) and machine learning (ML) offer transformative potential for the design and optimization of nanocarriers in gene delivery. These technologies can analyze vast datasets to predict the behavior and efficacy of nanocarriers in biological systems, speeding up the design process and identifying optimal formulations with improved precision(30). AI can also facilitate the modeling of nanocarrier interactions with cells and biological barriers, enhancing our understanding of their biodistribution and pharmacokinetics. Furthermore, machine learning algorithms can assist in identifying novel biomaterials and surface modifications to improve the targeting and biocompatibility of nanocarriers, ultimately leading to more effective and safer gene delivery systems(31).

Interdisciplinary approaches involving material science, biology, and engineering

The future advancements in nano targeted gene delivery will increasingly rely on interdisciplinary approaches that merge insights and methodologies from material science, biology, and engineering. Material scientists contribute by designing and synthesizing novel nanomaterials with tailored properties for gene delivery(32). Biologists play a crucial role in understanding the cellular and molecular mechanisms that underpin the interaction between nanocarriers and biological systems. Engineers apply principles of nanotechnology and biotechnology to develop scalable and reproducible manufacturing processes for nanocarriers(33). This collaborative approach fosters innovation and accelerates the translation of nano targeted gene delivery systems from the laboratory to clinical applications, offering new solutions for challenging medical conditions and opening new avenues for personalized medicine(34).

CONCLUSION

Summarize the current status of nano targeted gene delivery

The field of nano targeted gene delivery is at a promising juncture, having made significant strides in addressing complex medical challenges. Advancements in nanotechnology have enabled the development of sophisticated nanocarriers capable of delivering genetic material with unprecedented precision and efficiency. These innovations have found applications across various domains, including cancer therapy, genetic disorders, and infectious diseases, demonstrating potential to fundamentally transform treatment paradigms. Despite these advances, the field is still evolving, with ongoing research focused on enhancing the specificity, safety, and efficacy of gene delivery systems.

Reiterate the importance of overcoming current challenges for future advancements

To realize the full potential of nano targeted gene delivery, it is imperative to address the existing technical, biological, and regulatory challenges. Overcoming technical hurdles related to the design, manufacturing, and characterization of nanocarriers is crucial for ensuring their performance and reproducibility. Addressing biological challenges, such as immune response, targeting accuracy, and gene expression control, is essential for enhancing the efficacy and safety of gene therapies. Additionally, navigating ethical and regulatory landscapes is vital to ensure that these advanced technologies are safely and effectively translated into clinical practice, benefiting patients while adhering to the highest standards of medical ethics.

Final thoughts on the potential impact of these advancements on healthcare

The advancements in nano targeted gene delivery hold transformative potential for healthcare, offering new avenues for the treatment of diseases that were once considered untreatable. By enabling precise and efficient delivery of therapeutic genes, this technology has the potential to revolutionize personalized medicine, providing treatments tailored to individual genetic profiles. Moreover, the integration of emerging technologies like AI and interdisciplinary approaches will further accelerate the development of innovative solutions, enhancing patient outcomes and healthcare efficiency. As the field continues to evolve, it is poised to play a pivotal role in shaping the future of medical treatments, ultimately leading to a new era in healthcare where gene therapy becomes a cornerstone of medical practice.

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Table 1: Nanomaterials Used in Nano Targeted Gene Delivery

Nanomaterial	Properties	Applications
Liposomes	Biocompatible vesicles; encapsulate hydrophilic and hydrophobic substances	Widely used in gene delivery for various diseases
Dendrimers	Highly branched, star-shaped macromolecules with surface functionality	Targeted gene delivery to specific cell types
Nanoparticles	Customizable size, shape, and surface properties; includes metallic, polymeric, and solid lipid nanoparticles	Versatile platforms for gene delivery, enhancing cellular uptake and targeting
Quantum Dots	Possess unique optical properties	Studied for targeted gene delivery and imaging
Carbon Nanotubes	Known for their unique electrical properties	Investigated for their potential in gene delivery

Table 2: Challenges and Future Directions in Nano Targeted Gene Delivery

Challenge/Future Direction	Description
Technical Challenges	Includes issues in design, manufacturing, and characterization of nanocarriers, needing advanced techniques for consistent performance.
Biological Challenges	Encompasses immune response, targeting accuracy, gene expression control, necessitating sophisticated targeting ligands and understanding of biological interactions.
Ethical and Regulatory Considerations	Involves addressing long-term safety, potential off-target effects, and compliance with evolving regulatory standards.
Integration of AI and Machine Learning	Utilizing AI and ML for optimizing nanocarrier design, predicting behavior, and enhancing the efficiency of gene delivery systems.
Interdisciplinary Approaches	Combining insights from material science, biology, and engineering to innovate and accelerate the translation of nano targeted gene delivery systems into clinical applications.

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RESEARCH ARTICLE

A Deep Learning Framework for Medical Imagineering Precision Liver Tumor

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ABSTRACT

Surgeons' planning depends on precisely differentiating between hepatic and liver cancers in CT scans. Manual liver tumor extraction from CT scans is difficult, time-consuming, and dependent on clinical knowledge, though, given the blurry boundaries and low contrast between healthy and malignant tissue. Automated means to classify liver and hepatic cancers into different categories will help to improve surgical planning, treatment, and follow-up care. This work offers a user-friendly method for locating malignancies in the liver on CT scans. The suggested system makes use of region-based segmentation methods and ResUNet architecture. The procedure starts with portions of the liver being divided and subsequently finds malignancies inside the hepatic capsule. While region-level segmentation significantly enhances the general quality of the segmentation map, ResUNet—a network trained on annotated CT scans—accurately predicts the location of liver tissue. The publicly accessible 3D-IRCADb dataset is used in evaluation of the model. The Dice coefficient and volumetric overlap error (VOE) assessed the suggested method's performance. For the tumor, the ResUNet model scored 0.96; for the liver, it scored 0.97. It also dropped the VOE for the tumor to 0.615 and for the liver to 1.90.The ResUNet model suggested in this work shows better performance than before described techniques. The accuracy and output quality are much improved by using U-Net into the building of the model.

Keywords: blurry boundaries, techniques, VOE, cancers, ResUNet, architecture.

INTRODUCTION

According to the World Health Organization (WHO), liver tumors are one of the worst types of cancer. Each year, they cause about 8.5 million new cases and almost 7 million deaths. The American Cancer Society projects that 41,210 fresh instances of primary liver cancer will arise in the United States in 2023, leading to 29,380 fatalities [1]. These numbers point to an increasing incidence of liver cancer in general. One often utilized method for liver cancer detection and liver segmentation is computed tomography (CT) imaging [2]. Still, manually spotting liver tumors from CT scans is a time-consuming task mostly dependent on operator skill and expertise. Thus, enabling doctors to precisely identify liver cancer depends on the development of a competent computer-aided diagnosis (CAD) system. Comprising a right lobe and a left lobe, the liver links itself to the gallbladder, pancreas, and intestines. Two key causes of its cancer susceptibility are the high density of liver cells and the possibility for malignant cells to spread from other body parts.

Figure 1 shows patients with liver cancer broken out by stage. Automatic liver tumor segmentation is used in medical imaging is a method used to precisely identify, classify, and isolate liver tissue from surrounding tissues, so separating cancerous from healthy cells. Training deep learning models on a vast collection of precisely labeled liver and tumor segments, annotated by medical professionals including doctors and radiologists, is an effective strategy. These models can be included into software or computer-aided diagnosis systems following exhaustive testing and validation. Without depending on medical professionals, developing a precise and efficient liver tumor segmentation algorithm can result in major savings in both cost and time as well as the possible to save lives [3]. Two key types of current deep learning segmentation methods are 3D-FCN, which employs 3D convolutions instead of the conventional 2D convolutions [4] and fully convolutional networks (FCN), which comprise U-Net, multi-channel FCN, and VGG-based FCN. An individual's life expectancy is largely influenced by the location of cancer inside the body (as depicted in Figure 1) and determines treatment choices. Usually referred to as stage 1, cancer is often categorized as localized when it stays limited to its original place within the body. Should the cancer have progressed to other areas of the body, it is classified as regional or distant. Early liver cancer diagnosis greatly increases the likelihood of survival five years following diagnosis [5]. This localized stage of diagnosis accounts for 44.6 percent of liver and intrahepatic bile duct cancers.

LITERATURE REVIEW

Deep learning (DL) and medical imaging have had notable developments recently [6–8]. Extensive studies have concentrated on employing medical imaging methods coupled with deep learning models including convolutional layers to detect cancer or tumors. Researchers Sharma et al. [9] used machine learning (ML) techniques called random forest (RF) and k-nearest neighbor (k-NN) to figure out which women were most likely to get breast cancer. In a different study, Khari et al. [10] used CNNs to find brain tumors. [11] examined several machine learning methods closely for brain tumor detection and classification. Tumours are sometimes split in surgical operations into smaller pieces. Monitoring treatment progress over time depends on accurate knowledge about the location and shape of the tumor, which will help doctors to maximize therapy methods for several phases of liver cancer. Liver cancer can be broken up for study into several sections. Roy et al. [12] suggested a method to distinguish liver cancer nuclei by means of histomorphology scans and edge detection Anter et al. [13] investigated extensively the use of machine learning (ML) methods to enhance the identification of liver tumors. Another work [14] showed that deep learning can cluster and categorize liver cancers rather successfully. Using common image processing, computer vision, and machine learning methods, CT picture features like pixel intensities, color, texture, tumor size, and shape are put together [15]. These traits are then used using a classifier technique to find segmentation pictures. CNNs vary between high-level and low-level characteristics of CT images by means of several convolutional layers [16, 17]. Crucially, the creation of a specific Computer-Aided Design (CAD) system for liver cancer detection calls for [18]. There are several deep learning models at hand to help with this work. Figure 2 offers a summary of the approaches

covered in different research projects. ML [19–21], clustering, graph-cut, and other semi-automatic liver tumor segmentation models [22–24] have been extensively studied.

APPROACH

This work explain a method based on systematic deep learning to effectively differentiate hepatic malignancies from liver tissue in CT scan pictures. The research turned out numerous important results: By increasing the amount of image samples, I. Data augmentation methods include rotation, flipping, zooming, cropping, and color corrections provide variety into the dataset. II. Reducing the kernel count in every convolution layer greatly speeds up the learning process of the network, therefore enabling its more effective use of the given input. III. The method discards frames without tumor pixels and keeps those with all the necessary information, hence improving tumor detection in CT images. This procedure helps to reduce the performance difference among students from many backgrounds. Figure 3 shows the suggested architectural sequential flow. The structure uses these guidelines: Raw CT scan images make up the dataset; these are filtered and standardized during pre-processing to eliminate extraneous noise. IV. ReLU activation function followed by batch normalisation (BN) is applied during encoding process. Semantic meaning of the image is captured by the encoder in segmentation. While max-pooling shrinks the size of feature maps through downsampling, convolutional layers offer thorough information about the background. Following the convolution and ReLU activation layers are introduced max-pooling layers. Between the encoder and decoder, this intermediary layer forms a bottleneck. Considered the bottleneck layer, it comprises two convolutional layers after a batch normalisation layer. This layer mostly serves to find and extract intricate visual elements from the image. Situated halfway between the encoder and decoder paths, it lets the network mix finely-grained geographical features with semantically rich information.

The decoder consists in four upsampling and decoding phases. The deconvolution or up-convolution layers in these blocks bring back feature maps to their original sizes and provide additional spatial information about the segmented image. There are two up-convolution layers in each stage, with layers from the encoder scattered throughout the expanding path layers. The background is separated from the liver and tumor using a sigmoid activation function in final stage. Figure 5 shows a flowchart of the suggested method including pictures.

Instructed and Evaluated The Binary Deep Neural Network (DNN) Classifier

The ResUNet model is made up of an input layer, three hidden layers for both the contraction and expansion paths, and an output layer. The output layer contains two nodes, but the input layer has 26 nodes.The three secret levels have 20, 30, and 15 nodes, respectively. Each neuron in the network is first assigned arbitrary weights and biases.

The Rectified Linear Unit (ReLU) activation function transports gradients from each neuron to the hidden layers. Assume X to be the input image matrix; W the weight matrix; B the bias matrix. Every neuron then generates an output signal expressed as a matrix. ReLU activation function defines the maximum of 0 and the input value (Y), therefore determining the output of a neuron. L2 regularization—adding a term of ½ μw^2 to every computed network weight—is used to prevent overfitting. This work employs cross-entropy as the loss function for the binary classification challenge. The network is trained using the stochastic gradient descent (SGD) optimizer, with backpropagation used to change the weights. The process of instruction go on until the mistake is reduced. Then, the trained deep neural network (DNN) classifier's weights and parameters are stored to assess the network on test data.

Data Set

CT scan pictures [25] carefully annotated by medical experts to distinguish and identify different anatomical components make up the 3D-IRCADb database. Three-dimensional computed tomography (CT) scans of ten male and ten female livers are in the collection. Line spacing ranges from 0.57 to 0.87 mm; the slices are 1.6 to 4 mm apart. Throughout the acquisition of these CT scans, the subjects were in the "inhaling" posture. Ten scans make up the training set of data; five scans constitute the test set. Trained on photos of different sizes, the model shows better performance on 512x512 images than lower-resolution ones with a 2% and 7% increase in accuracy correspondingly separating liver tissue from malignancies. Down sampling lowers tumor segmentation's accuracy. Consequently,

images with a 512x 512 resolution train and test the models. Given their identical resolution, the accuracy is much enhanced from both datasets.

FINDINGS AND ANALYSIS

The outcomes of modeling and applying the grading and segmentation techniques are covered in this chapter. Specifically a 64-bit i5 CPU with a clock speed of 3.6 GHz and 8 GB of RAM, a Python application was used to replicate a computer system running Windows 10. Two different machine learning techniques—Support Vector Machine (SVM) and Deep Neural Network (DNN)—had to be used in the classification challenge. We examined and contrasted the outputs of various algorithms. We assessed each pixel class in the tumor and liver areas using accuracy (AC), sensitivity (SN), and specificity (SP). Using volumetric overlap error (VOE), dice similarity coefficient (DSC), and valid dice coefficient (VDC), the proposed approaches are evaluated in relation to past used ones.

The confusion matrix in Figure 6 illustrates ResUNet's liver and non-liver pixel identification accuracy and errors. Figure 7 illustrates ResUNet's tumor segmentation confusion matrix. The confusion matrices represent the percentage of correctly categorized pixels in a class (compared to the total number). Performance of the model was assessed just using average symmetric surface distance, relative volume difference, VOE, and DSC criteria. A more exact representation of the segmentation data is obtained using the Dice coefficient; a higher value denotes a best result. As Table 1 shows, we effectively divided the liver using ResUNet. As Table 2 shows, we effectively segregated tumors using our suggested ResUNet model. Random data from the test set is used to test the model. Figure 8(a) demonstrates a true value accuracy of 99.4% and 98.1%. The liver that is anticipated can be observed in Figure 8(b). The provided text illustrates a random sample of the validation data that was employed to evaluate the model. Figure 9(a) displays a random sample with a precision of 99.8%, a True Value Accuracy of 93.8%, and a die coefficient of around 95.2%. The anticipated expansion is depicted in Figure 9(b). Support Vector Machines (SVM) and Deep Neural Networks (DNN) are the two most common approaches for classifying tumors.

CONCLUSION

Using the ResUNet model, which requires a far smaller volume of training data than U-Net, this work offers a two-tier method to differentiate between liver and tumors. Both of which are well used techniques, the suggested strategy beats the SVM classifier and the DNN classifier. This work evaluates the proposed ResUNet model using the publicly accessible 3D-IRCADb dataset. The efficacy of the approaches is assessed using performance criteria including Volumetric Overlap Error (VOE) and Dice Similarity Coefficient (DSC). Regarding both measures, the recommended approach always produces better results as time passes. Moreover, the U-net design ensures that the final image preserves the same degree of quality and exact proportions as the original input picture. The approach used in this work eliminates the need for any later data modification to improve the quality of the outcomes. One can improve and test the model using different specimens. Through some changes, the suggested approach implementation can be applied in related medical situations. Many datasets can be combined for analysis should future computational capability be suitable. Furthermore, this approach can be used to separate several approaches related to organs such lungs, kidneys, brain, etc., as well as different modalities of medical imaging including ultrasounds, MRI, etc.

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Table 1. The Experimental outcomes for liver segmentation with the ResUNet model

S.No	Evaluation Metrics	ResU-Net Network
1	DSC	0.893
2	Accuracy	0.97
3	Precision	0.950
4	Specificity	0.957
5	VOE	13.15
6	RVD	7.23

Table 2. Training and validation dice coefficient (F1 score) findings for the ResUNet liver segmentation model

Epoch	Epoch dice coefficient (F1 Score)	Valid dice coefficient(F1 Score)
1	0.8695	0.8931
2	0.9009	0.843
3	0.9252	0.9053
4	0.9348	0.0208
5	0.9472	0.9398
6	0.9583	0.9168
7	0.9653	0.9332
8	0.9692	0.9549
9	0.9735	0.9737
10	0.9854	0.9852
11	0.9958	0.9976

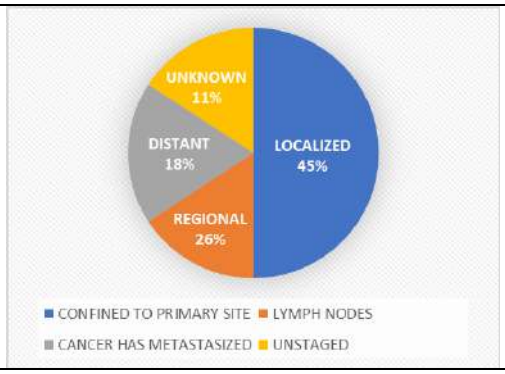


Figure 1. Distribution of liver cancer cases by stages

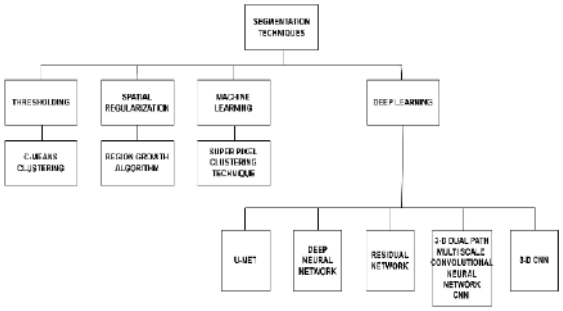


Figure 2: Strategies for Liver Cancer Segmentation: A Review of Relevant Literature

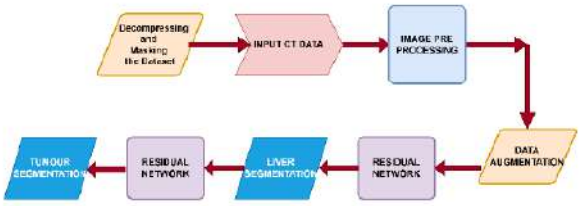


Figure 3. suggestions for a method to separate the liver and tumors

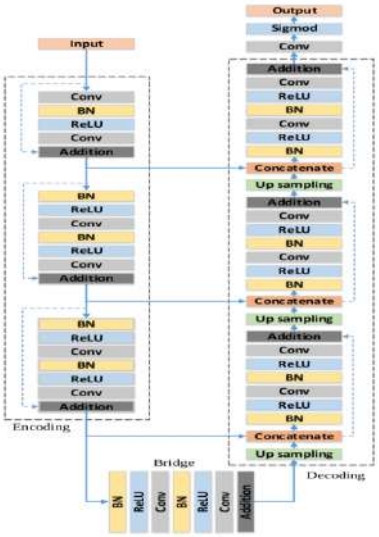


Figure 4: Residual UNET Architecture

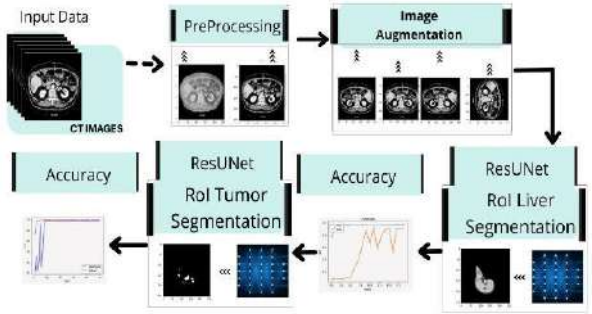


Figure 5: Proposed Method for Liver Tumour And Liver Segmentation

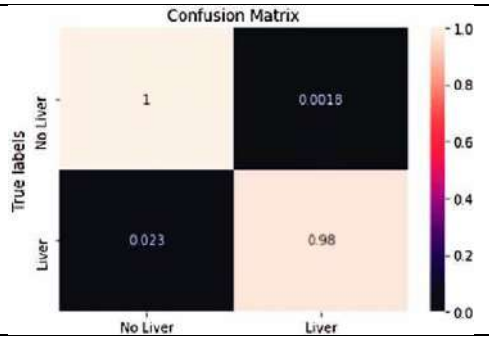


Figure 6. Confusion Matrix After Liver

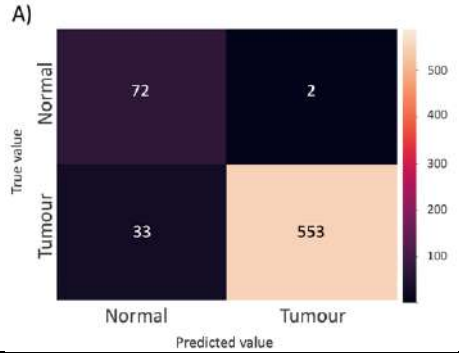


Figure 7. Confusion matrix for tumor based on the proposed model

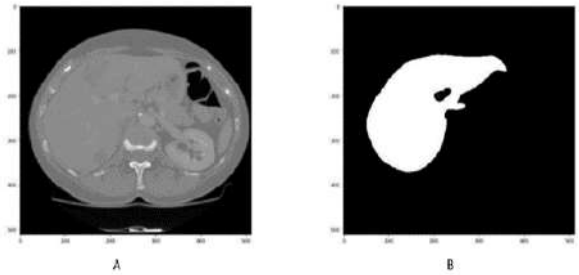


Figure 8. (a) A randomly selected image from the dataset (b) The liver that has been isolated from the selected image
Figure

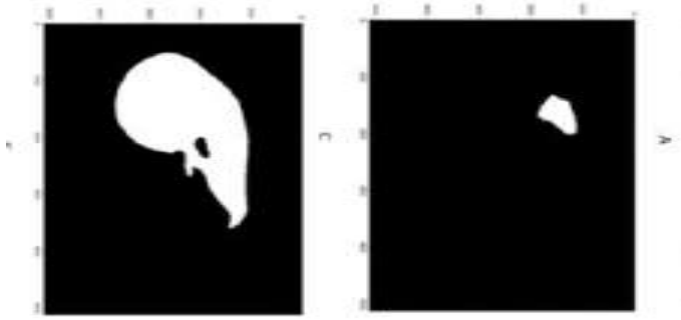


Figure 9. (a) An image randomly selected from the dataset. (b) The tumor that has been isolated and identified from the selected sample.

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RESEARCH ARTICLE

AI International Film Festival [AIIFF] can Foster Entrepreneurship and Creative Innovations in Film Industry

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ABSTRACT

This paper explores the role of AI in film festivals and how such technologies or plat forms democratize the film making process for independent artists and startups, hence breaking traditional barriers. Among the main challenges filmmakers face, other than securing funds, time management, and technical resources from pre-production to post- production final editing, is the hope for a profitable ROI by the independent producer.AI Festival platforms help film makers create unique visuals and animations despite the restrictive budget of a conventional film and serve as a no-frills but competitive product to stay in the market. These festivals give an opportunity for upcoming filmmakers to showcase their work and bring them into the limelight. For independent filmmakers, receiving an award at an international festival may give them a chance to realize their dream of perfecting the craft of AI film making by creating more innovative projects. Different films with different styles will testify to the grand canvass on which storytelling has been painted, allowing filmmakers to experiment and innovate, bringing artists, technologists, and industry leaders together to leverage the creative synergies between human imagination and AI. Events such as business schools' AI Film Festivals bridge the gap by allowing the artists and AI specialists to collaborate and understand the know-how for new creative alliances and business opportunities. This kind of film festival enables filmmakers to also acquire business skills in developing the pitch for one's ideas, investment, branding, and marketing projects. It is quite common for many startups and production companies to go through a transition from that story idea on the back of the sketch to a first version on a shoestring budget. Equally, it prepares the film maker aspirants with the necessary skills to turn their creative vision in to a

Successful business venture. In short, AI film festivals create access to film making, uncover new talent, inspire creativity, encourage collaboration, and cultivate future creative entrepreneurs and content communities.

Keywords: Data collection; Innovation, Experimentation; Talent Showcase; Access.

INTRODUCTION

Artificial Intelligence enhances the art of storytelling in short films greatly by applying different advanced techniques and tools that make the entire creative process faster, efficient, and packed with value in stories. AI technologies currently help filmmakers make the very first steps in developing ideas and surmounting creative obstacles. For example, OpenAI could suggest names of characters, plots, and dialogues that could constitute the premise of original stories. Indeed, a fast-thinking AI can create multiple ideas connected with certain criteria much faster than humans can produce, which allows filmmakers to explore more variations of ideas in less time.

Improvement in Visuals and Audio: AI tools like Midjourney and Runway ML can help creators with stunning visuals and pictures. These tools are capable of generating concept art or entire sequences that might be helpful in better visualization for the creators.

Voice overs and Sound Design: AI helps to temporarily voice over and create other vital sound elements in films. Services such as Eleven Labs provide high-quality audio that is helpful in short films to enhance the storytelling experience in all aspects of filmmaking.

Editing and Animation: With the help of AI, editing has become somewhat easier because it automates all the mundane tasks such as transitions between scenes and image stabilization.

Emotional Engagement: Through AI, stories can be built emotionally to resonate with viewers. The tools analyze viewer preferences and trends to help filmmakers create narratives that emotionally engage the audience.

METHODOLOGY: LOGICAL PROCESSING

NAVRASA encompasses the nine fundamental emotions that exist in human life. By integrating AI technology at different levels of filmmaking, we were able to successfully arrange a festival featuring the business schools of different institutions.

EARLY PLANNING PHASE

AI greatly enhances the early planning phase by managing and automating many complex facets of this process, allowing a much greater level of creativity. The following are the major roles of AI for filmmakers in this stage:

Automated Script Analysis: AI, through platforms like Filmustage, uses machine learning to auto-analyze scripts. What earlier needed several hours of manual work now only takes a few minutes as AI breaks down the script and organizes all elements involving cast, locations, and props.

Potential Risks Identification: AI helps filmmakers make out any potential threats to their scripts and production plans. For example, Filmustage AI Labs Analysis scan for vulnerabilities, such as safety concerns or copyright issues, and come up with ways to diminish these risks.

More Effective Team Collaboration: AI-driven platforms ensure better collaboration among the team members by

hosting all pre-production aspects on a single interface: script analysis, filming scheduling, and budget management.

Lessons from Scripts and Audience: The extraction of vital data-everything from emotional journeys to the narrative structure-is heavily reliant on analytic AI tools. With integrated NLP, filmmakers now can tune their scripts for crowd reactions expected hence trying to involve audiences even more in telling the story.

AI Assists in Actor Selection: It does so by assessing their performance and character to best decide if they would be good enough for the chosen role. The use of tools like Casting Droid or Largo AI helps in discovering newer talent and making diverse casts, ultimately improving the quality of the film.

Location Suggestions: AI speeds up location scouting, suggesting places that fit the scenery described in the script.

Storyboard and Visualization: AI-powered storyboard generators let filmmakers visualize scenes and their compositions in minimal time. Using D-ID and Cuebric, filmmakers can rapidly see scenes on screen to help them make quick decisions over shot and composition planning.

Production phase

Artificial Intelligence has transformed film production by introducing efficiency, creativity, and quality. Its major roles in this critical stage of filmmaking are pegged on the following aspects:

Efficient Shooting Schedules: AI-powered tools like Scenechronize and Celtx use historical production data, weather forecasts, and equipment availability to optimally plan a shoot. By anticipating probable delays, such platforms adjust timelines in tandem with such
expectations.

Automation of camera operations: Traditional methods of film shooting are now replaced by AI-operated cameras and robotic cinematography devices. Companies like ARRI and RED are leading the development of highly technical cameras, which could automate aspects such as framing, focus, and exposure. Difficult camera movements can be done with a small crew using this technology, hence reducing production costs.

Better Cinematography: Filmmakers can create much better visuals through the use of AI- powered techniques, with much less effort. AI helps in innovative storytelling by enhancing camera movement and shot composition.

Real-time Performance Analysis: With tools such as Analysis Morph Cast and Affectiva, actors are monitored in real time for their facial expressions and emotions while filming. This serves as a way to deeply understand and build more character-driven stories.

Continuity Monitoring: AI tools like Filmustage help a continuity supervisor in consistently reproducing scenes and correctly placing props throughout the shoot.

Predictive Analytics for Resource Allocation: By looking at data from different points related to the production process, such as cast schedules, location availability, and equipment logistics, AI makes good predictions of resource needs and allocates them appropriately.

Post-Production

Automated Editing: AI algorithms can sift through a huge number of footage pieces to select the best scenes, close-ups, and reactions. This can make editing quite easier and faster. Softwares like Adobe Sensei handle jobs like scene segmentation and prioritizing color grading.

RESULTS

Assess the research on comparing AI film production with traditional film production:
Pre-Production AI Film Production: Writing the Script and Planning the Story: Artificial Intelligence.Tools even analyze scripts to determine the emotional intensity, character development, and appeal the characters will have with an audience. Filmmakers receive insights on which projects to base their work. AI-driven platforms, like ScriptBook, predict audience reactions and box office success by informing decisions.

Casting and Location Search: AI algorithms find ideal actors' past performance and audience demographic matches for more diverse casting.

Traditional Film Production:
Human Creativity: It finds its basis in human creativity and experience. There is much brainstorming and discussions among filmmakers, which forms a story supported by the relationship between characters.

Production Stage
AI Film Production - Automated Cinematography: Cameras equipped with AI can automate a lot of tasks, such as focusing and exposure, to ensure uniform shots and footage during complex camera movements, without having to involve many crew members. Other tools like Scenechronize optimize shooting schedules based on historical data and current conditions.

Performance Evaluation: AI can assess the actors' facial expressions when filming a scene and advise the director on where performance improvements are needed to sustain the emotions across different scenes.

Post-Production:
Such special visual effects, with the power of AI, can be created in a photorealistic way in a far more effective manner, removing the heavy time and manpower required to achieve these special effects. This allows filmmakers to work with larger-scale scenes that were not possible using earlier VFX techniques.

Artistic Editing in Traditional Film Production: Human editors have creative insights they bring into the editing process. They naturally have an idea about pacing, transition, and emotional subtlety that may be beyond the grasp of AI.

DISCUSSIONS

Pros of Human Editing:
Handcrafted VFX Work: Traditional creation of visual effects involves manual creation and compositing of effects by skilled artists; this is indeed a very laborious process but at the same time gives tremendous creative control and customization options.

Ethical and Creative Issues of AI:
The contribution of AI creates questions regarding authenticity in creative output and ownership rights and devaluation of human artists in creating any work .

Difference between Traditional and AI Film Festivals
Focus and Themes
Traditional Film Festivals: These festivals highlight a wide-ranging breadth of genres and storytelling approaches that hail the human creative spirit and artistic expression. They present films that represent visions for humanity, social

causes, or important messages.A number of themes, ranging from dramatic and comic to documentary and experimental film.

AI Film Festivals: These festivals showcase stories that are heavily dependent on AI tools in their production or narrate how AI will influence the future world. They feature creative Two films that explore the potential of AI in vision creation, narrative development, and
performance generation. Running parallel to the technical research, this also opens discussions on the ethical use of AI in filmmaking-the future of creativity and precisely what the role of technology is as opposed to art.

Submission and Selection Process:
Traditional Film Festivals: These are highly selective festivals in which films are selected based on are chosen based on their artistic merits, storytelling, and production values. Selection committees are usually composed of professionals in the industry.

Virtual AI Film Festivals: These highlight the aspects of innovation, and only those films which showcase new ways of using the AI technologies will be selected, and thus inspire filmmakers to try out new tools and techniques. This can also lure creators from genres leaning towards technology and digital art.

Audience Engagement and Experience
Classic Film Festivals: The classic film festivals provide for active audience involvement through discussion, question-and-answer sessions, and networking with the artists.

Artificial Intelligence Film Festivals - Interactive Experiences: Interaction within artificial intelligence film festivals might be applied to live demonstrations of AI technology, workshop activity, and deliberations on the future of AI in film.

Impact on Film Industry:
Traditional Film Festivals: Canonical Status of Film Festivals: Films get discovered, distribution contracts get signed, and prizes are awarded in conventional events such as Cannes, Sundance, and Tribeca. They powerfully influence culture as these festivals often set trends in film and influence civic discourses on important social issues.

AI Film Festivals: Growing Recognition Despite being relatively new, AI film festivals are fast gaining recognition as the place to show the future of filmmaking. Distribution and Promotion of Traditional Films:

Broadcast to the Masses: Films reach a wider audience through a network of theaters. They are also licensed to various TV networks for broadcast, reaching an even wider audience through the comfort of their living rooms.

Physical Distribution: Films are distributed through DVDs, Blu-rays, and other physical formats that people can purchase or rent. This appeals to collectors or those who do not have good access to the internet.

CONCLUSION

Distribution and Promotion in the Age of AI: Online Streaming Platforms: They distribute films through their online services and come up with recommendations based on a viewer's preferences and viewing history to extend discovery and guide viewers to films.

Social Media Marketing: AI chatbots and targeted advertisement in social media provide great interaction with the audience and sentiment analysis, thereby updating marketing strategies to make film advertising more dynamic.

Predictive Analytics: AI can predict the success of a film using data available and informs decisions regarding the release date, marketing budget, and distribution channel.

Automation of Film Content Creation: AI technology can quickly analyze any movie to produce a trailer that captures the essence of the film, rating the overall experience swiftly. Investments by Nvidia and Google in film festivals using AI, such as the Runway AI Film Festival, are increasing their prestige in the tech world in several ways:

Leadership in AI Development: Participation in festivals about AI technology for movies places both Nvidia and Google ahead of others, having this technology. This alone signifies their commitment to innovation and creativity in the film industry and boosts their brand image and corporate identity as cutting-edge companies. The presence of AI across industries demonstrates its multifaceted and broad potential outside traditional boundaries, such as gaming and enterprise solutions.

Talent and Startup Attraction: Younger Creatives Engagement: In return for funding AI film festivals, companies can engage with newer filmmakers and technologists. This exposes them to discovering and attracting new talent that might be helpful in creating future AI and film innovations. Supporting Startups: By investing in these platforms, the tech giants foster relationships with startups and independent creators of AI-driven films. In return, this could provoke further partnerships and collaborations, even investment opportunities, in their strategic vision.

Brand Image Improvement: Encouraging a Relationship with Creativity and Art: In sponsoring AI film festivals, companies align their brands with creative expression and artistic interests. This could build a relationship with artists, filmmakers, and audiences at large that have a predilection for innovative storytelling.

Building Community Relations: Building Brand Image as Supportive Force in the Arts: Being part of these events helps the companies to draw public favor for themselves and build a positive brand image as supporters of the arts.

Shaping Industry Trends: Guiding Market Direction: The participation by these companies in the AI Film Festivals signals to the technology industry that this is a good market for AI in filmmaking and is lucrative. This could encourage more and more technology companies to invest in similar ventures.

AI film festivals are also attracting more investors: There is a dire need for strategic steps that show the promise of novelty, investors' opportunities, and the shifting face of filmmaking.

Key Strategies

Showcase Success Stories: Demonstrate how AI has actually added value to filmmaking by highlighting successful projects/case studies. Highlight those films that have gained critical acclaim or box office success with the help of AI technologies.

Workshops and Panel Discussions on Business Aspects of AI in Filmmaking: Organize workshops and panel discussions on the business aspects of AI in filmmaking to help potential investors.

Potential Risks: To the companies involved in product development, investment in AI film festivals has proved very beneficial, especially for those companies dealing in AI technologies. Such companies can utilize their participation in events of 'Demonstration of **Technology Capabilities**': AI film festivals provide a platform to the companies to show case their AI tools and technologies. Examples include how Runway's models could be featured by films shot using their software to illustrate their work and its use in practical applications. Revenue streams for the festival might include **Sponsorships and Partnerships:** AI film festivals draw sponsorships from technology companies like Nvidia and Google looking to showcase their AI tools and technologies in action, thus building awareness for the products of

the sponsors Ticket Sales and Entry Fees: For most events, tickets are sold to attendees for screenings, panels, and workshops, and these may provide considerable income. Merchandising and Sales: Merchandise sold during the festival, such as branded items like t-shirts, posters, and other memorabilia, can be an added source of income. Workshops and Paid Educational Programs: Most AI film festivals organize workshops and master classes with professionals that can be arranged for a fee as another revenue line. Grants and Funding: Some festivals receive grants from arts and culture organizations or governments to further innovation in the arts. Investor Perspective: Investment Return: They are looking for projects that can realize commercial success, expansible growth, and innovative discontinuity to shake the market. Market Forecasts and Innovations: They interact with the prevailing market trends and signals

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2. .IBM WATSON.,Nvidea.,Google., Market research Biz., Market research news publication., Vision Research Reports., Art credits: Alistair, Phisigma, Gerd Altmann, Jean-Louis Servais, Jim Cooper, Suzy from [PixaBay], SCMP Graphics.,Sanscrata Navarasa prints.com, Arts peaksindia.com, massive.io flawless ai.com

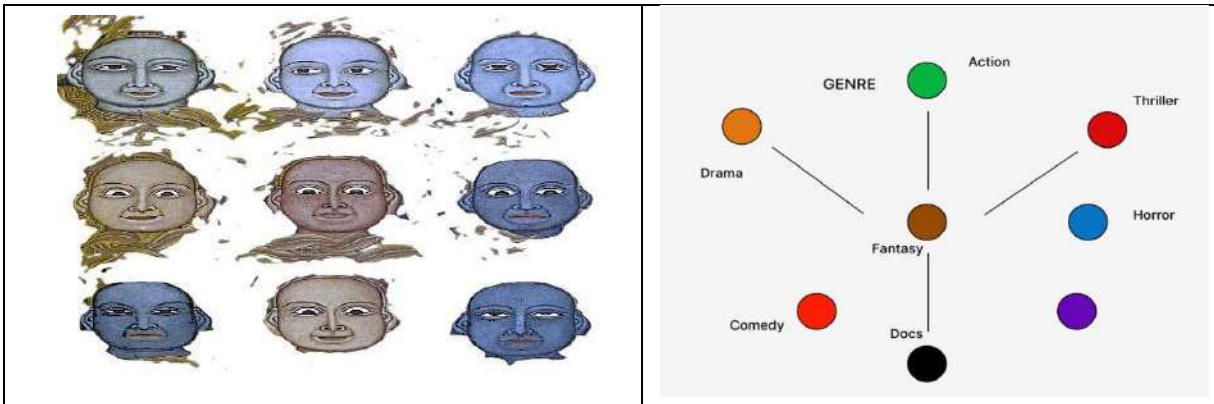


Fig.1. Logical Processing

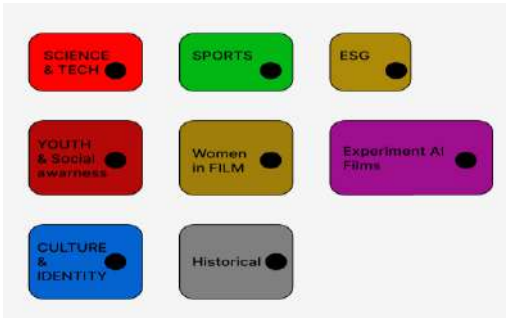


Fig.2.Topics





Fig.3. Post-Production

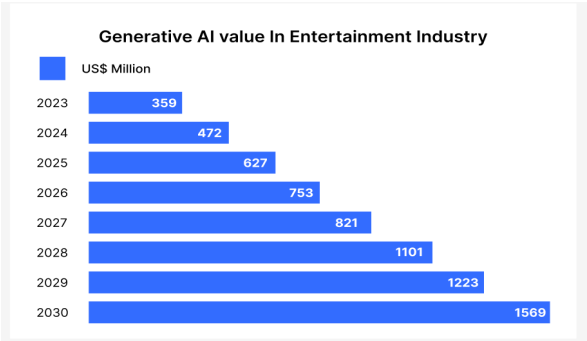


Fig.4

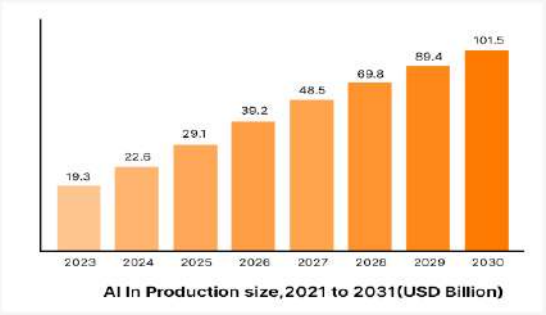


Fig.5.

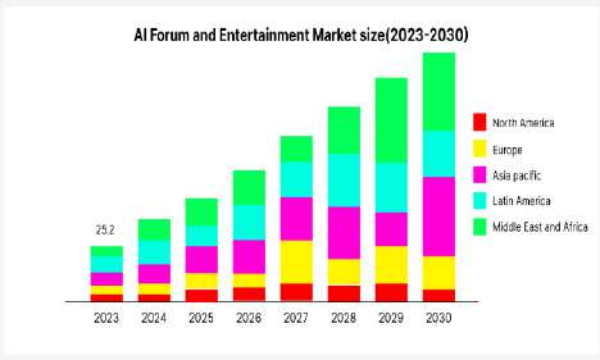


Fig.6

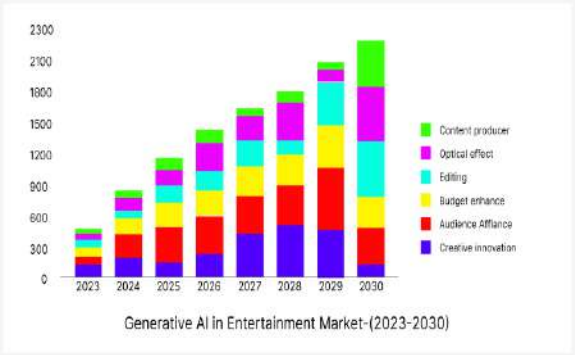


Fig.7

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RESEARCH ARTICLE

Natural Language Processing : Trends and Challenges

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ABSTRACT

Avant-garde of technological revolution, Natural Language Processing (NLP) is at the apex of computer science and Artificial Intelligence on one hand and linguistics on the other to facilitate a machine's abilityto understand and analyze as well as generate speech in natural languages. The rising incidence of applying chatbots along with virtual assistants in the fields of customer care, health care, and personal assistance has led to the development of conversational AI being a priority. In accomplishing the language tasks, it has shifted the manner it can be done, enabling the study of the transfer of this model and reducing the complexity needed in the everyday, low-level task understanding. Language models have extended the sphere of application of NLP, and the range of languages used is constantly expanding, hence inclusive and variable language processing. Further, methodologies of transfer learning have enabled a quick increase in various aspects of natural language processing, such as data collection, analysis, attitude determination, and the dialogue component. Nevertheless, the NLP industry is still bearing many long-standing problems as Data Privacy, Bias, Context Understanding, Scalability of the model, Multi-modal Integration, Domain optimization and others. The call for real-time NLP applications of current techniques means that there is a need for and enhanced system that will accommodate and analyze large amounts of information within the shortest time possible with the objective of enabling the user to arrive at sustainable decisions, which are also comprehensible.

Keywords: NLP, Text Classification, Speech Recognition, Transformer Models, Language Models

INTRODUCTION

Natural Language Processing (NLP) is a branch of Artificial Intelligence (AI) that tries to address the gap between humans' ways of communicating and information processing machines As a subject that uses methods from computer science, computational linguistics, and AI applied here, NLP allows the machine to comprehend language and find it meaningful and useful. This is mainly to enhance the aspect of human computer interface or interaction in which interaction between humans and computers or devices is enhanced through consumption of natural language processing. This is even more relevant in today's big data processing paradigm where new stories and speeches are created in real-time. Using the given information, an effective NLP system makes it easier to understand the information and analyze it with a view of improving the business processes and the decision-making process.

IMPORTANCE OF NLP

NLP is important for enriching technologies and enablement of natural ways through which people can engage a device. This is particularly relevant today as information flow is presented in the form of stories and speeches is increasing day by day due to the availability of big data. The described information can be preprocessed and analyzed by an effective NLP system to garner insights, enhance business operations, and optimize decision-making mechanisms.

Text analysis: on both the general comprehension of texts as well as the extraction of significant information from a text. This entails, for example, text mining involving such processes as; sentiment analysis, entity identification, data gathering and more.

Speech Recognition: transforms speech to text. The majority of modern gadgets and applications like Siri and Alexa make the usage of NLP while processing the voice commands.

Machine Translation: It convert text or spoken words form one language to another language. An example of this kind of application, which has widespread popularity, is Google Translate.

Natural Language Generation: It is text created from the data entered by the users, being a form of natural language content. It is used in tasks like chatbots and generating content automatically.
Information Retrieval: Assists to look for information from the large data by the online tools such as Google.

LITERATURE SURVEY

Comparison and Summary of The Literature Survey on Various Topics in Natural Language Processing (NLP) And Related Fields:

Knowledge Graphs

Hogan et al. (2021) in Artificial Intelligence Journal: This paper surveys the construction and utilization of knowledge graphs, emphasizing their role in enhancing NLP tasks through structured relational information. Applications include improved question answering systems, semantic search, and information retrieval [1].

Language Models

Devlin et al. (2019) in Transactions of the Association for Computational Linguistics (TACL): Introduced BERT, a bidirectional transformer model for language understanding that set new benchmarks across various NLP tasks by capturing context from both directions [2].
Vaswani et al. (2017) in Journal of Machine Learning Research (JMLR): Introduced the Transformer model, which relies on self-attention mechanisms, eliminating the need for recurrence and improving performance in tasks like machine translation and text summarization [3].

Text Classification

owsari et al. (2019) in Information Retrieval Journal: Reviewed traditional and modern text classification algorithms, highlighting the shift from traditional machine learning methods to deep learning approaches like CNNs, RNNs, and Transformers

Deep Learning Architectures

Young et al. (2018) in IEEE Transactions on Neural Networks and Learning Systems: Provided a comprehensive review of deep learning architectures (CNNs, RNNs, Transformers) applied to NLP, discussing their strengths, limitations, and applications [5]. Kim (2014) in IEEE Transactions on Pattern Analysis and Machine Intelligence: Demonstrated the effectiveness of CNNs for sentence classification, adapting them from image processing to text classification tasks [6].

Named Entity Recognition (NER)

Yadav and Bethard (2018) in Expert Systems with Applications: Reviewed deep learning models for NER, comparing approaches like CNNs, RNNs, and Transformers, and evaluating their performance on standard NER benchmarks [7].

Natural Language Generation (NLG)

Gatt and Krahmer (2018) in Artificial Intelligence Review: Provided a comprehensive review of NLG tasks such as text summarization, report generation, and dialogue systems, discussing evaluation metrics and the importance of NLG in creating coherent text [8].

Sequence-to-Sequence Models

Sutskever et al. (2014) in Journal of Artificial Intelligence Research (JAIR): Introduced the Seq2Seq model using LSTM networks, which revolutionized machine translation and sequence prediction tasks by effectively encoding and decoding sequences [9]. Cho et al. (2014) in Neural Computation: Developed the RNN Encoder-Decoder model for machine translation, significantly improving translation quality and efficiency [10].

Generative Models

Rezende et al. (2014) in Computational Linguistics: Explored variation auto encoders (VAEs) in NLP, enhancing the generative capabilities of models for tasks like text generation and language modelling [11].

Sentiment Analysis

Medhat et al. (2014) in ACM Computing Surveys: Reviewed various sentiment analysis approaches, including lexicon-based methods, machine learning techniques, and hybrid approaches, discussing their applications in social media monitoring and mark et research [12].

Key NLP Metrics Related To Trends And Challenges

Trends Metrics

Model Size and Performance

GPT-3: 175 billion parameters; benchmarks like SuperGLUE score of 89.8 (as of its release).

BERT: 110 million parameters (base model); achieves 84.5 F1 score on the SQuAD 2.0 reading comprehension dataset.

Multimodal Models

CLIP (Contrastive Language-Image Pretraining): Can match images and texts with 76% accuracy in zero-shot image classification tasks.

DALL-E: Can generate images from text descriptions, achieving high fidelity and creativity.

Low-resource Languages
mBERT (Multilingual BERT): Supports 104 languages; performance varies with resourceavailability, but it improves over previous multilingual models

Conversational AI
Dialogflow (Google): Used in millions of conversations daily effectiveness varies by implementation and training.

Ethics and Fairness
Bias Benchmarks: Various benchmarks like the "Word Embedding Association Test" (WEAT)show biases in models (e.g., 60-70% of gender bias in word embeddings).

Challenges Metrics
Bias and Fairness
Gender Bias: Models like word2vec show a 70% correlation with gender stereotypes in wordassociations.
Sentiment Analysis Bias: Models might misclassify sentiments by up to 15% depending on demographic attributes.

Data Privacy
Data Leakage: Incidents where sensitive data is inadvertently exposed can impact model trustworthiness; exact figures vary but incidents are reported regularly.

Interpretability
Explain ability Techniques: Current explain ability techniques (e.g., LIME, SHAP) have limitations in NLP, with effectiveness ranging between 60-80% in terms of interpretability.

Resource Intensity
Training Costs: Training large models like GPT-3 costs millions of dollars in computationalresources.
Carbon Footprint: Training large NLP models can result in significant carbon emissions; estimates suggest that training GPT-3 can produce approximately 552,000 kg CO2e.

Generalization
Domain Adaptation: Performance drop of 10-20% when models trained on one domain are applied to another without fine-tuning .

Trends: As of today, NLP fashions turn into more specialized in expertise context; shooting discords, context-changes, and dealing with multi-way conversations. This shift points at the need to increase the

relevance of context understanding in surrounding even higher correct and human-like models. Workers also are researching strategies to improve pass-area generalization, so as to increase NLP fashions' performance in other domains or subject areas. Also, as the use of applications that require translation like chatbots and virtual personal assistants increases in the near future, there may be pressure to enhance the speed of NLP models. These quantities have grow to be large and intricate, and the need to make them extra of a scale and exceptional has initiated cognate attempts to enhance scalability and performance.

Challenges: Nevertheless, some of the following difficulties are still present: As any other database system, the privateness and safety of the data are crucial troubles, significantly in relation to sensitive records, the protection of privateness remains the principle concern. Prejudice and inclusion are also active problems due to the fact that biases in NLP models should be avoided in order not to cause discrimination. Another undertaking is to work on the appropriate NLP fashions for low-sensible source languages that are nevertheless behind in terms of aid and

accuracy. Last but not the least, the desire for better quality assessment is also implied, and enthusiasts strive to develop improved methods to comparethe effectiveness of NLP models.

Data sources: Data collected from studies of language models including GPT-3, BERT (Base), mBERT, T5, and RoBERTa.

Analysis: This plot compares the model size of the models with their corresponding performance scores. The blue bars represent the image size, while the red lines indicate performance scores. GPT-3, with a larger model size, shows significantly higher performance scores. In contrast, BERT (Base), mBERT, T5, and RoBERTa, despite having smaller image sizes, maintain comparable performance scores, with T5 slightly outperforming the others in terms of performance time compared to its size.

Implications: The data shows that large models such as the GPT-3 can provide superior performance. However, sub models such as BERT (Base), mBERT, and RoBERTa still achieve competitive performance, indicating that model efficiency and construction also play an important role in determining performance outcomes This insight is valuable for models a choices based on trade-offs between computing resources and performance .

Data Source: Data amassed from performance critiques of NLP fashions with various sizes, measured in tens of millions of parameters.

Analysis: The plot demonstrates the version size and the actual-time processing capabilities or simply the request per second. The inverse courting also holds a lot of precision; the larger models are usually associated with diminished real-time processing capacity. As the version length grows, from round 2 hundred million parameters to more than 1 billion, the quality of generation improves significantly. When the quantity of parameters is 6 billion, the actual-time processing fee significantly decreases. This makes it imply that whereas larger models may also additionally provide for better accuracy or performance in sure duties, they will take greater computational resources, hence restricting their capability to procedure requests speedy.

Implications: This discovering is pivotal for actual-time applications that require fast decision- making and processing. Indeed, for scenarios where a large number of inputs need to be processed all at once, it could be beneficial to go for the small models even at the cost of accuracy. This alternate-offhas to be taken into consideration when deciding on models for the packages that need both performance and efficiency.

Data Source: The records for this evaluation become collected from overall performance opinions of numerous NLP models. These fashions have been tested with various sizes, measured in hundreds of thousands of parameters.

Analysis: Plot shows the mapping of model size with the Real Time processing capacity depicting the requests per second (RPS). As would be expected there is direct and inverse relationship, which is where as the size of the models increases the real time processing capability declines. While increasing the modelsize from a level of 200 million parameters to over a billion: Precisely, when working with approximately 6 billion parameters, the speed of real-time processing is hundreds of times less than what is exhibited above. This indicates that as much as larger models may claim to have better accuracy or performance in a given task, they are slower in processing requests due to the higher amount of recourses that they use.

Implications: However, this outcome is significant for any application type that requires fast computations in real time. Regarding the high-throughput computing applications, smaller models may work the best despite lesser accuracy, than larger ones. This trade-off becomes important when the models are being chosen for use in applications requiring both speed and resource optima.

Data Source: The facts for this evaluation were obtained from the performance reviews of various NLP models, each tested with different sizes, in terms of hundreds of thousands of parameters.

Analysis: The plot shows the bias tiers of every extraordinary NLP models and the comparison of their ranges. The greatest degree of bias is formerly recommended by GPT-3, as indicated by means of the precise tallest bar inside the plot, at 70%. This implies that despite the fact that GPT-3 is highly developed,it is still biased to a certain extent. Per the bias degree discovered in CLIP, the mannequin has a 50% bias which means it's slightly biased – nonetheless, it is higher than some prior fashions and inferior to GPT-3. Moving to the next session with the lowest levels of bias we have word2vec with 45% bias degree. As you remember this level is not as high as GPT-3 or CLIP Nevertheless, word2vec demonstrates a rather significant degree of bias. Concerning the bias stage, BERT (Base) can be characterized as forty%, and that means that it is solely slightly much less prejudiced than word2vec however nevertheless a giant one. The bar with the shortest height illustrates T3 as possessing the lowest bias percentage at 25% indicating that several of the models had the lowest form of bias. This makes T3 a potentially higher preference for applications where fairness is pinnacle precedence.

Implications: Analyzing the tiers of bias is important in creating non-prejudiced AI systems hence constructing truthful structures. Higher bias stages result in discriminating outcomes; therefore, one should consider these measures when choosing or implementing models. Of course, to decrease the achievement of bias, builders need to implement offset mechanisms at some level of the training and quality-tuning stages in version development. Fostering solutions to bias can assist in the development of a fairer kind of AI packages.

CONCLUSION

The concept of NLP has come a long way and has even improved the manner that humans interface with computers. These enhancements of context, real-time, as well as cross-domain generalization make modern NLP models more realistic and powerful to implement the hitherto inconceivable applications. These are changes that are redefining specific sectors and they range from the customer service where chat bots are now being used to the healthcare system that is now employing virtual assistants to the creation of content and even language translation. But, the path does not end here. Nevertheless, numerous issues are still unresolved that can prevent the optimum performance of NLP. Data management, especially the question of privacy and protection, can be considered among these challenges because the use of big data implies work with large sets of sensitive data. Another important topic is bias mitigation as NLP models are increasingly integrated into more significant and consequential settings, and reinforcement of bias should be avoided. The problem ofscalability is another one that becomes even more acute as models become larger and more complex and the useful techniques are needed to achieve the same level of performance in terms of scalability.

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Table 1. Literature Survey

Topic	Paper	Journal/Conference	Summary
Knowledge Graphs	Hogan etal. (2021)	Artificial Intelligence Journal	Surveys the construction and utilization of knowledge graphs, highlighting their role in enhancing NLP tasks such as question answering,semantic search, and information retrieval.
Language Models	Devlin etal. (2019)	Transactions of the Association for Computational Linguistics (TACL)	Introduced BERT, a bidirectional transformer model for language understanding that set new benchmarks across various NLP tasksby capturing context from both directions.
	Vaswani etal. (2017)	Journal of Machine Learning Research (JMLR)	Introduced the Transformer model, relying on self-attention mechanisms,eliminating the need for recurrence, and improving performance in tasks like machine translation and text summarization.
Text Classification	Kowsari etal. (2019)	Information Retrieval Journal	Reviewed traditional and modern textclassification algorithms, highlightingthe shift from traditional machine learning methods to deep learning approaches like CNNs, RNNs, and Transformers.
	Young etal.	IEEE Transactions on	Provided a comprehensive review ofdeep learning architectures

Deep Learning Architectures	(2018)	Neural Networks and Learning Systems	(CNNs, RNNs, and Transformers) applied toNLP, discussing their strengths, limitations, and applications.
	Kim (2014)	IEEE Transactions on Pattern Analysis and Machine Intelligence	Demonstrated the effectiveness of CNNs for sentence classification, adapting them from image processingto text classification tasks.
Named Entity Recognition (NER)	Yadav and Bethard (2018)	Expert Systems with Applications	Reviewed deep learning models for NER, comparing approaches like CNNs, RNNs, and Transformers, andevaluating their performance on standard NER benchmarks.
Natural Language Generation (NLG)	Gatt and Krahmer (2018)	Artificial Intelligence Review	Provided a comprehensive review of NLG tasks such as text summarization, report generation, anddialogue systems, discussing evaluation metrics and the importance of NLG in creating coherent text
Sequence-to-Sequence Models	Sutskeveret al. (2014)	Journal of Artificial Intelligence Research (JAIR)	Introduced the Seq2Seq model using LSTM networks, revolutionizing machine translation and sequence prediction tasks by effectively encoding and decoding sequences.
	Cho et al. (2014)	Neural Computation	Developed the RNN Encoder-Decodermodel for machine translation, significantly improving translation quality and efficiency.
Generative Models	Rezende etal. (2014)	Computational Linguistics	Explored variational autoencoders (VAEs) in NLP, enhancing the generative capabilities of models for tasks like text generation and languagemodeling.
Sentiment Analysis	Medhat et al. (2014)	ACM Computing Surveys	Reviewed various sentiment analysis approaches, including lexicon-based methods, machine learning techniques,and hybrid approaches, discussing their applications in social media monitoring and market research.

Table 2. Trend and Challenges in NLP

Category	Trend/Challenge	Description
Trends	Pretrained Language Models	Rise of large-scale pretrained models such as GPT-3, BERT, T5, and their variants.
	Multimodal NLP	Integrating text with other data typeslike images, audio, and video.
	Few-ShotLearning	Techniques allowing models to perform tasks with little to no task-specific training data.
	ConversationalChatbots	Development of conversational agents. sophisticated
	Explainability Interpretability	Increasing focus on making NLP modelsmore interpretable.
	Ethics and Bias Mitigation	Addressing ethical issues and biases in NLP models.
	Domain Adaptation and Customization	Tailoring models to specific industriesor applications.
Challenges	Data Privacy and Security	Handling sensitive ensuring data privacy. information
	Bias and Fairness	NLP models inheriting biases from their training data.
	Low-Resource Languages	NLP models performing poorly on
		languages with limited annotated data.
	Context Understanding	Difficulty in understanding context, especially long-range dependencies.
	Evaluation Metrics	Existing metrics may not fully capturethe quality and nuances of NLP tasks.
	Real-Time Processing	Processing and generating text in real-time.
	Scalability and Efficiency	Large models requiring significant computational resources.
	Cross-Domain Generalization	Models failing to generalize well across different domains.

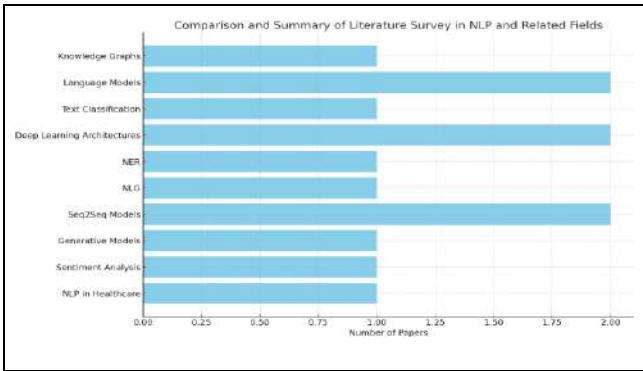


Fig. 1.Comparison Graph in NLP Rated fields



Fig. 2. Trend and Challenges in NLP

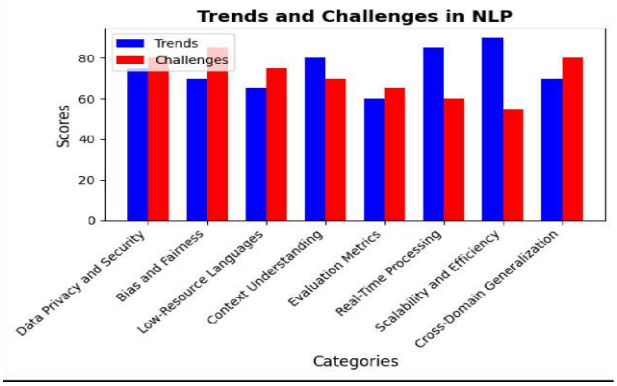


Fig. 3. Trends and Challenges in NLP

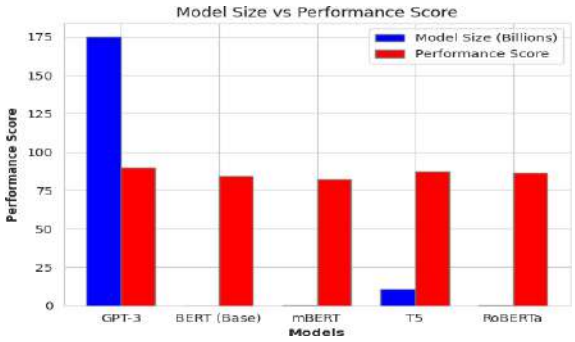


Fig. 4. Model size and performance scores

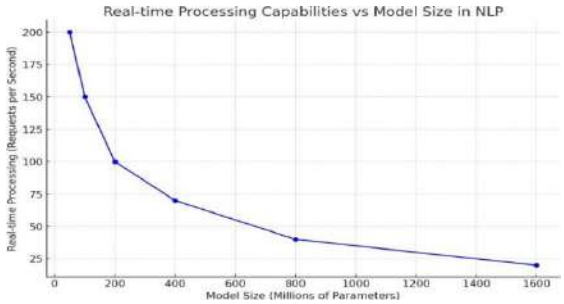


Fig 5. Real-time Processing Capabilities Vs Model Size in NLP

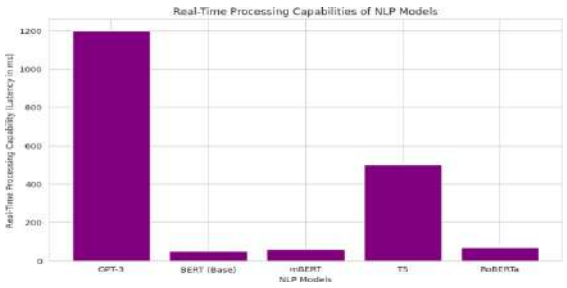


Fig 6. Real-time Processing Capabilities vs Model Size in NLP

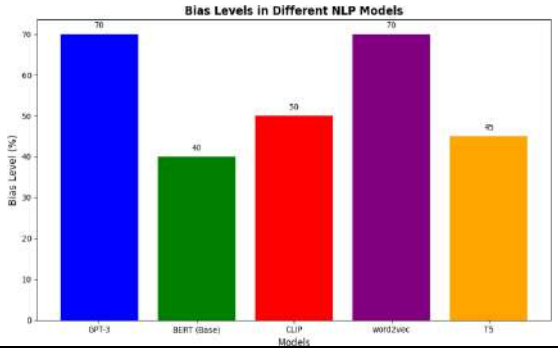


Fig.7. Bias Levels in Different NLP Models

RESEARCH ARTICLE

On Hypersoft Topology

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ABSTRACT

Hypersoft sets are a generalization of soft sets that have gained importance and are being studied for possible uses in various mathematical fields. Musa and Asaad investigated numerous aspects and defined a number of fundamental concepts on hypersoft topological spaces. This work further develops the idea of hypersoft topology on hypersoft sets and looks at some of its characteristics, such as a hypersoft set's neighbourhood, closure, interior, limit point. We also introduce the notions of hypersoft basis, hypersoft subspace topology and hypersoft Hausdorff space. To help understand the recently defined concepts, examples are provided.

Keywords : Hypersoft set, hypersoft power set, hypersoft topology, hypersoft basis, subspace topology, closure, interior, limit point, and hypersoft Hausdorff space.
AMS Subject Classification: 54C50, 54F65**.**

INTRODUCTION

In 1999, Molodtsov [11] presented the idea of soft sets as a broad mathematical tool for handling various types of uncertainty. The proposal of soft topology utilising the soft sets provided by Cagman and Enginoglu [3] and the definition of a soft set using its soft subsets. Shabir and Naz [17] proposed the idea of soft topology defined on a classical set by utilising soft sets over it at the same era. Many studies have since been given on this idea, including [2,4-8,10,14-16,20,21].

Smarandache[16] expanded the concept of soft sets into hypersoft sets by converting the argument function F into a multi-argument function. One recently developed method for solving realworld issues is the idea of hypersoft sets. The fundamental operations of union, intersection, complement, and difference of hypersoft sets were established by Mujahid Abbas et al. [1]. The foundations of hypersoft sets, including hypersoft subset, complement, not hypersoft set, and aggregation operations, were presented by Muhammad Saeed et al. [12]. Inthumathi et al.[9] presented the concepts of hypersoft semi-open sets, hypersoft semi-closed sets, hypersoft semiinterior and hypersoft semi-closure in hypersoft topological spaces (HTS). Recently Smarandache et al.[18] developed the concept of hypersoft sets in a game theory-based decision making model. Set theory concepts are central to modern topology. Musa and Asaad [13] investigated numerous aspects and defined a number of fundamental concepts on HTS. This work further develops the idea of hypersoft topology on hypersoft sets and looks at some of its characteristics, such as a hypersoft set's neighbourhood, closure, interior, limit point. We also introduce the notions of hypersoft basis, hypersoft subspace topology and hypersoft Hausdorff space.

PRELIMINARIES

The fundamental definitions and findings of hypersoft set theory that may be found in previous research are presented in this part.

Definition 2.1. [4]. A soft set F_A on the universe U is defined by the set of ordered pairs $F_A = \{(x, f_A(x)) : x \in E, f_A(x) \in P(U)\}$, where $f_A : E \to P(U)$ such that $f_A(x) = \Phi$ if $x \notin A$. Note that the set of all soft sets over U will be denoted by $S(U)$

Definition 2.2. [3]. Let $F_A \in S(U)$. A soft topology on F_A, denoted by τ, is a collection of soft subsets of F_A having the following properties:

i. $F_\emptyset, F_A \in \tau$

ii. $\{F_{A_i} \subseteq F_A \; i \in I \subseteq N\} \subseteq \tau \Rightarrow \bigcup_{i\in I} F_{A_i} \in \tau$

iii. $\{F_{A_i} \subseteq F_A : 1 \leq i \leq n, n \in N\} \subseteq \tau \Rightarrow \bigcap_{i=I}^{n} F_{A_i} \in \tau$

The pair (F_A, τ) is called a soft topological spaces.

Definition 2.3. [1]. Let U be a universe of discourse, $P(U)$ the power set U and $E_1, E_2, \ldots, E_n$ the pairwise disjoint sets of parameters. Let A_i be the nonempty subset of E_i for each $i = 1, 2, \ldots, n$. A hypersoft set can be identified by the pair $(\phi, A_1 \times A_2 \times \ldots \times A_n)$, where $\phi : A_1 \times A_2 \times \ldots \times A_n \to P(U)$.

Throughout this work, we write the symbols $\boldsymbol{E}$ for $E_1 \times E_2 \times \ldots \times E_n$, $\mathbf{A}$ for $A_1 \times A_2 \times \ldots \times A_n$, $\tilde{\alpha}$ for an element of the set $\boldsymbol{A}$ and $\boldsymbol{\alpha}$ for an element of the hypersoft set $(\phi, \boldsymbol{A})$. We also suppose that none of the set A_i is empty. The set of all hypersoft sets over U will be denoted by $H[U]$

Example 2.4. [1]. Let $U = \{x_1, x_2, x_3, x_4\}$. Define the attributes sets by $E_1 = \{a_{11}, a_{12}\}$, $E_2 = \{a_{21}, a_{22}\}$, $E_3 = \{a_{31}, a_{32}\}$. Suppose that $A_1 = \{a_{11}, a_{12}\}$, $A_2 = \{a_{21}, a_{22}\}$, $A_3 = \{a_{31}\}$ are subsets of E_i for each $i = 1, 2, 3$ respectively. Let the hypersoft set $(\phi, \boldsymbol{A})$ be defined by

$$(\phi, \boldsymbol{A}) = \{((a_{11}, a_{21}, a_{31}), \{x_1, x_2\}), ((a_{11}, a_{22}, a_{31})\{x_2\}), ((a_{12}, a_{21}, a_{31}), \{x_3, x_4\}), ((a_{12}, a_{22}, a_{31}), \{x_1, x_4\})\}$$

Definition 2.5. [1]. Let U be a universe of discourse and $\boldsymbol{A}$ a subset of $\boldsymbol{E}$. Then $(\boldsymbol{\phi}, \boldsymbol{A})$ is called

i. a null hypersoft set if for each parameter $\tilde{\alpha} \in \boldsymbol{A}$, $\phi(\tilde{\alpha})$ is an 0. We will denote it by $\boldsymbol{\Phi_A}$.

ii. an absolute hypersoft set if for each parameter $\tilde{\alpha} \in \boldsymbol{A}$, $\phi(\tilde{\alpha}) = U$. We will denote it by $(\boldsymbol{\phi}, \boldsymbol{A})$.

Definition 2.6. [1]. Let $(\boldsymbol{\phi}, \boldsymbol{A})$ and $(\boldsymbol{\varphi}, \boldsymbol{B})$ be two hypersoft sets over U. Then $(\boldsymbol{\phi}, \boldsymbol{A})$ is called a hypersoft subset of $(\boldsymbol{\varphi}, \boldsymbol{B})$ $\boldsymbol{if}$ $\boldsymbol{A} \subseteq \boldsymbol{B}$, and $\phi(\tilde{\alpha}) \subseteq \varphi(\tilde{\alpha})$ for all $\tilde{\alpha} \in \boldsymbol{A}$.

We denote this by $(\boldsymbol{\phi}, \boldsymbol{A}) \subseteq (\boldsymbol{\varphi}, \boldsymbol{B})$. Thus $(\boldsymbol{\phi}, \boldsymbol{A})$ and $(\boldsymbol{\varphi}, \boldsymbol{B})$ are said to equal if $(\boldsymbol{\phi}, \boldsymbol{A}) \subseteq (\boldsymbol{\varphi}, \boldsymbol{B})$ and $(\boldsymbol{\phi}, \boldsymbol{A}) \supseteq (\boldsymbol{\varphi}, \boldsymbol{B})$.

Definition 2.7. [1]. Let $(\boldsymbol{\phi}, \boldsymbol{A})$ and $(\boldsymbol{\varphi}, \boldsymbol{B})$ be two hypersoft sets over U. Then union of $(\boldsymbol{\phi}, \boldsymbol{A})$ and $(\boldsymbol{\varphi}, \boldsymbol{B})$is denoted by $(\boldsymbol{\psi}, \boldsymbol{C}) = (\boldsymbol{\phi}, \boldsymbol{A}) \cup (\boldsymbol{\varphi}, \boldsymbol{B})$ with $\boldsymbol{C} = C_1 \times C_2 \times \ldots \times C_n$, where $C_i = A_i \cup B_i$ for $i = 1, 2, \ldots, n$ and ψ is defined by

$$\psi(\tilde{\alpha}) = \begin{bmatrix} \phi(\tilde{\alpha}) & if\ \tilde{\alpha} \in \boldsymbol{A} - \boldsymbol{B} \\ \varphi(\tilde{\alpha}) & if\ \tilde{\alpha} \in \boldsymbol{B} - \boldsymbol{A} \\ \phi(\tilde{\alpha}) \cup \varphi(\tilde{\alpha}) & if\ \tilde{\alpha} \in \boldsymbol{A} \cap \boldsymbol{B} \\ 0 & else \end{bmatrix} \text{ Where } \tilde{\alpha} = (c_1, c_2, \ldots c_n) \in \boldsymbol{c}.$$

Definition 2.8. [1]. Let $(\boldsymbol{\phi}, \boldsymbol{A})$ and $(\boldsymbol{\varphi}, \boldsymbol{B})$ be two hypersoft sets over U. Then intersection of $(\boldsymbol{\phi}, \boldsymbol{A})$ and $(\boldsymbol{\varphi}, \boldsymbol{B})$ is denoted by $(\boldsymbol{\psi}, \boldsymbol{C}) = (\boldsymbol{\phi}, \boldsymbol{A}) \cap (\boldsymbol{\varphi}, \boldsymbol{B})$, where $\boldsymbol{C} = C_1 \times C_2 \times \ldots \times C_n$ is such that $C_i = A_i \cap B_i$ for $i = 1, 2, \ldots, n$ and ψ is defined as $\psi(\tilde{\alpha}) = \phi(\tilde{\alpha}) \cap \varphi(\tilde{\alpha})$, *where* $\tilde{\alpha} = (c_1, c_2, \ldots, c_n) \in \boldsymbol{c}$. If C_i is an empty set for some i, then $(\boldsymbol{\phi}, \boldsymbol{A}) \cap (\boldsymbol{\varphi}, \boldsymbol{B})$ is defined to be a null hypersoft set.

HYPERSOFT TOPOLOGY

The notion of hypersoft topology on a hypersoft set and its associated attributes are defined in this section.

Definition 3.1. Suppose $(\boldsymbol{\phi}, \boldsymbol{A})$ be a hypersoft set. The hypersoft power set of $(\boldsymbol{\phi}, \boldsymbol{A})$ is defined by $P[(\boldsymbol{\phi}, \boldsymbol{A})] = \{(\boldsymbol{\phi}, \boldsymbol{A})_i : (\boldsymbol{\phi}, \boldsymbol{A})_i \subseteq (\boldsymbol{\phi}, \boldsymbol{A}), i \in I \subseteq N\}$ and its cardinality is defined by $|P[(\boldsymbol{\phi}, \boldsymbol{A})]| = 2^{\sum_{\tilde{\alpha} \in \boldsymbol{A}} |\phi(\tilde{\alpha})|}$, where $|\phi(\tilde{\alpha})|$ is the cardinality of $\phi(\tilde{\alpha})$

Example 3.2. Let $U = \{x_1, x_2, x_3\}$. Define the attributes sets by $E_1 = \{e_1, e_2, e_3\}$ $E_2 = \{e_4, e_5\}$ $E_3 = \{e_6, e_7\}$. Suppose that $A_1 = \{e_1, e_2\}$ $A_2 = \{e_4, e_5\}$ $A_3 = \{e_7\}$ are subsets of E_i for each $i = 1,2,3$ respectively. Let the hypersoft set $(\boldsymbol{\phi}, \boldsymbol{A})$ be defined by $(\boldsymbol{\phi}, \boldsymbol{A}) = \{((e_1, e_4, e_7)\{x_1, x_2\}), ((e_2, e_5, e_7)\{x_2, x_3\})\}$. Consider all the hypersoft subsets of $(\boldsymbol{\phi}, \boldsymbol{A})$ that are given by $(\boldsymbol{\phi}, \boldsymbol{A})_1 = \{(e_1, e_4, e_7), \{x_1\}\}$, $(\boldsymbol{\phi}, \boldsymbol{A})_2 = \{(e_1, e_4, e_7), \{x_2\}\}$.$(\boldsymbol{\phi}, \boldsymbol{A})_3 = \{(e_1, e_4, e_7), \{x_1, x_2\}\}$, $(\boldsymbol{\phi}, \boldsymbol{A})_4 = \{(e_2, e_5, e_7), \{x_2\}$, $(\boldsymbol{\phi}, \boldsymbol{A})_5 = \{(e_2, e_5, e_7), \{x_3\}\}$, $(\boldsymbol{\phi}, \boldsymbol{A})_6 = \{(e_2, e_5, e_7), \{x_2, x_3\}\}$, $(\boldsymbol{\phi}, \boldsymbol{A})_7 = \{((e_1, e_4, e_7), \{x_1\}), ((e_2, e_5, e_7), \{x_2\})\}$, $(\boldsymbol{\phi}, \boldsymbol{A})_8 = \{((e_1, e_4, e_7), \{x_1\}), ((e_2, e_5, e_7), \{x_3\})\}$, $(\boldsymbol{\phi}, \boldsymbol{A})_9 = \{((e_1, e_4, e_7), \{x_1\}), ((e_2, e_5, e_7), \{x_2, x_3\})\}$ $(\boldsymbol{\phi}, \boldsymbol{A})_{10} = \{((e_1, e_4, e_7), \{x_2\}), ((e_2, e_5, e_7), \{x_2\})\}$.$(\boldsymbol{\phi}, \boldsymbol{A})_{11} = \{((e_1, e_4, e_7), \{x_2\}), ((e_2, e_5, e_7), \{x_3\})\}$, $(\boldsymbol{\phi}, \boldsymbol{A})_{12} = \{((e_1, e_4, e_7), \{x_2\}), ((e_2, e_5, e_7), \{x_2, x_3\})\}$, $(\boldsymbol{\phi}, \boldsymbol{A})_{13} = \{((e_1, e_4, e_7), \{x_1, x_2\}), ((e_2, e_5, e_7), \{x_2\})\}$, $(\boldsymbol{\phi}, \boldsymbol{A})_{14} = \{((e_1, e_4, e_7), \{x_1, x_2\}), ((e_2, e_5, e_7), \{x_3\})\}$ $(\boldsymbol{\phi}, \boldsymbol{A})_{15} = (\boldsymbol{\phi}, \boldsymbol{A})$, $(\boldsymbol{\phi}, \boldsymbol{A})_{16} = \boldsymbol{\Phi_A}$, so $|P[(\boldsymbol{\phi}, \boldsymbol{A})]| = 2^4 = 16$.

Definition 3.3. Let $(\phi, A) \in H[U]$. A hypersoft topology on (ϕ, A), donoted by τ, is a collection of hypersoft subsets of $(\phi, \mathbf{A})$ having the following properties.

i. $\Phi_A, (\phi, A) \in \tau$

ii. $\{(\phi, A)_j \subseteq (\phi, A) : j \in J \subseteq N\} \subseteq \tau \Rightarrow \bigcup_{j\in J}(\phi, A)_j \in \tau$

iii. $\{(\phi, A)_j \subseteq (\phi, A) : 1 \leq j \leq n, n \in N\} \subseteq \tau \Rightarrow \bigcap_{j=1}^{n}(\phi, A)_j \in \tau.$

The pair $((\phi, \mathbf{A}), \tau)$ is called a HTS.

Example 3.4. Let us consider the hypersoft subsets of (φ, A) that are given in Example 3.2 then

$\tau_1 = \{\Phi_A, (\phi, A)\}$
$\tau_2 = P[(\phi, A)]$ and
$\tau_3 = \{\Phi_A, (\phi, A), (\phi, A)_2, (\phi, A)_{11}, (\phi, A)_{13}\}$ are hypersoft topologies on (ϕ, A).

Definition 3.5. Let $((\phi, A), \tau)$ be a HTS. Then every element of τ is called hypersoft open set. Clearly Φ_A, (ϕ, A) are hypersoft open sets. A hypersoft set is closed hypersoft set if its complement is open hypersoft set

Definition 3.6. Let $((\phi, A), \tau_1)$ and $((\phi, A), \tau_2)$ be two HTSs. If $\tau_2 \supseteq \tau_1$, then τ_2 is finer than τ_1 or τ_1 is coarser than τ_2. If $\tau_2 \supset \tau_1$, then τ_2 is strictly finer than τ_1. If either $\tau_2 \supseteq \tau_1$ or $\tau_2 \subseteq \tau_1$, then τ_1 is comparable with τ_2.

Example 3.7. Let us consider the hypersoft topologies on (ϕ, A) that are given in example 3.4. Then hypersoft topology τ_2 is finer than hypersoft topologies τ_1 and τ_3, hypersoft topology τ_3 is finer than hypersoft topology τ_1. So τ_1, τ_2 and τ_3 are comparable hypersoft topologies.

Definition 3.8. Let $((\phi, A), \tau)$ be a HTS and $\mathfrak{B} \subseteq \tau$. If every element of τ can be written as the union of elements of $\mathfrak{B}$, then $\mathfrak{B}$ is called a hypersoft basis for the hypersoft topology τ. Each element of $\mathfrak{B}$ is called a hypersoft basis element.

Example 3.9. Let us consider Examples 3.2 and 3.4. Then
$\mathfrak{B} = \{\Phi_A, (\phi, A)_1, (\phi, A)_2, (\phi, A)_4, (\phi, A)_5\}$ is a hypersoft basis for the hypersoft topology τ_2.

Theorem 3.10. Let $((\phi, A), \tau)$ and $((\phi, A), \tau')$ be two HTSs and $\mathfrak{B}$, $\mathfrak{B}'$ be hypersoft bases for τ and τ' respectively. If $\mathfrak{B}' \subseteq \mathfrak{B}$, then τ is finer than τ'.
Proof. Let $\mathfrak{B}' \subseteq \mathfrak{B}$. Then for each $(\varphi, B) \in \tau'$ and $(\psi, C) \in \mathfrak{B}'$
$(\varphi, B) = \bigcup_{(\psi,C)\in\mathfrak{B}'}(\psi, C) = \bigcup_{(\psi,C)\in\mathfrak{B}}(\psi, C)$. Therefore $(\varphi, B) \in \tau$, hence $\tau' \subseteq \tau$

Theorem 3.11. Let $((\phi, A), \tau)$ be a HTS and $\mathfrak{B}$ be hypersoft basis for τ. Then τ is the collection of union of elements of $\mathfrak{B}$.
Proof: The proof is trivial.

Definition 3.12. Let $((\phi, A), \tau)$ be a HTS and $(\varphi, B) \subseteq (\phi, A)$. Then the collection $\tau_{(\varphi,B)} = \{(\phi, A)_i \cap (\varphi, B) : (\phi, A)_i \in \tau, i \in I \subseteq N\}$ is called a hypersoft subspace topology on (φ, B). Hence, $((\varphi, B), \tau_{(\varphi,B)})$ is called a hypersoft topological subspace of $((\phi, A), \tau)$.

Theorem 3.13. Let $((\phi, A), \tau)$ be a HTS and $(\varphi, B) \subseteq (\phi, A)$. Then a hypersoft subspace topology on (φ, B) is a hypersoft topology.
Proof : Indeed, it contains Φ_A and (φ, B) because $\Phi_A \cap (\varphi, B) = \Phi_A$ and $(\phi, A) \cap (\varphi, B) = (\varphi, B)$, where $\Phi_A, (\phi, A) \in \tau$. Since $\tau = \{(\phi, A)_i : (\phi, A)_i \subseteq (\phi, A), i \in I\}$ is closed under finite intersections and arbitrary unions. $\bigcap_{i=1}^{n}((\phi, A)_i \cap (\varphi, B)) = (\bigcap_{i=1}^{n}(\phi, A)_i) \cap (\varphi, B))$

$$\bigcup_{i\in I}((\phi, A)_i \cap (\varphi, B)) = (\bigcup_{i\in I}(\phi, A)_i) \cap (\varphi, B))$$

Example 3.14. Let us consider the hypersoft topology τ_3 on (ϕ, A) given in example 3.4. If $(\varphi, B) = (\phi, A)_9$, then hypersoft subspace topology $\tau_{(\varphi,B)} = \{\Phi_A, (\phi, A)_9, (\phi, A)_5, (\phi, A)_7\}$, and so $((\varphi, B), \tau_{(\varphi,B)})$ is a hypersoft topological subspace of $((\phi, A), \tau_3)$.

Theorem 3.15. Let $((\phi, A), \tau)$ be a HTS, $((\varphi, B), \tau_{(\varphi,B)})$ be a hypersoft topological subspace. If (ψ, C) is hypersoft open in $\tau_{(\varphi,B)}$, then there exists at least one element (χ, D) of τ such that $(\psi, C) \subseteq (\chi, D)$.
Proof: It is clearly seen from Definition 3.12.

Theorem 3.16. Let $((\phi, A), \tau)$ be a HTS. If $\mathfrak{B}$ is a hypersoft basis for τ, then the collection $\mathfrak{B}_{(\varphi,B)} = \{(\phi, A)_i \cap (\varphi, B) : (\phi, A)_i \in \mathfrak{B}, i \in I \subset N\}$ is a hypersoft basis for the hypersoft subspace topology on (φ, B).
proof : Take as given each $(\psi, C) \in \tau_{(\varphi,B)}$. From the definition of hypersoft subspace, $(\psi, C) = (\chi, D) \cap (\varphi, B)$, where $(\chi, D) \in \tau$. Because $(\chi, D) \in \tau$, $(\chi, D) = \bigcup_{(\phi,A)_i \in \mathfrak{B}} (\phi, A)_i$. Therefore $(\psi, C) = \left(\bigcup_{(\phi,A)_i \in \mathfrak{B}} (\phi, A)_i\right) \cap (\varphi, B) = \bigcup_{(\phi,A)_i \in \mathfrak{B}} ((\phi, A)_i \cap (\varphi, B))$. Hence $\mathfrak{B}_{(\varphi,B)}$ is a hypersoft basis for hypersoft subspace topology $\tau_{(\varphi,B)}$ on (φ, B).

Theorem 3.17. Let $((\phi, A), \tau)$ be a HTS. Then the following conditions hold

i. The empty set Φ_A and (ϕ, A) are hypersoft closed sets.
ii. Arbitrary intersections of the hypersoft closed sets are hypersoft closed.
iii. Finite unions of the hypersoft closed sets are hypersoft closed.

Proof:

i. By the definition of hypersoft closed set, $(\phi, A)^c = \Phi_A$ and ${\Phi_A}^c = (\phi, A)$ are hypersoft open. Then (ϕ, A) and Φ_A are hypersoft closed.

ii. If $\{(\phi, A)_i : (\phi, A)_i^c \in \tau, i \in I \subseteq N\}$ is a given collection of hypersoft closed sets, then $(\bigcap_{i \in I} (\phi, A)_i)^c = \bigcup_{i \in I} (\phi, A)_i^c$ is hypersoft open. Therefore $\bigcap_{i \in I} (\phi, A)_i$ is a hypersoft closed set.

iii. If $(\phi, A)_i$ is hypersoft closed for $i = 1,2,3,\ldots,n$. Then $(\bigcup_{i=1}^{n} (\phi, A)_i)^c = \bigcap_{i=1}^{n} (\phi, A)_i^c$ is hypersoft open. Hence $\bigcup_{i=1}^{n} (\phi, A)_i$ is a hypersoft closed set.

Definition 3.18. Let $((\phi, A), \tau)$ be a HTS and $(\varphi, B) \subseteq (\phi, A)$. Then the hypersoft interior of (φ, B), denoted $(\varphi, B)^\circ$, is defined as the union of all hypersoft open subsets of (φ, B). $(\varphi, B)^\circ = \cup \{(\varphi, B)_i : (\varphi, B)_i \in \tau, (\varphi, B)_i \subseteq (\varphi, B), i \in I \subseteq N\}$.
Note that $(\varphi, B)^\circ$ is the biggest hypersoft open set that is contained by (φ, B).

Example 3.19. Let us consider the hypersoft topology τ_3 given in example 3.4.
Let $(\varphi, B) = (\phi, A)_{12} = \{((e_1, e_4, e_7), \{x_2\}), ((e_2, e_5, e_7), \{x_2, x_3\})\}$. Then the hypersoft interior of (φ, B), $(\varphi, B)^\circ = \Phi_A \cup (\phi, A)_2 \cup (\phi, A)_{11} = (\phi, A)_{11}$.

Theorem 3.20. Let $((\phi, A), \tau)$ be a HTS and $(\varphi, B) \subseteq (\phi, A)$. (φ, B) is a hypersoft open set if and only if $(\varphi, B) = (\varphi, B)^{\circ}$.

Proof : If (φ, B) is an hypersoft open set, then the biggest hypersoft open set that is contained by (φ, B) is equal to (φ, B). Therefore $(\varphi, B) = (\varphi, B)^{\circ}$. Conversely, it is known that $(\varphi, B)^{\circ}$ is a hypersoft open set, and if $(\varphi, B) = (\varphi, B)^{\circ}$, then (φ, B) is hypersoft open set.

Theorem 3.21. Let $\left((\phi, A), \tau\right)$ be a HTS and $(\varphi, B), (\psi, C) \subseteq (\phi, A)$. Then

i. $(\,(\varphi, B)^{\circ})^{\circ} = (\varphi, B)^{\circ}$
ii. $((\varphi, B) \subseteq (\psi, C) \Rightarrow (\varphi, B)^{\circ} \subseteq (\psi, C)^{\circ}$
iii. $(\varphi, B)^{\circ} \cap (\psi, C)^{\circ} = ((\varphi, B) \cap (\psi, C)^{\circ}$
iv. $(\varphi, B)^{\circ} \cup (\psi, C)^{\circ} \subseteq ((\varphi, B) \cup (\psi, C)^{\circ}$

Proof:

i. Let $(\varphi, B)^{\circ} = (\chi, D)$. Then $(\chi, D) \in \tau$ iff $(\chi, D) = (\chi, D)^{\circ}$. Therefore $((\varphi, B)^{\circ})^{\circ} = (\varphi, B)^{\circ}$.
ii. Let $(\varphi, B) \subseteq (\psi, C)$. From the definition of a hypersoft interior, $(\varphi, B)^{\circ} \subseteq (\varphi, B)$ and $(\psi, C)^{\circ} \subseteq (\psi, C)$. $(\psi, C)^{\circ}$ is the biggest hypersoft open set that is contained by (ψ, C). Hence, $(\varphi, B) \subseteq (\psi, C) \Rightarrow (\varphi, B)^{\circ} \subseteq (\psi, C)^{\circ}$
iii. By the definition of a hypersoft interior, $(\varphi, B)^{\circ} \subseteq (\varphi, B)$ and $(\psi, C)^{\circ} \subseteq (\psi, C)$. Then $(\varphi, B)^{\circ} \cap (\psi, C)^{\circ} \subseteq (\varphi, B) \cap (\psi, C)$. $((\varphi, B) \cap (\psi, C))^{\circ}$ is the biggest hypersoft open set that is contained by $((\varphi, B) \cap (\psi, C))$. Hence, $(\varphi, B)^{\circ} \cap (\psi, C)^{\circ} \subseteq ((\varphi, B) \cap (\psi, C))^{\circ}$. Conversely, $(\varphi, B) \cap (\psi, C) \subseteq (\varphi, B)$ and $(\varphi, B) \cap (\psi, C) \subseteq (\psi, C)$ Then, $((\varphi, B) \cap (\psi, C))^{\circ} \subseteq (\varphi, B)^{\circ}$ and $((\varphi, B) \cap (\psi, C))^{\circ} \subseteq (\psi, C)^{\circ}$. Therefore, $((\varphi, B) \cap (\psi, C))^{\circ} \subseteq (\varphi, B)^{\circ} \cap (\psi, C)^{\circ}$.
iv. Let $(\varphi, B)^{\circ} \subseteq (\varphi, B)$ and $(\psi, C)^{\circ} \subseteq (\psi, C)$. Then $(\varphi, B)^{\circ} \cup (\psi, C)^{\circ} \subseteq (\varphi, B) \cup (\psi, C)$. $((\varphi, B) \cup (\psi, C))^{\circ}$ is the biggest hypersoft open set that is contained by $(\varphi, B) \cup (\psi, C)$. Hence, $(\varphi, B)^{\circ} \cup (\psi, C)^{\circ} \subseteq ((\varphi, B) \cup (\psi, C))^{\circ}$.

Definition 3.22. Let $\left((\phi, A), \tau\right)$ be a HTS and $(\varphi, B) \subseteq (\phi, A)$. Then the hypersoft closure of (φ, B) denoted by $\overline{(\varphi, B)}$, is defined as the intersection of all hypersoft closed supersets of (φ, B). $\overline{(\varphi, B)} = \cap \{(\phi, A)_i : (\phi, A)_i^c \in \tau, (\varphi, B) \subseteq (\phi, A)_i, i \in I \subseteq N\}$. Note that $\overline{(\varphi, B)}$ is the smallest hypersoft closed set that containing (φ, B).

Example 3.23. Let us consider the hypersoft topology τ_3 given in example 3.4. If $(\varphi, B) = (\phi, A)_9 = \{((e_1, e_4, e_7), \{x_1\}), ((e_2, e_5, e_7), \{x_2, x_3\})\}$ then $(\phi, A)_2^c = (\phi, A)_9 = \{((e_1, e_4, e_7), \{x_1\}), ((e_2, e_5, e_7), \{x_2, x_3\})\}$ and $\Phi_A{}^c = (\phi, A) = \{((e_1, e_4, e_7), \{x_1, x_2\}), ((e_2, e_5, e_7), \{x_2, x_3\})\}$ are hypersoft closed supersets of (φ, B). Hence $\overline{(\varphi, B)} = (\phi, A)_9 \cap (\phi, A) = (\phi, A)_9$

Theorem 3.24. Let $\left((\phi, A), \tau\right)$ be a HTS and $(\varphi, B) \subseteq (\phi, A)$. (φ, B) is a hypersoft closed set iff $(\varphi, B) = \overline{(\varphi, B)}$.

Proof: The proof is trivial.

Theorem 3.25. Let $\left((\phi, A), \tau\right)$ be a HTS and $(\varphi, B) \subseteq (\phi, A)$. Then $(\varphi, B)^{\circ} \subseteq (\varphi, B) \subseteq \overline{(\varphi, B)}$.

Proof: The proof is trivial.

Theorem 3.26. Let $((\phi, A), \tau)$ be a HTS and (φ, B), $(\psi, C) \subseteq (\phi, A)$. Then

i. $\overline{\overline{(\varphi, B)}} = \overline{(\varphi, B)}$
ii. $\overline{(\varphi, B)}^c = ((\varphi, B)^c)^\circ$
iii. $(\psi, C) \subseteq (\varphi, B) \Rightarrow \overline{(\psi, C)} \subseteq \overline{(\varphi, B)}$
iv. $\overline{(\varphi, B) \cap (\psi, C)} \subseteq \overline{(\varphi, B)} \cap \overline{(\psi, C)}$
v. $\overline{(\varphi, B) \cup (\psi, C)} = \overline{(\varphi, B)} \cup \overline{(\psi, C)}$

Proof:

i. Let $\overline{(\varphi, B)} = (\chi, D)$. Then (χ, D) is a hypersoft closed set. Therefore (χ, D) and $\overline{(\chi, D)}$ are equal. Hence $\overline{\overline{(\varphi, B)}} = \overline{(\varphi, B)}$.

ii. If we consider the definitions of a hypersoft closure and a hypersoft interior, we obtain

$$\overline{(\varphi, B)}^c = \left(\bigcap_{\substack{(\phi,A)_i \supseteq (\varphi,B) \\ (\phi,A)_i^c \in \tau}} (\phi, A)_i \right)^c = \bigcup (\phi, A)_i^c = ((\varphi, B)^c)^\circ$$

iii. Let $(\psi, C) \subseteq (\varphi, B)$. By the definition of a hypersoft closure, $(\varphi, B) \subseteq \overline{(\varphi, B)}$ and $(\psi, C) \subseteq \overline{(\psi, C)}$. $\overline{(\psi, C)}$ is the smallest hypersoft closed set that containing (ψ, C). Then $\overline{(\psi, C)} \subseteq \overline{(\varphi, B)}$.

iv. Let $\overline{(\varphi, B)}$ and $\overline{(\psi, C)}$ are hypersoft closed sets. So $\overline{(\varphi, B)} \cap \overline{(\psi, C)}$ is a hypersoft closed set. Since $(\varphi, B) \cap (\psi, C) \subseteq \overline{(\varphi, B)} \cap \overline{(\psi, C)}$ and $\overline{(\varphi, B)} \cap \overline{(\psi, C)}$ is the smallest hypersoft closed set that containing $(\varphi, B) \cap (\psi, C)$, $\overline{(\varphi, B)} \cap \overline{(\psi, C)} \subseteq \overline{(\varphi, B)} \cap \overline{(\psi, C)}$.

v. Let $(\varphi, B) \subseteq \overline{(\varphi, B)}$ and $(\psi, C) \subseteq \overline{(\psi, C)}$. Then $(\varphi, B) \cup (\psi, C) \subseteq \overline{(\varphi, B)} \cup \overline{(\psi, C)}$. Since $\overline{(\varphi, B) \cup (\psi, C)}$ is the smallest hypersoft closed set that containing $(\varphi, B) \cup (\psi, C)$, $\overline{((\varphi, B) \cup (\psi, C))} \subseteq \overline{(\varphi, B)} \cup \overline{(\psi, C)}$. Conversely, $(\psi, C) \subseteq \overline{(\psi, C)} \subseteq \overline{(\varphi, B) \cup (\psi, C)}$ and $(\varphi, B) \subseteq \overline{(\varphi, B)} \subseteq \overline{(\varphi, B) \cup (\psi, C)}$. Therefore, $\overline{(\varphi, B)} \cup \overline{(\psi, C)} \subseteq \overline{(\varphi, B) \cup (\psi, C)}$. Hence, $\overline{(\varphi, B)} \cup \overline{(\psi, C)} = \overline{(\varphi, B) \cup (\psi, C)}$

Definition 3.27. Let $((\phi, A), \tau)$ be a HTS and $\alpha \in (\phi, A)$. If there is a hypersoft open set $(\varphi, B) \in \tau$ such that $\alpha \in (\varphi, B)$, then (φ, B) is called a hypersoft neighborhood of α. The set of all hypersoft neighborhood of α donoted by $HN(\alpha)$, is called the family of hypersoft neighborhoods of α, $HN(\alpha) = \{(\varphi, B): (\varphi, B) \in \tau, \alpha \in (\varphi, B)\}$

Example 3.28. Let us consider the HTS $((\phi, A), \tau_3)$ in Example 3.4 and $\alpha = ((e_1, e_4, e_7), \{x_1, x_2\}) \in (\phi, A)$. Then $HN(\alpha) = \{(\phi, A), (\phi, A)_{13}\}$

Definition 3.29. Let $((\phi, A), \tau)$ be a HTS, $(\varphi, B) \subseteq (\phi, A)$ and $\alpha \in (\phi, A)$. If every neighborhood of α intersects (φ, B) in some points other than α itself, then α is called a hypersoft limit point of (φ, B). The set of all limit points of (φ, B) is denoted by $(\varphi, B)'$. In other words, if $((\phi, A), \tau)$ is a HTS, $(\varphi, B), (\psi, C) \subseteq (\phi, A)$ and $\alpha \in (\phi, A)$, then $\alpha \in (\varphi, B)' \Leftrightarrow (\psi, C) \cap ((\varphi, B) \setminus \{\alpha\}) \neq \Phi_A$ for all $(\psi, C) \in HN(\alpha)$.

Example 3.30. Let us consider the Example 3.28. If $(\varphi, B) = (\phi, A)_{13}$ and $\alpha = ((e_1, e_4, e_7), \{x_1, x_2\}) \in (\phi, A)$ then $\alpha \in (\varphi, B)'$. Since $(\phi, A) \cap ((\varphi, B) \setminus \{\alpha\}) \neq \Phi_A$ and $(\phi, A)_{13} \cap ((\varphi, B) \setminus \{\alpha\}) \neq \Phi_A$

Theorem 3.31. Let $((\phi, A), \tau)$ be a HTS and $(\varphi, B) \subseteq (\phi, A)$. Then $(\varphi, B) \cup (\varphi, B)' = \overline{(\varphi, B)}$.
Proof: If $\alpha \in (\varphi, B) \cup (\varphi, B)'$ then $\alpha \in (\varphi, B)$ or $\alpha \in (\varphi, B)'$. In this case, if $\alpha \in (\varphi, B)$ then $\alpha \in \overline{(\varphi, B)}$. If $\alpha \in (\varphi, B)'$, then $(\psi, C) \cap ((\varphi, B) \setminus \{\alpha\}) \neq \Phi_A$ for all $(\psi, C) \in HN(\alpha)$ and so $(\psi, C) \cap (\varphi, B) \neq \Phi_A$ for all $(\psi, C) \in HN(\alpha)$. Hence $\alpha \in \overline{(\varphi, B)}$. Conversely, if $\alpha \in \overline{(\varphi, B)}$, then $\alpha \in (\varphi, B)$ or $\alpha \notin (\varphi, B)$. In this case, if $\alpha \in (\varphi, B)$ it is trivial that $\alpha \in (\varphi, B) \cup (\varphi, B)'$. If $\alpha \notin (\phi, B)$ then $(\psi, C) \cap ((\varphi, B) \setminus \{\alpha\}) \neq \Phi_A$ for all $(\psi, C) \in HN(\alpha)$. Therefore $\alpha \in (\varphi, B)'$ so $\alpha \in (\varphi, B) \cup (\varphi, B)'$. Hence $(\varphi, B) \cup (\varphi, B)' = \overline{(\varphi, B)}$.

Theorem 3.32. Let $((\phi, A), \tau)$ be a HTS, and $(\varphi, B) \subseteq (\phi, A)$. Then (φ, B) is hypersoft closed if and only if $(\varphi, B)' \subseteq (\varphi, B)$.
Proof : $\overline{(\varphi, B)} = (\varphi, B) \Leftrightarrow (\varphi, B) \cup (\varphi, B)' = (\varphi, B) \Leftrightarrow (\varphi, B)' \subseteq (\varphi, B)$.

Theorem 3.33. Let $((\phi, A), \tau)$ be a HTS and $(\varphi, B), (\psi, C) \subseteq (\phi, A)$. Then

i. $(\varphi, B)' \subseteq \overline{(\varphi, B)}$
ii. $(\varphi, B) \subseteq (\psi, C) \Rightarrow (\varphi, B)' \subseteq (\psi, C)'$
iii. $((\varphi, B) \cap (\psi, C))' \subseteq (\varphi, B)' \cap (\psi, C)'$
iv. $((\varphi, B) \cup (\psi, C))' = (\varphi, B)' \cup (\psi, C)'$

Proof:

i. It is clearly seen from theorem 3.31.
ii. Let $\alpha \in (\varphi, B)'$. Then $(\chi, D) \cap \big((\varphi, B) \setminus \{\alpha\}\big) \neq \Phi_A$, for all $(\chi, D) \in HN(\alpha)$. Since $(\varphi, B) \subseteq (\psi, C), (\chi, D) \cap ((\psi, C) \setminus \{\alpha\}) \neq \Phi_A$ for all $(\chi, D) \in HN(\alpha)$. In other words $\alpha \in (\psi, C)'$. Hence $(\varphi, B)' \subseteq (\psi, C)'$.
iii. $(\varphi, B) \cap (\psi, C) \subseteq (\varphi, B)$ and $(\varphi, B) \cap (\psi, C) \subseteq (\psi, C)$.
Then $((\varphi, B) \cap (\psi, C))' \subseteq (\varphi, B)'$ and $((\varphi, B) \cap (\psi, C))' \subseteq (\psi, C)'$.
Therefore, $((\varphi, B) \cap (\psi, C))' \subseteq (\varphi, B)' \cap (\psi, C)'$
iv. $(\varphi, B) \subseteq (\varphi, B) \cup (\psi, C)$ and $(\psi, C) \subseteq (\varphi, B) \cup (\psi, C)$. Then $(\varphi, B)' \subseteq ((\varphi, B) \cup (\psi, C))'$ and $(\psi, C)' \subseteq ((\varphi, B) \cup (\psi, C))'$ Therefore $(\varphi, B)' \cup (\psi, C)' \subseteq ((\varphi, B) \cup (\psi, C))'$. Conversely, for all $(\chi, D) \in HN(\alpha), \alpha \in \big((\varphi, B) \cup (\psi, C)\big)' \Leftrightarrow (\chi, D) \cap \big[\big((\varphi, B) \cup (\psi, C)\big) \setminus \{\alpha\}\big] \neq \Phi_A \Leftrightarrow (\chi, D) \cap [(\varphi, B) \setminus \{\alpha\} \cup (\psi, C)) \setminus \{\alpha\}] \neq \Phi_A \Leftrightarrow \big[(\chi, D) \cap \big((\varphi, B) \setminus \{\alpha\}\big)\big] \cup \big[(\chi, D) \cap \big((\psi, C) \setminus \{\alpha\}\big)\big] \neq \Phi_A \Leftrightarrow \big[(\chi, D) \cap \big((\varphi, B) \setminus \{\alpha\}\big)\big] \neq \Phi_A$ or $\big[(\chi, D) \cap \big((\psi, C) \setminus \{\alpha\}\big)\big] \neq \Phi_A \Leftrightarrow \alpha \in (\varphi, B)'$ or $\alpha \in (\psi, C)'$
$\Leftrightarrow \alpha \in (\varphi, B)' \cup (\psi, C)'$. Hence $((\varphi, B) \cup (\psi, C))' \subseteq (\varphi, B)' \cup (\psi, C)'$. Thus $((\varphi, B) \cup (\psi, C)) = (\varphi, B)' \cup (\psi, C)'$.

Definition 3.34. Let $((\phi, A), \tau)$ be a HTS. If $\forall\, \alpha_1, \alpha_2 \in (\phi, A), \alpha_1 \neq \alpha_2$, there exists $(\varphi, B)_1 \in HN\{\alpha_1\}$ and $(\varphi, B)_2 \in HN\{\alpha_2\}$ such that $(\varphi, B)_1 \cap (\varphi, B)_2 = \Phi_A$, then $((\phi, A), \tau)$ is called hypersoft Hausdorff space.

Example 3.35. Let $U = \{x_1, x_2, x_3\}$ and $E_1 = \{e_1, e_2, e_3\}$ $E_2 = \{e_4, e_5\}$ $E_3 = \{e_6, e_7\}$. Consider the hypersoft set $(\phi, E) = \{((e_1, e_4, e_7), \{x_1, x_2\}), ((e_2, e_5, e_7), \{x_2, x_3\}), ((e_3, e_4, e_6), \{x_1, x_3\})\}$.

$If\ (\phi, E)_1 = \{((e_1, e_4, e_7), \{x_1, x_2\}), ((e_3, e_4, e_6), \{x_1\})\}$,$(\phi, E)_2 = \{((e_2, e_5, e_7), \{x_2, x_3\}),$ $((e_3, e_4, e_6), \{x_3\})\}$. Then $\tau = \{\Phi_A, (\phi, E), (\phi, E)_1, (\phi, E)_2\}$ is a hypersoft topology on (ϕ, E). Hence $((\phi, E), \tau)$ is a hypersoft Hausdorff space.

Theorem 3.36. Every finite point hypersoft set in a hypersoft Hausdorff space is a hypersoft closed set.

Proof : Let $((\phi, A), \tau)$ be a hypersoft Hausdorff space. It suffices to show that every one point set $\{\alpha_1\}$ is hypersoft closed. If $\alpha_2 \neq \alpha_1$ is a point of (ϕ, A), then α_1 and α_2 have disjoint hypersoft neighborhoods $(\varphi, B)_1$ and $(\varphi, B)_2$ respectively. Since $(\varphi, B)_1$ does not intersect $\{\alpha_2\}$, point α_1 cannot belong to the hypersoft closure of the set $\{\alpha_2\}$. As a result, the hypersoft closure of the set $\{\alpha_1\}$ is $\{\alpha_1\}$ itself, so it is hypersoft closed.

Definition 3.37. Let $((\phi, A), \tau)$ be a HTS and $(\varphi, B) \subseteq (\phi, A)$. Then the hypersoft boundary of (φ, B) denoted $(\varphi, B)^b$, is defined by $(\varphi, B)^b = \overline{(\varphi, B)} \cap \overline{(\varphi, B)^c}$

Example 3.38. Let us consider Example 3.23. For (φ, B), $\overline{(\varphi, B)} = (\phi, A)_2^c$ and $\overline{(\varphi, B)^c} = (\phi, A)$. Then $(\varphi, B)^b = \overline{(\varphi, B)} \cap \overline{(\varphi, B)^c} = (\phi, A)_2^c$

Theorem 3.39. Let $((\phi, A), \tau)$ be a HTS, and (φ, B), $(\psi, C) \subseteq (\phi, A)$. Then

i. $(\varphi, B)^b \subseteq \overline{(\varphi, B)}$
ii. $(\varphi, B)^b = ((\varphi, B)^c)^b$
iii. $(\varphi, B)^b = \overline{(\varphi, B)} \setminus (\varphi, B)^\circ$

Proof :

i. From the definition of a hypersoft boundary, the proof is trivial.
ii. Take as given $\alpha \in (\varphi, B)^b$
$\Leftrightarrow (\psi, C) \cap (\varphi, B) \neq \Phi_A$ and $(\psi, C) \cap (\varphi, B)^c = \Phi_A$ for all $(\psi, C) \in HN\{\alpha\}$.
$\Leftrightarrow (\psi, C) \cap (\varphi, B)^c \neq \Phi_A$ and $(\psi, C) \cap ((\varphi, B)^c)^c \neq \Phi_A$ for all $(\psi, C) \in HN\{\alpha\}$.
Hence $(\varphi, B)^b = ((\varphi, B)^c)^b$.
iii. Consider the definitions of a hypersoft closure and a hypersoft interior.

$$\overline{(\varphi, B)} \setminus (\varphi, B)^\circ = \overline{(\varphi, B)} \cap ((\varphi, B)^\circ)^c = \overline{(\varphi, B)} \cap \left(\bigcup_{\substack{(\varphi, B)_i \subseteq (\varphi, B) \\ (\varphi, B)_i \in \tau}} (\varphi, B)_i \right)^c$$

$$= \overline{(\varphi, B)} \cap (\cap (\phi, B)_i^c) = \overline{(\varphi, B)} \cap \overline{(\phi, B)^c} = (\varphi, B)^b.$$

CONCLUSION

One important branch of mathematics is topology. We introduced the idea of hypersoft topology on a hypersoft set and discussed its associated aspects in this work. The theoretical underpinnings of HTSs were then presented. This study might serve as a foundation for hypersoft set theoretic operations-based mathematical structures and notions. Many topological space features can be extended to HTS in the future.

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RESEARCH ARTICLE

Isolation and Identification of Symbiotic Bacteria (*Xenorhabdus*) from Entomopathogenic Nematode

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ABSTRACT

Entomopathogenic nematodes represent a group of soil inhabiting nematodes that parasitize a wide range of insects. These nematodes belong to two families: Steinernematidae and Heterorhabditidae. Until now, more than 70 species have been described in Steinernematidae and there are about 20 species in Heterorhabditidae. The nematodes have a mutualistic partnership with Enterobacteriaceae bacteria and together they act as a potent insecticidal complex that kills a wide range of insect species. Many nematodes are associated with insects and their host interactions range from beneficial to detrimental. The pathogenic effect is in fact conferred by their interaction with facultative anaerobic enteric bacteria. The bacteria are vectored from one insect host to another by the only free-living nematode stage, the third-stage infective juvenile which lives in soil. Once inside the insect, the nematodes release the bacteria into the insect's hemolymph, which kill the insect host by massive septicemia. In the present investigation is toisolate *Xenorhabdus*(symbiotic bacteria) from EPN . It also focuses on the insect-baiting technique, a widely used approach for the isolation of EPN from soil samples, and the modified white trap technique which is popularly used for the recovery of these nematodes from infected insects. The third segment of the cadaver was given a cut to extract hemolymph. The hemolymph was streaked on sterile plates of Nutrient Bromothymol Blue Triphenyltetrazolium chloride agar NBTA. The Plates was incubated at 28°

C in dark for 4 days. After 4 days of incubation, bacterial colonies were observed. The characteristics of the colonies was dark blue, convex and swarm colonies. There will be a phase shift from blue to orange and finally the colonies will be observed as yellowish orange colour.

Keywords: *Xenorhabdus*, EPN, Triphenyl tetrazolium chloride,Bromothymolblue

INTRODUCTION

Xenorhabdus spp. (members of the family Enterobacteriaceae) are symbiotically associated with Entomopathogenic nematodes in the families Steinernematidae and Heterorhabditidae, the nematodes act as vectors transporting their bacterial symbionts in to the hemocoel of the insect host. *Xenorhabdus* spp. contribute to the symbiotic relationship by providing nutritional requirements for their nematode partners.Economic importance of entomopathogenic nematodes (EPN) belonging to the genera Steinernema is increasing because of their potential use in biological control of numerous pests (Gaugler and kaya 1990). The non feeding infective juveniles carry the symbiotic bacteria, *Xenorhabdus* in their gut. The nematode search for an ambush a suitable insect host, enter through natural opening and also through cuticle and release their symbiont bacteria into the hemolymph. Proliferation of the bacterium leads to death of the insect host within 24-48 hours followed by nematode development and reproduction (kaya et al., 1993) The Genus *Xenorhabdus* -Steinernema life cycle insect larvae are infected and killed,while both mutualists produce bioactive compounds,a single strain of *Xenorhabdus* may produce a variety of antibacterial and antifungal compounds,some of which are also active against insects,nematodes,Protozoa and cancer cells. *Xenorhabdus* spp., entomopathogenic bacteria symbiotically associated with the nematode of the family steinernematidae are shown to produce different lipases when they are grown on suitable nutrient agar.*Xenorhabdus*spp.occur spontaneously in two variants, phase I and phase II. Phase I variants absorb dyes on agar plates produce several antibiotics, secrete a variety of protiens. The main objectives of our study were to isolate and identify EPNs and their symbiotic Bacteria of *Xenorhabdus*. The main objective of the present research was to isolate and identify EPNs and their Symbiotic Bacteria of *Xenorhabdus*.

MATERIALS AND METHODS

Soil Sample Collection

10 Samples were collected from two locationsat Tirunelveli and Kanyakumari district. Soil Samples with plant debris were taken from a diverse of habitats,for example cashew, golden showers, coconut, mango, ixora, Date palm, Nerium Plant from Tirunelveli district (The Indian Agriculture College) and coconut, mango, Banana, Tamarind, Jack fruit from Seynamvilai village of kanyakumari district**.**

Mass multiplication of EPN

The EPNs were isolated from the soil samples using the *C. cepholonica* Baiting technique as described by Bedding and Akhurst. White trap were used to isolate the emerging infective juvenile EPNs from the *C.cepholonica*c adavers. The infective juveniles of EPN were collected in 100 ml of clean sterile distilled water. The infective juveniles of EPN were surface sterilized by adding 1 ml 0.25 % (w/v) to the suspension and washed with sterile water 2 to 3 times in the Laminar air flow chamber with a sterile micro pipette, most of the supernatant was removed without disturbing the infective juveniles settled at the bottom of the tube. At the final step the surface sterilized infective juveniles which were collected in a beaker with sterile distilled water. The juvenile nematodes kept at 13-15° C in distilled water prior to molecular identification.

Isolation of *Xenorhabdus* from the Nematodes:

Xenorhabdus bacteria were isolated from the hemolymph of rice moth larval cadavars *(Corcyra cepholonica)* infected with EPN's. To propagate EPN's (500µl) was placed on to a sterile petridish containing 5 larvae of rice moth (*C*

cepholonica). The petridish was then sealed with parafilm and incubated in the dark at room temperature. The insect larvae was observed daily for 2-3 days. The resulting insect cadavers were then washed with 95-100% ethanol and placed on another sterile petridish. The third segment from the mouth parts of the C.cephalonica larvae were opened using fine sterile forceps to obtain the hemolymph containing *Xenorhabdus*. Adrop of hemolymph was streaked on sterile plates of nutrient bromothymolblue triphenyltetrazolium chloride agar (NBTA) which were then stored in the dark at room temperature. After 4 days of incubation, preliminary identification of these bacteria was performed by observing the colony morphology.The colonies of species of the genus *Xenorhabdus* are dark blue, convex, umbonated and swarm. This yellowish orange colour due to the phase shift from blue to orange.

NBTA Media Composition

Nutrient Bromothymol blue triphenyl tetrazolium chloride agar:

Nutrient agar	8.0 g
Bromomethyl blue	25 mg
2,3,5-trimethyl tertazolium chloride	40 mg
distilled water	1000 ml

Molecular Identification of *Xenorhabdus* Species

Sequence analysis of twelve isolates was done to confirm species identity, which initially has been done based solely on morphological parameters. Comparison of oligonucleotide fragments of 16SrRNA sequences, which included the 5.8 S gene and the flanking ITS1 and ITS2 regions, with reference sequences from public databases, showed that they were very similar. (Santhana Bharathi S and Reetha, 2022)

RESULTS AND DISCUSSION

Based on the colony morphology on the NBTA *Xenorhabdus* were isolated from the EPNs (Entomopathogenic Nematode) and were preliminarly characterized based on a dark blue,or dark red colony colour with a convex or umbonated surface and swarming colony on NBTA after three to four days at room temperature (25° C).EPNs are able to infect a broad host range of insects, but in terms of symbiosis the relationship between the host nematode and its symbiont i.e bacterium is very close. Taxonomic studies by using morphological, biochemical and molecular analysis of conserved genes of genera i.e., *Xenorhabdus* in steinernema and *photorhabdus* in heterorhabdetis were conducted by several investigators (Euzeby and Boemare, 2000, Boemare and Akhurst, 2000, 2001: Akhurst and Boemare, 2001. EPNs were obtained from infected *C.cepholonica* larvae. The first phenotypic evidence in the identification of these bacteria was the cadavers colouration. Those *C.cephalonica* infected by steinernema become brownish colour. *Xenorhabdus* are unique in the bacterial world and beneficial due to their ability to form a mutualystic symbiosis in one host and mount and aggressive pathogenic against a totally different phylum.The Selected isolate TCX 1 were molecular level characterized by 16S rRNA sequencing and identified as *Xenorhabdusnematophila* the sequence data were submitted to the NCBI Gen Bank, and the allocated accession number is OR633290.A Phylogenetic tree was also constructed using the 16S rDNA genesequence data at Figure 7.

>OR633290 *Xenorhabdus*nematophila - TCX

CONCLUSION

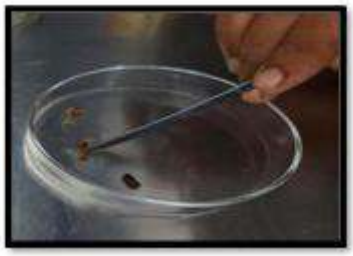
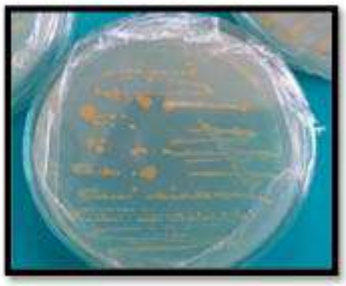
Xenorhabdus is an important component in Integrated pest management strategies. In the present study reported the TCX *Xenorhabdusnematophila* exhibit a monoxenic association between each isolate and its nematode by amplifying and sequencing bacterial 16S rRNA sequence from crushed adult and juvenile nematode and from bacterial cultures isolated from infected hosts.

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Table1: Identified species: *Xenorhabdusnematophila*

Selected Isolates	Locations (Tirunelveli)	Source	Selected Isolates	Locations (kanyakumari)
T1-TCX	TIAC-Cashew	Soil	T8–KCX	Coconut
T2-TGX	TIAC-Golden Shower	Soil	T9-KMX	Mango
T3-TCOX	TIAC-Coconut	Soil	T10-KBX	Banana
T4-TMX	TIAC-Mango	Soil	T11- KTX	Tamarind
T5-TIX	TIAC-Ixora	Soil	T12- KJX	Jack Fruit
T6 –TDX	TIAC-Date Palm	Soil		
7–TNX	TIAC-Nerium Plant	Soil		

	
FIGURE :1 Rice moth larva infected with EPN	**FIGURE:2 Surface Sterlized with 70% Ethanol**
	
FIGURE:3 Cutting of cadavar at 3rd segment	**FIGURE:4Taking Hemolymph from Corcyra larva**
	
FIGURE :5 Hemolymph streaked on NBTA Media	**FIGURE:6 *Xenorhabdus* CULTURE**

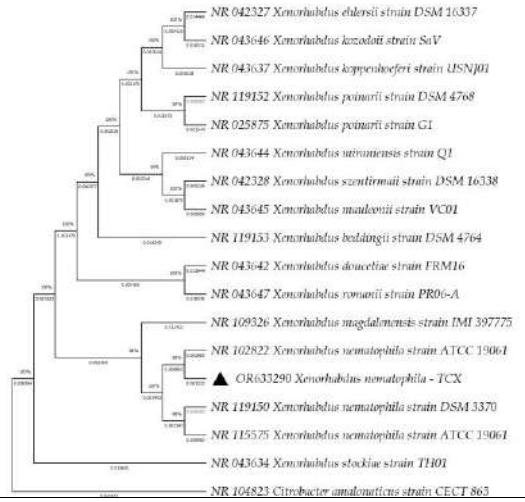


Figure 7. Phylogenetic tree of isolate TCX*Xenorhabdusnematophila*

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REVIEW ARTICLE

Review of Global and Ongoing Sustainable Environment Policies for Implementation of BGI in India

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ABSTRACT

Globally, there is a growing recognition of the importance of blue-green infrastructure for sustainable development. Several policies for sustainability can be implemented for environmental and infrastructure planning, however relating to the nature-based sustainable model i.e., blue-green infrastructure, the development becomes unorganized. This paper intends to focus on the review of global policies for implementing blue-green infrastructure and the ongoing environment and sustainable policies used for implementing BGI in India. However, there is a gap, as no such policy in India is directly related to the integrated blue-green infrastructure in the Inclusive planning process. Moreover, the fragmented nature of policymaking in India also contributes to the gaps between policy and implementation. The above-mentioned gap between policy and implementation of blue-green infrastructure in India requires a comprehensive framework of ongoing policies in a global context which can be further overlapped with the existing sustainable and environmental policies of India in identifying the gap since the implementation of sustainable policies for blue-green infrastructure which is directly responsible towards the environment is crucial for ensuring long-term environmental, social, and economic sustainability. The methods used for the research are purely qualitative, the paper describes the detailed global and Indian policies and best practices related to BGI.

Keywords: Infrastructure planning, Blue-Green Infrastructure, Sustainability, Environment policy, Inclusive Planning

INTRODUCTION

Multifunctional infrastructures are appealing to society because they can integrate urban ecology with reliable and efficient spaces. [1]. "The term 'blue-green' or 'green/blue' infrastructure developed at the turn of the previous decade as a rising awareness of the need for a more integrated systems-approach to the management of Green and Blue Infrastructure. [2]."It (BGI) refers to an integrated system of created and natural elements that work together to manage water resources, enhance biodiversity, reduce flooding risk, and provide other environmental and socioeconomic benefits. BGI is seen as an essential investment and an advancement over traditional infrastructure. [3]. In context with the BGI, the 11th Sustainable Development Goals established by the United Nations General Assembly in 2015 as Sustainable Cities and Communities, the main aim of this goal is "to make cities inclusive, resilient, safe and sustainable [4]."SDG 11 promotes inclusive and sustainable urbanization. It includes investments in public transit, better urban planning and resource management, as well as measures for climate adaptation and disaster resilience. SDGs are now widely recognized as a framework to shape sustainability initiatives within governments and NGOs[5]. Similar to this, activities aimed towards particular SDGs in line with a long-term vision are increasingly integrating sustainability reporting into projects or organization plans. A growing number of nations are establishing policies and programs to encourage the use of BGI as a crucial instrument for climate change adaptation and sustainable development. Cities like Melbourne, Rotterdam, and Portland have become models in this regard. [6].

Background

The EPA defined two spatial scales for green infrastructure in its definition. At the city or county scale, green infrastructure refers to "the patchwork of natural areas that provide habitat, flood protection, cleaner air and cleaner water", whereas at the neighborhood or site scale, green infrastructure refers to "storm water management systems that mimic nature soak up and store water [7, 8]." "Natural infrastructure and blue infrastructure are the two most recently coined terms." [9, 10]"Natural infrastructure was first used to emphasise the importance of wetlands in freshwater system management." [11] The "Blue" recognizes the importance of the physicality of water and works on the principles of utilizing rainwater, allowing its infiltration and managing the storm water that drains off the land into waterways and corridors, while the "Green" connects urban hydrological functions with vegetation systems in urban landscape design. The resulting BGI has overall socio-economic benefits that are greater than the sum of the individual components. Following the debates at the Rio Earth Summit in 1992, Swedish legislation was changed to emphasise sustainability, notably the necessity of green space in and around cities. According to the new legislation, urban planning should promote a healthy living environment, biodiversity, and the effective use of energy and other resources. [12]

METHODOLOGY

The methodology had three major steps for identification of potential BGI Literature review firstly review of ongoing global BGI policies and Projects with extracting the major parameters taken into consideration. Second is the review of existing policies indirectly related to BGI in India. And the third and final step is the comparative analysis of both policy initiative related to both Indian and Global context in context of overlapping of policies, parameters, sectoral plans and gaps.

Blue-green Infrastructure &Sustainable Development

A sustainable city is one that maintains a balance of economic, social, and ecological components. Integrating all effective BGI initiatives, as well as derived services, may unlock the true potential of BGI strategies in improving our towns and cities. [13]. Urbanisation not only influences landscape characteristics but also affects the process of natural systems such as the hydrological cycle, greenhouse gas emissions, biodiversity levels, and metal and nutrient biochemical cycles. [14]. Blue-green infrastructure serves both people and animals. Its presence can improve air and water quality, carbon storage, as well as flood and temperature management, noise reduction, resource

efficiency, biodiversity, and amenity value. These features, in turn, increase resistance to the effects of climate change, including increased temperatures and flooding. BGI has primarily received excellent feedback in nations such as the Netherlands; yet, widespread adoption appears to be challenging due to a lack of awareness

Importance of blue-green infrastructure in sustainable development

The covid-19 pandemic has impacted global and domestic funding capacity for projects related to the UN's sustainable development goals (SDG's).blue-green infrastructure has the potential to fulfill multiple targets outlined in the SDGs, such as those related to Clean water & sanitation (SDG 6), Life on land (SDG 15), climate action (SDG 13), Sustainable cities & communities (social inclusion) (SDG 11) although it can also accelerate progress on green employment prospects (SDG 8**)**, positions in agriculture, manufacturing, R&D, administrative, and service activities aimed at substantially preserving or restoring environmental quality) Followed by these SDGs' various co-factors are related to the sustainability criteria of these SDGs and are important key connections between blue-green infrastructure and sustainable development that are as follows:

- Climate Change Mitigation and Adaptation: Blue-green infrastructure aids in climate change mitigation by sequestering carbon dioxide, cutting energy usage, and minimizing urban heat island effects. It also increases urban resilience by mitigating the effects of extreme weather events through storm water management, flood control, and soil erosion prevention.
- Water Management and Quality: Blue-green infrastructure incorporates natural water management measures such as rain gardens, artificial wetlands, and green roofs to collect and filter storm water runoff.
- Social and health benefits: Blue-green infrastructure improves urban people' quality of life by establishing green places for recreation, increasing air quality, and minimising noise pollution.
- Economic Opportunities: By producing green jobs, attracting investments, and increasing property values, blue-green infrastructure may produce economic advantages.

Challenges in implementing blue-green Infrastructure

Uncertainties surrounding hydrological performance and service delivery, as well as a lack of faith in communities and decision-makers to accept, support, and take holding of such infrastructure, are impeding the widespread adoption of Blue-Green Infrastructure (BGI). When compared to solely hydrological factors, social-institutional hurdles often provide the greatest challenge to the implementation of sustainable water management systems and have a stronger effect on the selected solution. [15]General approaches such as enhancing education and promoting awareness are critical to public understanding of BGI, often lack specifics and may require additional refining to overcome the various challenges in practice. [16] A study was conducted in new castle, an interview analysis was done using qualitative research software, with asking two major nodes i.e., Barriers to BGI' and 'Overcoming barriers' According to the study's findings, more than half of those polled stated that a lack of understanding, education, and awareness about BGI is a major obstacle to obtaining financing (including paying for continuing maintenance) from local governments and the general public, with three primary barriers being physical science/engineering uncertainty, a lack of suitable space, and future land use and climate.[16].

Review of global policies of BGI

International cities are shifting away from depending on just centralized grey infrastructure and towards decentralized facilities that employ BGI to locally retain, store, and reuse surface water, hence increasing their resilience to possible environmental difficulties.

Best Practices in blue-green infrastructure implementation

Case of: Blue-Green Cities Research Project, UK

By integrating water management and green infrastructure, a Blue-Green City aims to replicate a naturally directed water cycle while also contributing to the city's amenity. This is accomplished by integrating and conserving the urban landscape's hydrological and biological assets while also offering robust and adaptive flood mitigation methods. The Blue-Green Cities Research Consortium sought to create innovative ways for controlling urban flood risk as part of a larger, integrated urban planning effort aiming at environmental enhancement and urban

rejuvenation, with the numerous advantages of Blue-Green Cities systematically examined and understood [17]. The project's stakeholders were to be its primary focus, and the drainage systems were to be updated. Risks would be mitigated by studying gaps in the urban drain networks, developing adaptable strategies with the communities, establishing a flood footprint to estimate financial costs, identifying obstacles to flood prevention, and putting in place blue-green infrastructure.

Case of: Grey to Green Initiative, Portland, US

Portland has one of the oldest and most effective BGI programs in the country, and over the past 20 years, it has mad e significant investments in BGI to reduce the burden on the piped infrastructure system, enhance the quality of the water, and control the danger of flooding.The five-year 'Grey to Green' effort aided in the execution of the Portland Watershed Management Plan (2005), with overarching aims of safeguarding natural resources, restoring important ecosystems, and adopting storm water solutions that integrate urban regions with the natural environment [18].The initiative highlighted aspects such as street and yard tree planting, green streets and eco-roofs. [19].

Case of : Rotterdam, Netherlands

Rotterdam is a pioneer city in the transition to transformational climate governance. [20].and has a long history of combining urban water management, spatial planning, and climate change adaptation to increase the city's resilience to, for example, sea level rise and increasing occurrence of pluvial flood events, while improving the quality of life of urban residents. [21] Potential benefits of project were divided into three criteria: health, energy and carbon detachment; and community live ability with individual statistics to calculate best management practices, and avalidity scale that is used to illustrate the benefit's certainty degree. [22]

Case of: Active, Beautiful, Clean Waters Programme, Singapore

The Active, Beautiful, Clean (ABC) Waters Programme was launched in 2006 by Singapore's Public Utilities Department under the Ministry of Environment and Water Resources to realize the full potential of a progressively implemented drainage network of 17 reservoirs and 8,000 km of drains, canals, and rivers. Because catchment regions cover two-thirds of Singapore, holistic and sustainable storm water management was launched using onsite detention and retention systems, even as the need for more community engagement was recognized. [23]. The ABC Waters program's main goal was to turn streams and bodies of water into magnificent urban assets by integrating these drainage systems with the built environment and bringing people closer to water.

Case of: Sponge city, Wuhan, China

Due to current flooding and pollution challenges, the Wuhan government prioritized tackling the issue of water logging and complemented this with water pollution management and rainfall collecting and reuse through the sponge city project. Total 455 sponge projects were planned in the city's two demonstration regions, i.e., Qingshang and Six in Districts, which comprise 38.5 square kilometers [24].

Policy Frameworks and initiatives

Environment and sustainable policies in India

Overview

For acknowledging the importance of the environment, implementing sustainable policies in India is a need for a better future. A better understanding of the relationship between the environment and sustainable policy in India involves the term "environmental sustainability."Some aspects of environment sustainability for policy initiatives involve investment in water conservation, support for sustainable transportation, renewable energy, environmental conservation, and innovation in urban planning. In response to the UN Framework Convention on Climate Change and the UN's 'Green Economy Initiative,' India implemented the National Action Plan on Climate Change (NAPCC) in 2008.The initiative listed out the macroeconomic, sustainability, and poverty reduction implications of green investment in sectors like renewable energy and sustainable agriculture, and also guided catalysing increased investment in these areas.

Existing policies relevant to blue-green infrastructure

Green infrastructure was first referenced in an early debate of India's environmental policy in the Fourth Five Year Plan (1964-69), and it covers a wide range of challenges, including regulating air and water pollution and protecting forests, mangroves, and other natural resources. Renamed the Ministry of Environment, Forests, and Climate Change in 2014, it remains the focal point for environmental and climate policy planning, monitoring, and implementation, while the Ministry of Water Resources and Ganga Development oversees India's national water resources (the country's blue infrastructure). [25] Some of the existing policies that are relevant to the blue-green infrastructure are elaborated below:

- National Water Policy (2012): This policy focuses on the sustainable development and management of water resources, including the promotion of water conservation, rainwater harvesting, and efficient water use.
- National Mission for Sustainable Agriculture (NMSA): NMSA aims to promote sustainable agricultural practices, including water management, watershed development, and soil conservation.[26]
- National Urban Greening Guidelines: These guidelines provide recommendations for integrating green spaces into urban planning and development, promoting urban forests, parks, and green infrastructure.
- National River Conservation Plan (NRCP): NRCP is aimed at addressing water pollution and promoting the conservation and rejuvenation of rivers, which can contribute to BGI principles.
- National Mission for Clean Ganga (Namami Gange): is a prominent initiative aimed at restoring and protecting the Ganga River. The mission includes several projects, including sewage treatment, riverfront development,and riverbank afforestation. These initiatives not only boost the Ganga River's quality of water but also enhances overall blue-green infrastructure along the river.
- Sustainable habitat, water, agricultural, and forestry missions are multisectoral, overlapping, and cross-departmental in nature. [27] From the above-mentioned list, it is evident that post-independent era, there has been no comprehensive policies to integrate or implement storm water management system, which is a major component of BGI.

Challenges and Gaps in policy implementations

- One of the significant challenge is the lack of awareness and understanding advantages of blue-green infrastructure among policymakers, government officials, and the public. This leads to limited support and commitment to implementing such policies.
- Fragmented governance structure with multiple agencies responsible for various aspects of urban development and environmental management. The lack of coordination and integration among these agencies is also a major hindrance.
- Implementing BGI requires technical expertise in areas such as hydrology, landscape architecture, and urban planning. However, there is a shortage of professionals with the necessary skills and knowledge to design and implement such projects.
- Limited financial resources and competing priorities often result in inadequate funding allocation for these initiatives.
- BGI requires ongoing maintenance to ensure its long-term sustainability often a lack of clarity regarding the responsibility and funding for maintenance, which can lead to the deterioration of infrastructure over time.
- The mentioned policies in the above section are implemented with multiple measures in a single frame, also they fulfil the regulatory framework on an individual resource palette but not as an integrated resource for BGI. There are discrepancies, gaps, and conflicts in ongoing policies related to environmental policies, water policies, etc. For the integrated approach of the BGI, a participatory approach is needed to develop policy implementation. Figure 1. When it comes to complicated issues with a high level of ambiguity, the distance between the government's intentions and the tools utilized in policy execution might increase over time, resulting in an increasing mismatch.

Comparative Analysis between Global and Indian Policy & Initiatives

Comparative analysis of policies related to global and Indian context has been done on the basic key aspects that are important for policy implementation measures.

overlapping global and Indian aspects of BGI implementation

Global policies for blue-green infrastructure must be customized and localized for the Indian context, taking into account India's particular difficulties, cultural diversity, and socioeconomic circumstances. Concerning the local context, Different regions of India have different climates, topographies, and population concentrations. Policies should take into consideration these variations and be flexible enough to be applied in urban, peri-urban, and rural settings. About the current scenario, talking about the" green cities- a Sustainable Urban Future in Southeast Asia", a Technical Assistance document from ADB, guidelines for preparing a Green City Action Plan is provided, whereas similar guidelines and proposals are developed for a Green and blue Master Plan for the city of Bhopal. (Bhopal Smart City Development Corporation). Similarly, the sponge city concept has been adopted in India for flood control from the best practice of Wuhan, china. overlapping of global policies and framework onto the Indian context is adding value to the cities which are facing the same problem that the global cities have faced but one should take into consideration the similar geographical and climatic context as well as the stakeholder engagement, and future monitoring of policies which makes it a successful model of global policies related to BGI because implementing infrastructure is not difficult but to maintain it is a challenging task.

Parameters

By taking these factors into account, Indian and global policies have common goals and methods for every aspect of blue-green infrastructure Major parameters include flood resilience, storm water run-off, surface run-off, urban heat islands. Taking the reference of best practices and policies based on similar parameters, to overlap the policy initiatives needs local context, the character of the city, and its behavior. Referring to the case of Rotterdam, Netherlands the major parameter taken into consideration for BGI was the reduction of floods and the cases of drowning that essentially counter the problem and has been a successful model for flood resilience. Similarly, if we notice the case of Bengaluru, 2023 some parts of the city has been recently flooded due to the incapable storm water drainage and even the cases of flooding have extended to the intent of drowning resulting in the loss of life and collapsing of the entire building was despite new storm water drainage plan implemented by the city authorities. For the Indian context, it is essential to adopt the practices from the global context considering their parameters but the amalgamation of the city character, its typology, and context is necessary for any intervention of such policies

Individual /Sectoral Plans

Almost every city in India has a stormwater drainage plan which has specifications of the initial stage of the inlet of stormwater and the final discharge of water in the river or canal. But the idea of reuse, recharge, and harvest which is a sustainability measure for a city is missing in many of the implemented plans.The lack of established guidelines and policies requiring the inclusion of reuse and recycle principles in stormwater drainage designs might be a barrier. It is difficult to drive required changes and assure compliance if policies and regulations are not in existence or are not successfully implemented. Overlapping a case of ABC water program in Indian context, there is a need for making guidelines for stormwater runoff standards taking reference with the model.

Implementation Procedure

Every effective blue-green project featured a significant level of community involvement, like in Newcastle, UK. Initiatives in Bengaluru and Madurai, India, have also involved a significant amount of public participation. The general understanding of blue-green projects will be improved through active engagement with government, planners, policymakers, and other political representatives, foster ownership in the creation, formulation, implementation, and oversight of such activities.

Gaps in Coordination

Mapping global policies into the Indian context may face limitations due to data and information gaps. Accurate and up-to-date data related to the environment, land use, population dynamics, and socioeconomic factors are crucial for effective policy adaptation. Awareness among the stakeholder and a multidisciplinary approach must be done as, India's vast size and diverse regions pose challenges in obtaining comprehensive and reliable data, hindering the adaptation process.

CONCLUSION

Development of Indian policies related to BGI can create new opportunities for the implementation of nature-based solutions in cities .comparative analysis suggested that India has many ongoing sustainable policies that can be relevant to the BGI but that need to be Collaborative and bring different multidimensional departments into the same umbrella. The collaborative efforts of policymakers, researchers, professionals, and local populations are key to the development of blue-green infrastructure in India. It requires concerted effort, efficient governance, and the inclusion of several stakeholders. India can achieve sustainable development, improve urban resilience, and create a healthier and more liveable environment for its population by adapting global policies to the Indian context. Global policies serve as a basis for sustainable development and "blue-green" infrastructure as a whole must be customized to the Indian context by taking into account the demands of the nation, as well as local government systems, socioeconomic considerations, and environmental conditions. India should create contextual policies that address its particular difficulties and possibilities by coordinating global goals with national priorities. This will enable the creation of more efficient and inclusive blue-green infrastructure across the entire nation.

Recommendations for enhancing BGI implementation in India

BGI is acknowledged on a global scale for its numerous environmental, social, and economic benefits it suggests that policy and practice need to change to better implement BGI and make it multifunctional rather than being primarily focused on managing flood risk and only mentioning broader benefits in passing. BGI cannot be structured to provide all possible benefits simultaneously, many cities are likely to prioritize enhancing quality of life through high-quality BGI. Indian cities perspective, BGI design will be influenced by the geographic, climatological, socio-political, and governance features of cities, guided by each city's priorities and strategic objectives, and negotiated by the stakeholders involved in BGI projects to maximize benefits and determine which benefit trade-offs will be made.

It will be beneficial if we can implement BGI during the construction phase of other infrastructure projects. Annual environmental status reports containing information on natural characteristics and pollution indicators are published by numerous Indian cities. To set reasonable expectations, such actions must be included when conducting an annual blue-green audit for all communities. Governments must uphold uniform statutory terminologies and definitions and carry out the complete integration of all urban plans and documents that highlight environmental elements to streamline processes and ensure the integrity of the original blue-green canvas. Such a framework will provide a certain uniformity for parastatal agencies-incorporated initiatives, and local project initiatives as well.

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Table 1. Table elaborating the major policies related to the best practices in global context

S.No	Project	City, country	Population	Parameters for BGI	Individual/sectoral plans	Policy &Implementation Procedure
1.	**Blue-Green Cities Research Project**	**Newcastle, UK**	280,000	Flood resilience	Newcastle City Strategic Surface Water Management Plan	partnership between Newcastle City Council, the Environment Agency, and Northumbrian Water (private water and sewerage company) Stakeholder participation
2.	**Grey to Green Initiative,**	**Portland, US**	653000	Flood reduction, water quality improvement(e.g., by CSO reduction)	Portland Watershed Management Plan (2005)	Portland, Oregon U.S storm water management manual
3.	**Blue-green grid initiative**	**Rotterdam, Netherlands**	623000	Climate change resilience Drowning	Rotterdam Climate Proof Programme (2008), the Rotterdam Adaptation Strategy (2013), Resilience Programme (2014), and the Water Sensitive Rotterdam Programme (2015).	PPP, public participation
4.	**Active, Beautiful, Clean Waters Programme**	**Singapore**	5690000	Storm water run-off Surface runoff Green spaces (primary potential)	Implemented through a master plan, water design guidelines (2009)	Guidelines implemented through Drainage Handbook on Managing Urban Runoff by Public Utilities Board & Ministry of Environment and Water Resources The ABC Waters Certification scheme launched by PUB
5	**Sponge city programme**	**Wuhan china**			The National New-Type Urbanization Plan (2014–2020), Urban Climate	The finance ministry gives funding to identify fundraising

					Change Adaptation Action Plan (2016)	strategies based on an assessment index system based on national guidelines

Table 2. Showing the comparative analysis between global and Indian policy & initiatives with key aspects

Key aspects	Global context	Indian context
Policy Frameworks	International frameworks have strong emphasis on sustainable infrastructure and environmental preservation include the Paris Agreement, the Sendai Framework for Disaster Risk Reduction, and the Sustainable Development Goals (SDGs) of the United Nations. It has its regulations and policies, as well as universal guidelines.	The National Action Plan on Climate Change, Smart Cities Mission, National Water Policy, and Swachh Bharat Mission are policy frameworks in India that address parts of BGI and urban sustainability but are not directly implemented.
Local Context and Adaptation	Global policies give broad recommendations and best practices that must be modified for specific contexts and scales. They advise countries to analyze their individual requirements, priorities, and capacities when it comes to implementing BGI.	Adapting global policies to the Indian setting involves account variables such as different climatic zones, cultural preferences, socioeconomic gaps, and urbanization characteristics. Policies are not prioritized at an inclusive level.
Institutional Framework	Global policies often promote international collaboration, knowledge sharing, and capacity building to support the implementation of blue-green infrastructure.	India has a decentralized governance structure, involving multiple stakeholders, from national to local levels. The implementation of BGI policies requires coordination between various ministries, departments, and local bodies. Collaborative approaches involving government agencies, community organizations, and private sector entities are crucial for effective implementation.
Financing and Resource Mobilization	Global policies emphasize the need for financial resources, technology transfer, and innovative financing mechanisms to support sustainable infrastructure development.	India faces challenges in mobilizing adequate funds for BGI projects. The government encourages public-private partnerships, international collaborations, and leveraging climate finance mechanisms to bridge the resource gap. Efforts are being made to promote green financing, including sustainable bonds and impact investments.
Data and Information Systems	Global policies emphasize the importance of reliable data, monitoring systems, and evidence-based decision-making to assess the effectiveness of blue-green infrastructure.	India is working towards strengthening its data and information systems to support evidence-based policy formulation. Improving data collection, management, and sharing processes is crucial for monitoring and evaluating the impact of blue-green infrastructure initiatives.

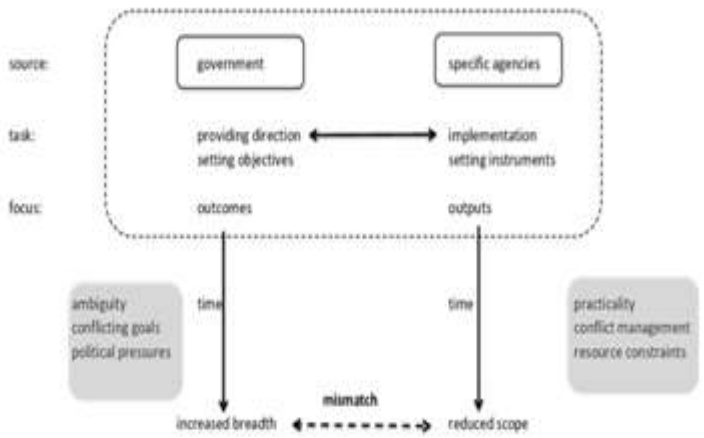


Figure 1. A framework explaining the gap between policy aspirations and implementation[41]

RESEARCH ARTICLE

Integration of Solar Technology with IoT solutions using Holographic Tech for Eco Entrepreneur's

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ABSTRACT

The advanced IoT-based super car model integrated with a Fresnel Prism-based Solar Energy system provides the feature of enabling the car to operate without any emissions. The following method called Δx is for the analysis, which is the difference between the temperature and the intensity of the sunlight, which in fact reduces the use of fossil fuels to a great extent, hence reducing the carbon emissions and finally aligned with the Sustainable Development Goals. The car is equipped with inbuilt solar panels of between 1.35 to 2.62 square feet each, that consist of Photovoltaic (PV) cells that are engineered to increase the absorption of sunlight to more than 25%. It also included a battery of 90 to 200 volts that consists electrical energy transformed into mechanical, thus making the car have additional solar 450. The vehicle is designed to process solar panels from 2.0 to 4.5 square feet, which generate from 15 to 48 km of electricity daily at speeds between 25 to 45 km/h, reducing the need to lean on a conventional charging station. This integration of prism lenses, solar cells, energy storage, and basic IoT solutions for performance tracking, speech recognition, and navigation will help in integrating mobility features directly into the car. The solar automobile market is expanding quickly as environmental concerns push consumers and venture capitalists toward sustainable transportation options. The possibility that vehicles could work on a large scale with little or no need for extensive charging is appealing both personally and commercially. There exists great potential for green entrepreneurship in this sector, given that there are many opportunities to startup companies that deal with solar cars. At such times when technology is changing at a rapid pace and a huge number are getting inclined towards sustainability, this unification of solar energy with the ML/Artificial Intelligence and holographic solar panels in vehicles has claimed to

presage an unbeatable game-changer in the coming future of transportation. New frontiers are opened up for salient entrepreneurial enterprise.

Keywords: Free Emission Operation, Energy Independence, Sustainable Transportation, Cost Savings, Prism Photovoltaic Cells, and Holographic Panels.

INTRODUCTION

The depletion of the crude oil resource is now a more heated debate as it involves political forces, industry players, and researchers. The burning need to find other sources of energy has become very imperative with the depletion of the conventional oil sources. Most solar-cars are wholly powered by the photovoltaic cells that convert sun rays into electrical energy, which powers the car's motors. These vehicles are often called "green" because they produce no greenhouse gases during operation. The electric power supplied by the photovoltaic cells can be conserved in batteries, and the DC motor is supplied with this to provide the kinetic energy of the vehicle. Solar vehicles have faced many obstacles, however. This low energy development by solar panels is a significant limitation, driving these vehicles mostly to require alternatives such as batteries or generators for proper functioning on extended trips. These panels have variable efficiency and do not succeed in generating the necessary power in sites where sunlight is reduced. The designed electric solar vehicle is quite complicated for the particular characteristics and systems regarding the management of energy that guarantee optimal workings under different conditions. For instance, using Fresnel Prism lenses, the intensity of sunlight that hits the plates can significantly influence the speed at which the battery will be charged. While the more direct sunlight is at its peak during midday, better charging performance is produced. This can raise the level of efficiency, but, at the same time, in the staff's device with an off-grid principle, the damages due to fluctuations in temperature have to be avoided by having the design in place with thought given to aspects such as a cooling system and trackers. Also, the financial cost of solar technology still remains prohibitive, though the price of photovoltaic cells has plummeted deliberately throughout the recent years. This all implies that new technology and design of the holographic solar panels, Fresnel prisms or lenses, and IoT integrations for these cars have to advance to make them more practicable and affordable for the masses with this growing size of the market. An International Energy Agency report states that with the present oil production capacity, a significant amount of it needs to be replaced by 2030 just for remaining at the current level; hence addressing oil depletion is very much important. Transition is necessary from traditional oil to alternative energy sources. With out good investment in renewable sources of energy in the context of "Green Eco Entrepreneurship" and in energy efficiency, the rate of decline of oil production might result in unimaginable repercussions in the global economy .

Expensive production and low output: |Special Parts|: Solar-powered cars require very complex photovoltaic (PV) panels and other special parts. They are thus expensive to produce. In these modern times, solar vehicle costs range between $17,500 and $100,000 on average, well above the cost of regular cars.

Challenges from Technology, Efficiency, and Environmental Factors: Solar panels on vehicles are still quite ineffective, usually 13.65% and 24.55 % at their very best.

METHODOLOGY

Components of solar powered automobiles

Solar vehicles benefit from a plethora of components, which makes it possible to harness solar power to the maximum, convert it into a usable form of energy, and provide for motion. Key components in our solar vehicle, along with a very short description of their role, are enumerated below:

Solar Panel Fresnel Prisms
Play: Converts light from the sun into electricity by the photovoltaic effect of photons and electrons. The cells are rated at 200W power, 24V voltage, and dimension >2.0, 3.0 feet. They capture sunlight and change it into electrical energy.

Lead-Acid Batteries
What the component does: It stores the electrical energy produced by the solar panels for use at a different time.

DC Series Electric Motor: What the component does: This converts the electrical energy from the batteries into mechanical energy, which later leads to impulse driving of the vehicle by use of a belt drive system ***Power-6500W 1 Horse Power Speed-2600-1440 rpm voltage- 24v current-100Amp.***

Charge Controller
Function: Manages voltage and current from the solar panels streamed to the batteries.
AC/DC Power Converter

Function: Serves as a power electronic interface which, if required/necessary, will adjust the DC output.

Energy Management System
Description: The energy management system actively and efficiently manages the distribution of energy between batteries, solar panels, and the motor. It is adaptive and would be able toaccommodate any changes going on, for instance, a good sunny day.

Super solar car Design Model: When combination in a solar car, they allow the solar vehicle to tap into and unlock the potential of the renewable energy used within it. We have elevated this solar energy utilization to an all-time high with the employment of F prisms and lenses in combination with IoT energy management. These vehicles have represented one of the greener and safer vehicle replacements ever to fossil fuel-based traditional transportation. Further developments and deployments of IoT technologies, along with mass production, will improve affordability and performance.. The solarmodule is used with the output range from *24V to 25V*.

RESULTS

We read through a number of techniques, and these are the key issues that we highlighted

IoT Integration: IoT technology applied in solar-driven battery electric vehicle tostrategically monitor and control. These EVs independently recharge themselves through solar power, and with the help of IoT technology, they further optimize it for effective performanceand efficiency. IoT-enabled features: - Real-time monitoring , follows the real-time monitoringof critical variables such as battery charge, solar panel output, and energy consumption throughsensors and IoT devices to provide instantaneous data.

***Predictive Maintenance*:** The IoT system will aggregate data to determine potential issues and plan maintenance.

Bifacial Fresnel-Design Prism: Prism-designed solar panels are capable of trapping light beaming upon the two sides of cells and hence able to produce *35% more energy* whencompared to its conventional peers.

Holographic Tuning: They filter the sun's energy through a single sunlight wavelength and

expose it on solar cells to remain at their optimal performance at any level of concentration. This spectrum selection keeps the cells operating at or near the peak performance, temperature,even at 3X-3.5X concentration.

Material Innovation. The creation of flexible and semi-transparent solar cells improved the look of solar cars and the ability for the technology to work efficiently. The means of such materials enable a significant level of integration to the designs of vehicles with no significantloss to the capture of energy.

Vehicle Design and Performance. The need for light and low-weight designs for efficiency. This includes models that can reach speeds of ***75-80 km/hr*** while keeping a low dragcoefficient.

Energy Management Systems: A stride in the incorporation of IoT tracking systems, providing the very best use of solar panelling power under whatever condition.

Sustainability and Environmental Benefits: Solar cars shall be able to bring radical cuts in carbon emissions. E.g., On an average, a solar car can save up to 280 kg of CO_2 emissions annually, providing a cleaner environment for cities. Below are a number of key insights from studies related to improving the effectiveness of solar-powered vehicles

Aerodynamic optimization: Our advanced solar car has helped us a great deal in getting insight into the optimization of shape in solar vehicles for better aerodynamics.

Cutting out drag*;* the force an automobile meets while in motion moving through the air. This will reduce drag, the more force that the vehicle faces and will need more energy to fight againstit to keep moving—more of the solar panel energy being consumed for this purpose.

Minimizing Flow Disturbances: The aim of aerodynamics design is to retain the air in stream with the vehicle surface, thereby avoiding it being detached from the surface, thus creatingturbulence and increasing drag.

Improve Energy Utilization: Shaping the vehicle in a manner that allows better airflow helps engineers ensure that more energy can be put into forward motion, rather than being completely spent in turbulence. As a matter of fact, industrialization should be based on aerodynamic design and streamlined shape in the making of a solar vehicle that would be efficient in operating.

DISCUSSION

Aero dynamics: Driving ability vs Vehicle hasten & Simulated solar radiation VS Temperature

One major benefit of integrating IoT into this equation would be the possibility of collecting and analyzing incoming data at runtime. The IoT devices are always working on essential parameters, e.g., the amount of energy produced by solar panels, battery condition, and environmental conditions.

Performance improvement – The performance of solar panels and parts of a vehicle can further be fine-tuned to boost energy efficiency by checking the pattern usage of energy and the conditions of the environment. IOT technology enables more effective management of energy in solar-powered cars.

Better User Experience: Real-time monitoring and control provide updates on how the car is driving, battery health, and when and how much energy is actually required. This visibility willtherefore help the user make more precocious judgments on his or her energy use and travel plans. the increasing efficiency and performance of Fresnel Prism-the primary ways in which IoT plays a role in

Real-time Data Tracking: IoT systems allow the continuous monitoring of various parameters related to solar panel performance including.

***Energy Production*:** The sensors attached to thesolar panels keep track of real-time energy output, which enables the user to assess the effectiveness of their solar energy system.

***Performance Improvement*:** The conjunction of IoT allows adaptive control of solar panels based on environmental parameters.

Variable Adjustments: The orientation or angle of solar panels can be adjusted to get more sunlight, based on changed real-time weather conditions and sunlight strength.

Remote Access and Control: IoT technology allows provision of any desired place access and control by customers on their solar panel system.

Software: Users can always monitor performance and health with their solar panels from any place through the mobile apps. This means swift interventions can be made into theoccurrences of problems like system failure or debris buildup.

Alerts and Notifications: The IoT system alerts the user of drastic changes in performance or potential problems, thus offering an opportunity to act in urgency in mitigating the problem.

Continuous Monitoring: These devices make it possible to keep track of key factors, such as energy production, at all times. Real-time data evaluates if the efficiency of solar panels isgood enough and drives them towards their optimized performance.

Data-Driven Decision Making: Massive volumes of data made available through IoT enable effective decisions such as:

***Trend Identification*:** Analyse the patterns of energy consumption to make adjustments leads to better efficiency and reduced costs.

Performance Insights: Elaborate analytics on how to increase the performance of the solar panels and battery allow much better overall efficiency of the vehicle.

CONCLUSION

Applying IoT to solar-powered EVs with better maintenance, energy management, user experience, and informed decision-making results in efficient andsustainable transportation.

A. Reduce Operating Costs: IoT solutions result in significant reductions of the operating costs of solar-powered EVs.

B. Reduces the Cost of Energy: Through the use of solar to charge your electric vehicle, there is less reliance on the grid's electricity, which is costly manya time.

C. Maintenance Savings: IoT-enabled predictive maintenance provides for advanced prediction of potential issues, thereby saving costs involved in too many repair works andminimizing down time

D. Great Mining of Economics: IoT technology infused into this solar- based EV results in an immensely high rate of return in savings.

E. Better Charging Operations: Charging could be done in a better and efficient way through the features of IoT solutions by the means of better charge-management functions, time optimization of energy inflows, duration reduction.

G. Long-term Investment Returns: Long-term monetary returns by investments in solar EVs installed with IoT technology.

H. Cost Neutralization: The commencing investment in solar panels and IoT systems can be balanced with long-term fuel and maintenance cost savings. It is depicted through research that the total related expenses in owning a vehicle over its lifetime can be minimized to a great extent, hence an economically rational plan. The economic impacts of integrating IoT technology gives better return on investment over time. Further, converting solar energy into usable power is yet too inefficient,between 16.5% and 17.5%. Problem can be rectified by using Fresel prism lens which is very efficient and boosts solar cells to around 30-35%. These challenges shall be circumvented as research in this arena gets more developed. Electric vehicles with solar powerintegration are a big market opportunity, and these

should be introduced to our daily lives aiming to meet the Sustainable Development Goals for OE (Organizational Excellence) and ESG (Environmental, Social, and Governance). The real question that arises: Why and how to go about it in research or practical applications.

Future research or applications need to be focused on Prism Solar Technologies: As they have manufactured novel bifacial solar panels with the holographic tuning technique for high efficiency and low costs. The defining characteristics of the novel Prism-based PVC solar panels are refraction and light concentration. When light enters a prism, the phenomenon of refraction occurs. This results in bending the light towards the normal for the reason of the shift of the medium from air to glass. Such bending can have the effect of focusing more light in anarea through which it has travel after passing through the prism, concentrating more energy in a particular area. The temperature of surfaces can be raised through concentrated energy generated by incident reflected or refracted light falling upon them. The dispersion of light occurs when sunlight passes through a prism, splitting it into its constituent colour, forming a spectrum. It is observed that various energies correspond to various wavelengths of light. Thermal measurements have shown that if a thermometer was placed exactly where the spectrum is projected, it would record a temperature increase. A few degrees difference in temperature will most likely show evidence of this reflected light if you place a thermometer in the chosen spot. A recommendation is to use Fresnel Prism Lenses that are more than twice the thickness of PVC. The panels use holographic tuning technology- the holographic optical components divert certain wavelengths of sunlight onto the solar cell. "Spectral selection" thus performs the magic of letting the cells work at or near their optimal temperature efficiency,all this despite a concentration dynamics of *3X-3.5X*: the total sun energy production is roughly *10000 times* more on earth as compared to what is needed for supplying power for all human beings present around the world. By employing holographic film to the materials selection, Prism Solar panels are able to reduce the use of costly silicon by *50-75%,* cutting on material expenses in their silicon without losing any much-needed efficiency by spectral tuning. Holographic tuning improves the performance of Prism Solar panels by optimizing light absorption via Fresnel prisms, ensuring more collected energy from both the front and rear sides of the panels, material saving, and enable reliable and repeatable operation. The prism- based, bifacial PVC panels from Prism Solar make its solar energy production more economicaland effective, all the more with a focus and high-quality design integration to focus on the innovation of holographic tuning and integration with Internet of Things (IoT) system. Solar technology-designed vehicles drive demand for sustainable products and businesses that are targeting environmentally concerned customers, thereby ratcheting sustainable demand acrossthe ESG sector. New research would pertain to products such as solar backpacks, solar pens, and solar umbrellas, contributing toward changing consumer behaviour serving both B2B and B2C purposes. The B2B Companies, who are the customers for the development of solar cars, would show a sense of environmentalism and contribute to expanding the market for solar cars after 2026.

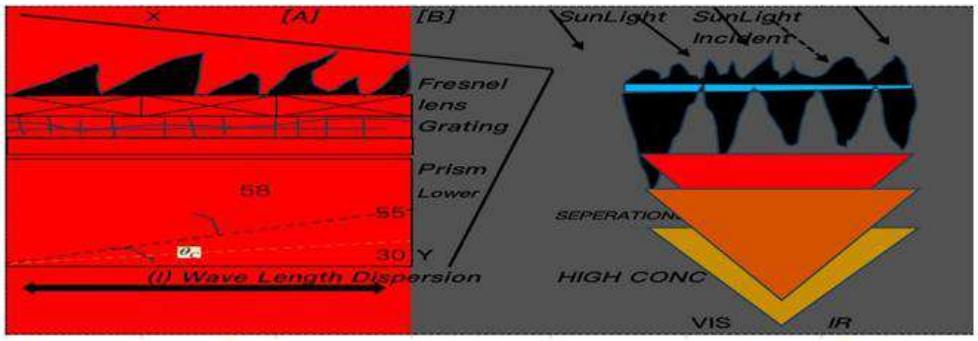
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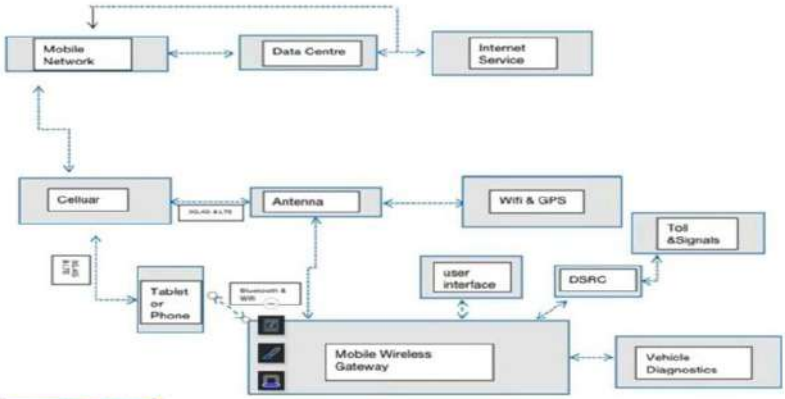
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PIC1 | Prism 1 | Pic 2 | Prism 2





Holographic Pic 1 **Holographic Pic 2** **Holographic Pic 3**

PIC 1 (Main design)



PIC 2

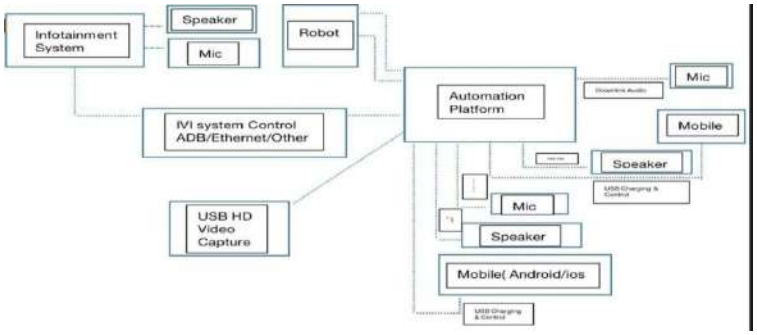


PIC 3

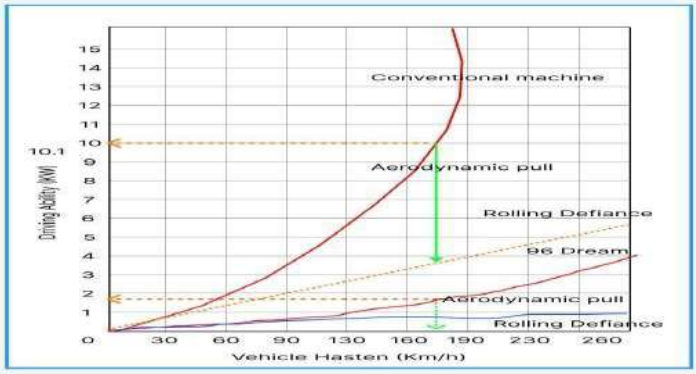


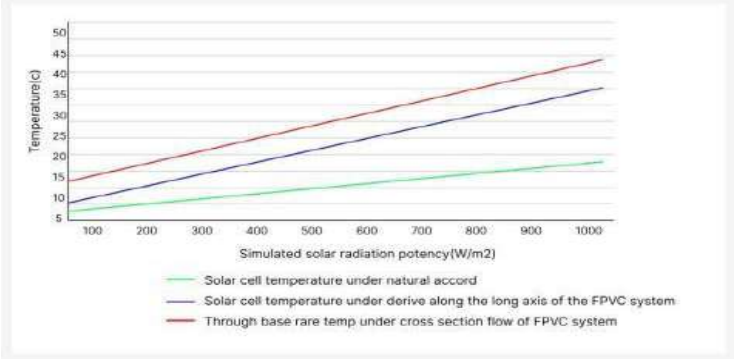
PIC 4



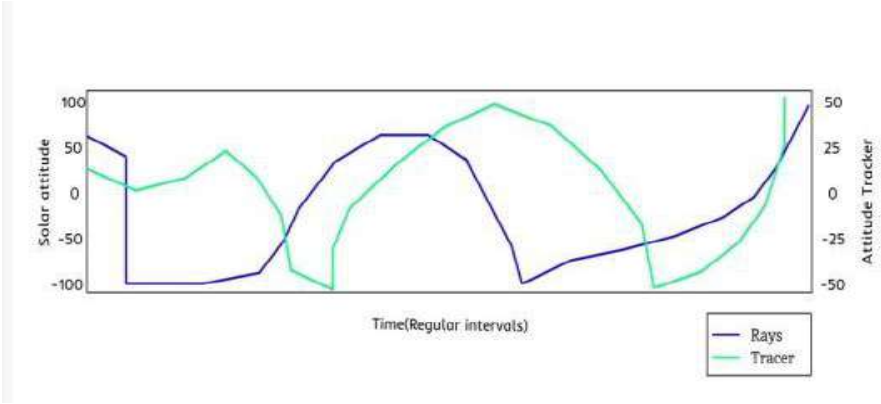


IOT (POWERTRACKER)









Time Intervals vs solar altitude & Cleft No Vs Prism degree



Other mechanical parts of Super solar car

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RESEARCH ARTICLE

Survey on Plant Diseases Detection Deep Learning and CNN"

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ABSTRACT

This survey aims to provide an overview of recent advances in plant disease detection using machine learning (ML) techniques, particularly deep learning, and convolutional neural networks (CNNs). With the growing demand for sustainable agriculture and increasing concerns about food security, timely and accurate diagnosis of plant diseases has become essential. Traditional methods of plant disease detection, such as visual inspection and laboratory testing, are time-consuming and labor-intensive. In recent years, ML-based approaches have shown great potential in automating the detection of plant diseases, which can significantly improve disease management and reduce crop losses. This survey discusses various ML-based methods and their applications in plant disease detection, including feature extraction techniques, image classification algorithms, and transfer learning. Furthermore, the challenges and future directions of this field are also discussed, highlighting the need for more comprehensive datasets, better training strategies, and more robust and interpretable models.

Keywords: Plant diseases, Convolutional Neural Network (CNN), Deep Learning, Feature Extraction

INTRODUCTION

Plant disease detection is an important task in agriculture, as plant diseases can cause significant damage to crops and reduce crop yields. Traditionally, plant disease detection has been done by visual inspection by experts or by chemical analysis, both of which can be time-consuming and costly. However, with the advent of computer vision and machine learning techniques, it has become possible to automate the process of plant disease detection using image analysis. Convolutional neural networks (CNNs) have shown promising results in plant disease detection, as they are able to learn complex features from images and classify them accurately. By training a CNN on a large dataset of plant images with known disease types, the model can learn to identify characteristic features of different

types of plant diseases, such as leaf spots, discoloration, and deformation. Once the CNN is trained, it can be used to analyze new plant images and identify any diseases present. This automated approach to plant disease detection has the potential to save time and resources, as well as improve accuracy compared to traditional methods. The paper also provides a critical evaluation of the current research in this area and identifies several key research directions for future work. These include the development of more robust and accurate CNN models, the integration of multiple sources of data, such as spectral and thermal imaging, and the development of real-time applications for automated plant disease detection. The paper provides a valuable resource for researchers and practitioners in the field of plant disease detection using CNNs, highlighting the key challenges and opportunities for advancing the state-of-the-art in this important area of research.

Overview of disease detection using CNN

CNN-based plant disease detection is a popular application of computer vision technology in agriculture. Convolutional Neural Networks (CNNs) are a type of deep learning algorithm that can effectively classify images by learning from a large dataset of labeled images. To build a plant disease detection system using CNNs, the first step is to collect a dataset of images of healthy and diseased plants. These images should be properly labeled and annotated to train the CNN model. The dataset should be diverse and large enough to capture various types of diseases and variations in plant appearances. The next step is to train the CNN model using the labeled dataset. The CNN model learns to classify plant images as healthy or diseased by analyzing the patterns and features of the images. During training, the model adjusts its internal weights and biases to optimize its accuracy in classifying images. Once the CNN model is trained, it can be used to classify new plant images as healthy or diseased. This can be done by passing the image through the trained model, and the model outputs the predicted class label. The accuracy of the model can be evaluated using a test dataset that was not used in the training phase.

DATASETS

PlantVillage Dataset

This dataset contains over 54,000 images of healthy and diseased plant leaves. The dataset covers over 38 plant species and 26 diseases.

PlantDoc

This dataset for visual plant disease detection. The dataset contains 2,598 data points in total across 13 plant species and up to 17 classes of diseases, involving approximately 300 human hours of effort in annotating internet scraped images.

New Plant Diseases Dataset

This dataset consists of about 87K rgb images of healthy and diseased crop leaves which is categorized into 38 different classes. The total dataset is divided into 80/20 ratio of training and validation set preserving the directory structure. A new directory containing 33 test images is created later for prediction purpose. The other data sets included in Kaggle are **Tomato Disease Dataset**, **Grape Disease Dataset, Potato Disease Dataset, Cassava Disease Dataset**, **Apple Disease Dataset, Citrus Disease Dataset** These datasets are often used to train machine learning models for plant disease detection, which can then be used to identify and classify diseases in real-time.

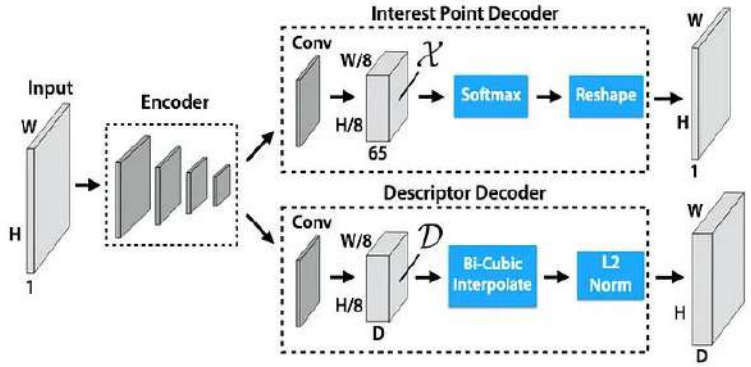
Convolutional Neural Networks (CNNs) based feature extraction

Traditional feature extractors can be replaced by a Convolutional Neural Network(CNN), since CNN's have a strong ability to extract complex features that express the image in much more detail, learn the task specific features and are much more efficient.

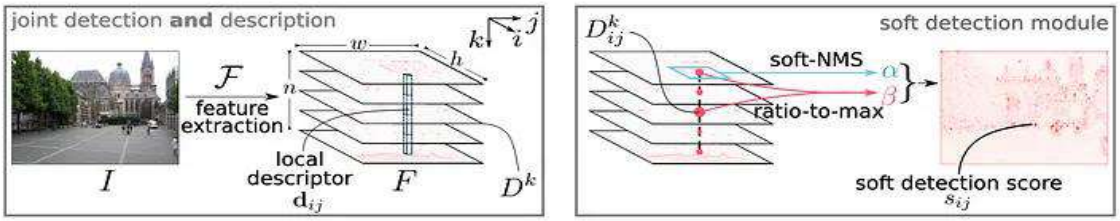
SuperPoint

Self-Supervised Interest Point Detection and Description — The authors [1]suggest a fully convolutional neural network that computes SIFT like interest point locations and descriptors in a single forward pass. It uses a VGG-style

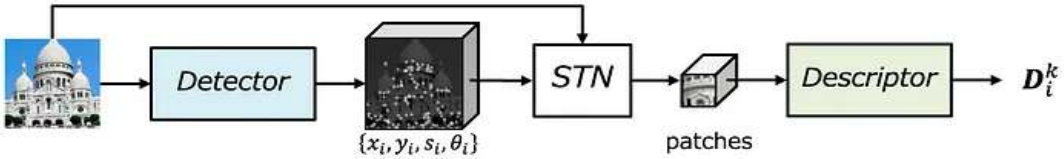
encode for extracting features and then two decoders, one for point detection and the other for point description.



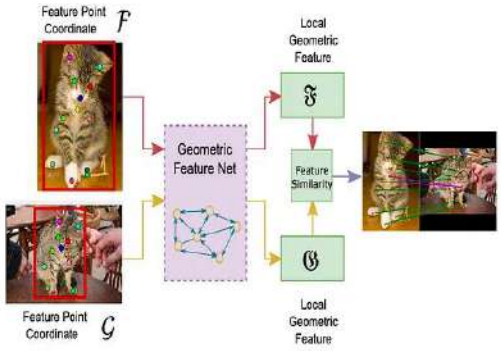
D2-Net: A Trainable CNN for Joint Description and Detection of Local Features — The authors[2] suggest a single convolutional neural network that is both a dense feature descriptor and a feature detector.



LF-Net: Learning Local Features from Images— The authors[3] suggest using a sparse-matching deep architecture and use an end-to-end training approach on image pairs having relative pose and depth maps. They run their detector on the first image, find the maxima and then optimize the weights so that when run on the second image, produces a clean response map with sharp maxima at the right locations.

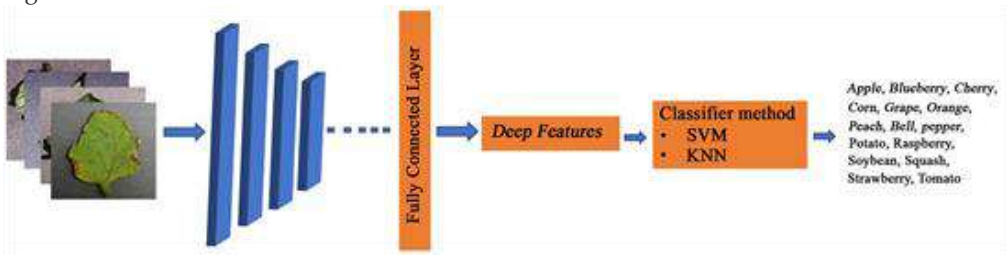


Deep Graphical Feature Learning for the Feature Matching Problem — They[4] suggest using a graph neural network to transform coordinates of feature points into local features, which would then make it easy to use a simple inference algorithm for feature matching.

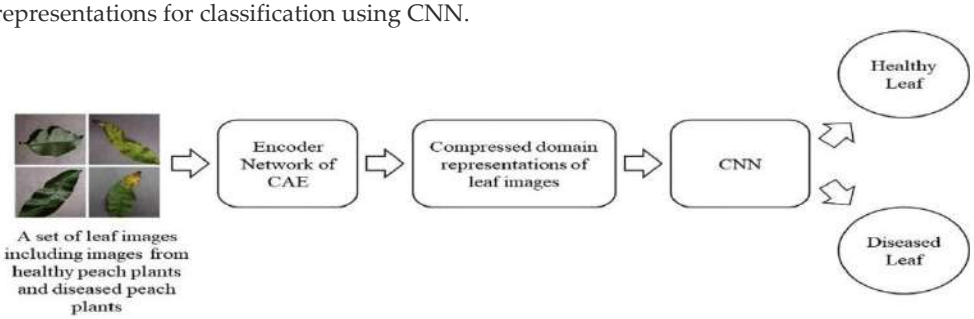


Deep Feature Extraction and Transfer Learning:[5] The techniques used were transfer learning as well as extracting features on various layers in the network. Later, the extracted features, as well as transfer learning were classified

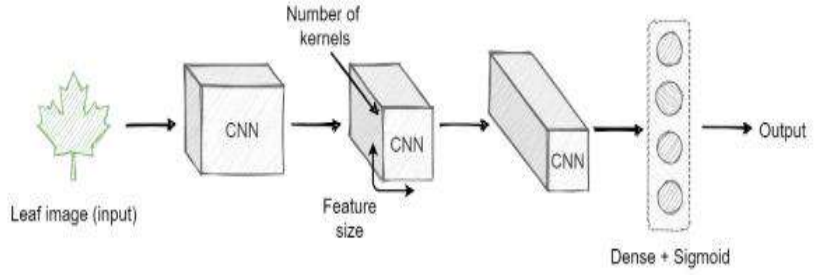
using Support vector machine and K-nearest Neighbor, their time of execution, F1 score, True positive and the True negative are determined.



Hybrid Feature Extraction techniques with ANN and SVM classifier: This paper[6] studies the use of deep-learning models (AlexNet, VggNet, ResNet) pre-trainedon object categories (ImageNet) in applied texture classification problems for plant disease detection In this paper [7], a novel hybrid model was proposed for automatic plant disease detection that was based on two Deep Learning techniques named Convolutional Autoencoder (CAE) network and Convolutional Neural Network (CNN). The proposed hybrid model first obtained compressed domain representations of leaf images using the encoder network of CAE and then used the compressed domain representations for classification using CNN.



In this research [8], authors propose a novel scheme for the detection of plant leaf diseases using deep convolutional neural networks (DCNN). From the segmented images, features are extracted using grey level co-occurrence matrix (GLCM). Dimensionality reduction of features is performed using principle component analysis (PCA). Finally, classification is done using a novel DCNN architecture. In this paper[9], the deep learning model's architecture namely, VGG16 and InceptionResNetV2, are used to train the model. These models are primarily made of convolutional layers. In this paper[10], The experimental results validate that the Xception and DenseNet architectures perform better in multi-label plant disease classification tasks.



The authors [11] proposed a trilinear convolutional neural networks model using bilinear pooling (T-CNN) for disease identification and use 3 CNNs, VGG-16, Inception v3, and ResNeXt-101, as the base networks for the model. The authors [12]proposed a novel deep convolutional neural network model, namely, the Dense Inception convolutional neural network (DICNN). Deep separable convolution is first used by DICNN to build the first two convolutional layers to reduce the number of parameters and prevent the overfitting problem of the model.

Challenges

CNN-based plant disease detection has made significant progress in recent years. However, there are still some challenges that need to be addressed to improve the accuracy and efficiency of the detection system. Here are some of the challenges:

Limited and Unbalanced dataset

In the case of plant disease detection, collecting a large and diverse dataset can be challenging, especially for rare or new diseases. Another challenge in plant disease detection is the class imbalance problem, which occurs when the number of samples in one class is significantly higher than the other class.

Quality of imaging

Illumination changes, shadows, and occlusions can all affect the quality of the image, which can lead to false positives or false negatives.

Similarity between healthy and diseased plants

Some plant diseases can be difficult to detect because the symptoms are not easily visible, or they may resemble symptoms of other diseases or even healthy plants.

Computational complexity

Deep learning models require significant computational resources to train and test, which can be a challenge, especially for resource-constrained devices like mobile phones and embedded systems.

Further improvements

Convolutional Neural Networks (CNNs) have shown great promise in plant disease detection, and there are several future enhancements that can be made to improve their accuracy and efficiency:

Integration of multi-modal data

CNNs can benefit from combining data from different sources such as hyperspectral imaging, thermal imaging, and 3D imaging to improve the accuracy of disease detection.

Transfer learning

Transfer learning can be used to transfer knowledge learned from one domain to another. Pretrained models can be used to train a CNN for plant disease detection.

Data Augmentation

Data augmentation techniques such as rotation, flipping, and cropping can be used to increase the size of the training dataset and improve the robustness of the CNN.

Ensemble methods

Ensemble methods can be used to combine the predictions of multiple CNNs to improve the accuracy of disease detection.

Real-time detection

Real-time detection can be achieved by using lightweight CNN architectures, pruning techniques, and hardware acceleration.

Domain adaptation

Domain adaptation can be used to transfer the knowledge learned from one crop to another, which can reduce the need for large, labeled datasets.

CONCLUSION

Based on the survey conducted on plant disease detection using CNN, it can be concluded thatCNN has proven to be a promising technique for the accurate and efficient detection of plant diseases. Most of the respondents have expressed their satisfaction with the performance of CNN-based models for detecting plant diseases. Additionally, the survey revealed that the accuracy of the CNN models is influenced by various factors, including the quality of the dataset, the size of the dataset, and the architecture of the model. To ensure optimal performance, it is important to carefully select these factors and optimize the CNN models accordingly. Overall, the survey results suggest that CNN-based models have great potential for the effective detection and prevention of plant diseases, which can significantly improve crop yields and ensure food security.

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RESEARCH ARTICLE

Antimicrobial and Wound Healing Properties of an Available Synthesized Silver Nanoparticle from *Mentha piperita* Plant Extract, and Encapsulation in Chicken Collagen

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ABSTRACT

Wound-healing activities are inferred in the medicinal plant *Menthapiperita* L. This research focuses on the preparation and incorporation of AgNPs with chicken collagen incorporated with *Menthapiperita* extract for their usage in wound healing and antimicrobial tests. The formation of AgNPs was also, determined by UV-Vis spectroscopy, FTIR, TEM and EDX. The AgNPs shows colour change as expected for SPB as well as the maximum absorbance at 430 nm elsewhere confirming the formation and stabilization of AgNPs. The antimicrobial tests of the collagen-coated AgNPs against *Bacillus subtilis*, *Staphylococcus aureus*, *Pseudomonas aeruginosa* and *Escherichia coli* resulted in zones of inhibition similar to Gentamicin with range of 20 to 22 min, this reveals that the nanoparticles have the ability to inhibit both the Gram positive as well as Gram negative bacteria demonstrating that the nanoparticles can be used as potent antib Vero cell cytotoxicity studies for synthesized AgNPs indicated that the cell proliferation percentage ranges between 89-98% for AgNPs at the concentration of 20, 50 and 100µg/ml. Besides, Chicken collagen not only improved the stability and bioavailability of nanoparticles but also stimulated cell growth and migrated rate to improve the healing process. Untoward effects revealed that these nanoparticles stimulate the vital events of wound healing especially the proliferation phase without showing much cytotoxicity thus supporting the ethnopharmacological use of *Menthapiperita* for skin

disorders. Therefore, it can be concluded that collagen-encapsulated AgNPs derived from *Menthapiperita* can be further used in the process of creating efficient wound healing agents with enhanced antibacterial efficacy. Successive researches should investigate the in vivo effects in order to assess the healing processes, the doses' elaboration, as well as the nanoparticles' long-term consequences. Furthermore, there is a possibility to expand this green synthesis approach for PTX to the industrial scale, which could potentially result in the development of more effective and eco-friendly wound care treatments in the clinical practice.

Keywords: *Menthapiperita*, silver nanoparticles, wound healing, antibacterial activity, collagen encapsulation

INTRODUCTION

Healing of wound is a complex and an active process from the inception of injury towards the formation of scar tissue, which is a delivery essential armory of human and health domain (Eming*et al.,* 2014). Since there is an increase in chronic wounds that are adjusted by changes like diabetes, infection, and aging then there is need for efficient and new treatment of these conditions. Standard approaches towards wound care often prove to be inadequate when it comes to complicated wounds, as they do not effectively manage the wound bed, and support proper tissue remodeling and re-epithelialization; therefore, prolonged healing time and higher propensity for infection become the consequences (Eming*et al.,* 2014). New trends in nanotechnology reveal great prospects in preventing microbial adhesion in biomedical devices through AgNPs; acknowledgeable for it antimicrobial properties and functionalities that can hinder the aggregation of microbes efficiently (Martinez-Zapata *et al.,* 2012). Among them, the utilization of AgNPs in wound healing is particularly interesting because of the nanoparticles' ability to eliminate bacterial contamination, which poses a challenge to the healing of chronic wounds (Martinez-Zapata *et al.,* 2012).

This research seeks to exploit the therapeutic use of *Menthapiperita* that has been used for ages in medicinal practices for various diseases and wound and skin infection. The healing potential of *Menthapiperita* can mainly be explained by the fact that it contains a number of phytochemicals including menthol, rosmarinic acid and flavonoids with antimicrobial and anti-inflammatory properties as well as the fact that wounds were treated with it (Velnar*et al.,* 2009). The preparation of AgNPs using plant extracts can be categorised into green methods as it does not involve the use of toxic chemicals and the phytochemicals are used to reduce metal ions to form nanoparticles and it support the green chemistry norms (Frykberg& Banks, 2015). The synthesis procedure of AgNPs integrated with collagen, an essential protein in the extracellular matrix of connective tissue is believed to improve the stability and biocompatibility of the synthesized nanoparticles mainly because of its significance in offering structural support and promoting tissue repair during the wound healing process (Nunan*et al.,* 2014). Hence, the encapsulation of nanoparticles in collagen offers great prospects since it can act as a support on which the new tissue can form; using AgNPs, it may enhance the therapeutic effect of these nanoparticles when integrated within the wound site. This research will propose the notion that dispersion of silver nanoparticles blended from *Menthapiperita* extract and chicken collagen and encapsulated chicken collagen provides superior wound healing benefits and taller antibacterial activity as compared to the option of the non-encapsulated silver nanoparticles. The particular aim of this work is as follows; To produce *Menthapiperita* extract mediated green synthesis of silver nanoparticles; To encapsulate chicken collagen on the nanoparticles; and to determine the efficiency of the collagen-coated AgNPs against strains of wounds and their skin repairing proficiency through various in vitro methods.

METHODOLOGY

Preparation of the extracts

Collection and Preparation of Plant Materials

The leaves of this plant were obtained from mint (*Menthapiperita* L.), manthari (*Bauhinia purpurea* L.), white chaste tree (*Vitexleucoxylon* L.), mehandhi (*Lawsoniainermis* L.), hibiscus (*Hibiscus rosa-sinensis* L.), and Indian mint (*Saturejadouglasii*) grown in and around Chennai, which was taken from perfectly growing plants. The leaves were washed with running tap water to clear the debris and then with distilled water to minimize any contamination. The leave was then sun-dried for three days after washing with distilled water to prevent destruction of phytochemicals by light and heat. The leaves were then sun dried and ground into a fine powder using a brand-new heavy duty blender commonly used in laboratories. Four grams of the powdered leaves were then required with 100ml of distilled water, and the mixture was placed in a water bath at 55°C for fifteen minutes. After allowing the extract to cool to the room temperature the extract was filtered by Whatman No. 1 filter paper to eliminate any solid particles that may be present and later kept in the refrigerator at temperature of 4°C for the next phase of the nanoparticle preparation.

Synthesis of silver nanoparticles (AgNPs)

Reduction Process

Silver nanoparticles was synthesized using green synthesis procedure by reducing and stabilizing agent using *Menthapiperita* extract. A 1 mM solution of silver nitrate (AgNO3) was prepared which was then allowed to react with the *Menthapiperita* extract at different concentrations for the enhancement of the synthesis process. After that, the mixture was stirred continuously and heated at 60° C. The reaction progress was judged by an appearance of brown color of the solution from initial pale yellow color due to formation of AgNPs due to reduction of Ag+ ions to Ag0.

Optimization of Parameters

A number of factors that may affect the size and stability of AgNP were consequently altered in order to assess the effect of these variables on the reaction:

Concentration of Plant Extract

Preliminary studies on the variation of nanoparticle formation were carried out using the 1%, 1.5%, 2%, 2.5% and 3% concentration of *Menthapiperita* extract. The absorbance of the extracts and the identification of the highest value corresponding to the concentration of the extract were made using UV-Vis spectrophotometry.

pH

To the reaction mixture the pH was adjusted with 0. 1 N HCl and 0 (zero as in the previous step). 1N NaOH to keep the PH between 5/9. The effect of pH concerning nanoparticle synthesis was endorsed through the absorbance of each developed pH, however pH 8 signified the highest degree of generation and efficiency for AgNPs.

AgNO3 Concentration

Chemical disinfection process with silver nitrate solution of the following concentrations: 0. 5 mM to 2. To ensure that adequate silver ions were available for reduction, 5 mM was chosen and tried. By using UV-Vis spectroscopy the efficiency of nanoparticle synthesis at various concentrations of AgNO3 was determined.

Temperature

At the same time, the influence of the reaction temperature on the synthesis process was investigated; it was increased from 22 to 42 degrees Celsius. UV-Vis measurements were performed at all the temperatures for stable formation of nanoparticles.

Characterization of Silver Nanoparticles

Visual Inspection: The synthesis of AgNPs was first revealed by colour change of the reaction mixture to grey colour. The color change to a dark brown color meant that there was a decrease in silver ions and the development of AuNPs exploding the surface plasmon resonance (SPR). These visual patterns could be used as the first clue demonstrating that the nanoparticles had been successfully produced.

UV-Vis Spectroscopy

UV-Vis spectrophotometry analysis was performed to affirm formation of AgNPs and to study the optical behavior of the sample. Samples were analyzed in the UV–Visible region by scanning wavelength from 300–700nm and a peak at 430nm was obtained. This specific value is due to the SPR of silver nanoparticles and implies the formation and stability of the synthesized AgNPs.

FTIR Analysis

FTIR was conducted because it allows for identification of functional groups responsible for reduction and stabilization of the AgNPs. The authentication of *Menthapiperita* extract and AgNPs was performed and the spectrum of the two samples was super imposed to observe changes made after the preparation of nanoparticles. Some broad bands were captured at 3284cm−1 that was due to O-H stretching along with the reduction of AgIons and 2120cm−1 C=C=O stretching, 1637 cm−1C=C stretching, 1476 cm−1 C-H bending and 1272 cm−1 C-O stretching indicated that all those functional groups existed in the extract (Islam, M. *et al.,*

Transmission Electron Microscopy (TEM)

The synthesized AgNPs were characterized by TEM which is useful in determination of the size and disaggregate morphology. The specimens were obtained by placing a drop of the nanoparticle solution on to a carbon coated copper grid, which was then allowed to air dry. The morphology characterization of the synthesized nanoparticles was done using TEM and the results depicted that it has a mostly spherical shape and the size of nanoparticles is in the range of 10–200 nm. The average particle diameter of the synthesized AgNPs was ~ 20 nm; Therefore, the information disrupted the structural characteristics of the synthesized AgNPs and as a consequence indicating that they are nano sized (Thuraisingam*et al.,* 2010).

Energy Dispersive X-ray (EDX) Analysis

Energy-dispersive X-ray spectroscopy also known as EDX was administered in order to neutralize the concentration of elements and purity levels of the produced AgNPs. At this stage the obtained nanoparticles were characterized by the use of scanning electron microscope equipped with an EDX. Taking the spectrum analysis results into consideration now, here are some observations: While analyzing the spectrum of the solution, a high intensity of silver was recorded at 3 keV, followed by a very low intensity of other elements, so it means that silver nanoparticles have been synthesized on the solution without much of the other elemental interference.

Incorporation of AgNPs with Chicken Collagen

Collagen Extraction and Encapsulation

The process of Collagen extraction, and encapsulation of silver nanoparticles (AgNPs) were pivotal in expanding the functional characteristics of the developed nanoparticles, especially with regard to dispersion stability and bioavailability. Triturated skin of chicken was used to isolate collagen for this study which was preferred due to its high collagen content and ease of extraction. To start the process, the chicken skins were first washed and deboned then trimmed of excess fat and ensure all were free from any other unwanted substances. The sex separated cleaned skin was then treated to an acid digestion process using acetic acid which was used to solubilize the collagen fibers.After the acid digestion, the collagen solution was purified for non-collagenous proteins and other materials which was followed by precipitation. The process of purification included dialysis of the collagen solution against distilled water; this helped in the removal of smaller molecules inclusive of residual acids thus concentrating the collagen solution. The resulting collagen was lyophilized to get it in a powder from which the collagen was confirmed to be pure and of the correct structure by UV-VIS and FTIR studies. The percentages of collagen

incorporation and the efficiency of fibroblast adhesion of the scaffold were investigated using UV-Vis spectroscopy, and characteristic absorption maxima were obtained Characterization of the functional groups in collagen and the confirmation that there is no appreciable degradation or contamination were done using FTIR analysis (Li *et al.,* 2007). In the preparation of the AgNPs with the extracted collagen, the idea was to improve the functional properties of the nanoparticles by coating the AgNPs with collagen to make it better compatible with biological systems. In conjugating the synthesized AgNPs with collagen, the AgNPs dispersion was mixed with a collagen solution under controlled conditions to effect coating of the particles with the protein. The prepared suspension was stirred slowly in order to enhance the nanoparticles/collagen molecules interaction which will enhance the encapsulation process (Calin*et al.,* 2010).

Antimicrobial activity and Wound Healing Assays

To determine the curative effects of the collagen-encapsulated AgNPs, the antimicrobial and in vitro wound healing activities were assayed. These assays were supposed to determine the effectiveness of the nanoparticles to reduce the formation of biofilm and to stimulate the process of healing in the cells.

Antimicrobial Activity

The attempts for the use of collagen-encapsulated AgNPs were made to determine the yields in terms of its antimicrobial activity against various species of bacterial pathogens such as *Staphylococcus aureus*, *Escherichia coli* and *Pseudomonas aeruginosa* using the standard disc diffusion techniques. Disc diffusion methods incorporated using autoclaved discs with collagen encapsulated-nanoparticles that were then applied gently on nutrient agar plates seeded with the target bacteria. The bacterial plates were then incubated under the best condition for the bacterial growth and the measuring of the zones of inhibition around the discs was done after the specific time of incubation was over. The size of the inhibition zones allowed for a more comparative evaluation of the nano-template's antimicrobial properties with bigger zones suggesting greater effectiveness.

***In vitro* wound healing assays**

The wound healing ability of the nanoparticles was further assessed by wound healing assays which are in vitro models that try to mimic the wound healing process. These assays were cytotoxicity assay and the wound healing migration assay which were done on Vero cells, a type of cell line generally used for in vitro wound healing assays.

Cytotoxicity Assay

Cytotoxicity assay was then performed to determine the biocompatibility of the collagen-coated AgNPs on Vero cells to know their toxic impact on cell survival. Cell signaling studies were performed treating cells with 0, 10, and 100 μg/mL of the nanoparticles. This assay and determined the overall metabolic activity of cells thereby giving an estimation of the viable cells present. Altogether, the findings suggested that the particles were relatively harmless at the disclosed concentrations and exerts negligible influence on the cell death rate (Badylak, *et al.,* 2002).

Scratch Assay

Scratch assay was carried out to assess the cell migration ability, an important factor of wound healing with the help of nanoparticles. Wound healing was performed with Vero cells growing in a monolayer: a scratch was made in the monolayer, and the cells' migration into the scratch was observed with time while in the presence of collagen-encapsulated AgNPs. Cell migration and the rate at which the scratch was closed was determined and higher rates of closing was an indication of better wound healing properties. The studies proved that the nanoparticles enhanced the migration of cells tremendously and thereby have a potential to enhance the process of healing (Badylak*et al.,* 2002).

RESULTS AND DISCUSSION

Synthesis and Characterization of AgNPs

Collection of Medicinal Plant Materials

Six different plant species were used in the study from particular site of Chennai.The collected plants are mint (*Menthapiperita* L.), manthari (*Bauhinia purpurea* L.), white chaste tree (*Vitexleucoxylon* L.), mehandhi (*Lawsoniainermis* L.), hibiscus (*Hibiscus rosa-sinensis* L.), and Indian mint (*Saturejadouglasii*). The plants were selected depending on the favorable environmental factors, health of the plants etc. Reliability of the said materials is paramount for replication of these results because, collection sites influence the phytochemical profile of the plant species used in the synthesis of nanoparticles.

Extraction of Phytochemicals from Plant Materials

Six different plant species were used in the study and phytochemical extracts were extracted by using water based processes (Figure 1). The extraction process proved helpful in the isolation of the bioactive compounds required in the restoration of silver compounds by transforming Ag+ into Ag0. Concerning the color and clarity of the extracts obtained from the various plants, they differed, thus pointing to the different phytochemicals extracted and required for the green synthesis of AgNPs (Gurtner*et al.,* 2008). This method of extraction ensures the retention of active components which are very vital in the formation of nano particles going with other authors who found that water based extraction is very useful in getting potent reducing agents (Richmond *et al.,* 2013).

Synthesis of Silver Nanoparticles (AgNPs)

Particularly, the synthesis of AgNPs was carried out by boro-hydride reduction method. The color change to brown in the solution was highly enhanced from *Menthapiperita* L. extract indicating a higher concentration of the extract and effectiveness in the reduction of silver ions. This colour change is explained by the formation of nanoparticles, by surface plasmon resonance (SPR) phenomenon present in metallic nanoparticles (Rodero and Khosrotehrani, 2010). The incorporation of a capping agent was effective in the prevention of nanoparticle aggregation and maintaining nanoparticles stability in the solution which concurs with other publications that describe green synthesis approaches of plant mediated methods in nanoparticle synthesis where the role of plant extracts play the function of stabilizing agents (Choi & Webster, 2012).

Optimization of Various Parameters for Silver Nanoparticle Synthesis

Concentration of Plant Extracts

Accordingly, the amount of *Menthapiperita* extract which was most effective was the one in the concentration of 2. 5% in a 1mM AgNO3 solution for the preparation of the CSP. From UV-visible spectrophotometric study, it was observed that at this concentration, there was a maximum absorbance at 430 nm as shown in Figure 2. This peak shows that AgNPs formed effectively, since the high concentration of plant extract avail the large number of reducing agents that hasten the formation process. The concentration of 2. 5% contributed to the almost ideal reaction environment which further corroborates with the mentioned research findings that increased concentrations help in increasing the reduction efficiency of plant mediated nanoparticle synthesis.

pH

This study reveals that the optimum pH for the synthesis of AgNPs was pH 8. From the UV-visible spectrophotometric data, it was determined that pH8 depicted the highest absorbance peak and hence the best conditions for the synthesis of nanoparticles in this case (Figure 3). Stabilizing the pH at 8 proved to affect the charge and stability of the nanoparticles and thus promoted their formation and growth because literature shows that the pH level dramatically affects the synthesis and stabilization of nanoparticles (Choi & Webster, 2012).

Concentration of $AgNO_3$

From the above investigation, the highest production of AgNPs was achieved at a concentration of 2 mM with regards to AgNO3. Concentration of 5 mM, confirmed from the UV-visible spectrophotometric analysis shown in figure 4. This concentration gave the maximal absorbance peak which confirm or shows that the Ag ions are readily available for reduction. Patterns of optimum concentration reveal that higher values result into generation of more nanoparticles; however, high concentration is limited due to aggregation since high ionic solution may result to unplanned growth of the particles (Bera&Basak, 2014).

Temperature

From the above findings it can be concluded that the temperature at which the synthesis of AgNPs was most optimum was 42°C. This was, again in support with the UV-visible spectrophotometric analysis, where the peak absorbance was recorded at this temperature, which is the optimum temperature for the development of nanoparticles (Figure 5). This temperature increase helps in the faster reduction and synthesis hence faster formation of the nanoparticles and perhaps the formation of even smaller nanoparticles because of faster nucleation probably as a result of temperature optimization in studies of nanoparticles (Li et a., 2007).

Stability Analysis

The prepared AgNPs using *Menthapiperita* were stable from 1hr to 90 days and its UV-Vis showed the peak at 435 nm as depicted in the Figure 6. As time went on, the peak becomes clearer, which suggests that the nanoparticles are progressively becoming more stable. Changes were detected at 435 nm in 6 hours, while the steady peaks at 450 nm were put in 24 hours and 3 months. This stability imply a constant size and shape of the synthesized nanoparticles over a period of time which is important when being used in biomedical fields (Frykberg& Banks, 2015).

Characterization of Green Synthesized Silver Nanoparticles

Visual Inspection

The formation of *Menthapiperita* extract mediated AgNPs was further corroborated biinally by the change in color from light yellow to dark brown color. This change is characteristic of nanoparticles' formation because of the surface plasmon resonance (SPR) phenomenon, which regards the interaction of a material or an object with light of certain wavelength corresponding to its size and geometry. The detected change in color complies with general features of metallic nanoparticles' appearance after synthesis, indicating the process's completion. This visual confirmation of synthesized AgNP is in tune with literature reports where the color change of the solution is reported during the green synthesis of silver nanoparticles employing plant extracts (. Ullah and Bussmann, 2017). This colour change due to SPR is typical of metallic nanoparticles and helps in arguing the presence of silver at the nanoscale (Ullah & Bussmann, 2017). This testifying change produced by *Menthapiperita* supports its role of a reducing and stabilizing agent characteristic in the synthesis of nanoparticles that were disclosed in other research works where plant extracts were used in green synthesis.

UV-Vis Spectroscopy

The UV-Vis spectra of the biosynthesized AgNPs presented a shoulder band in range of 340-450 nm, the higher maximum absorbance value at 430 nm for *Menthapiperita* L extracts (Figure 7). These values of absorbance are characteristic to silver nanoparticles and represent the surface plasmon resonance and therefore the synthesis and stabilization of the nanoparticles are successful. This particular range of absorbance matches what has being found from other related research on AgNPs that has been synthesized using various biological techniques. Therefore, the extent of size reduction and stabilization of nanoparticles as proxied by the UV-Vis spectra corroborates the efficiency of *Menthapiperita* extract for the green synthesis of AgNPs as portrayed in the literature on optical characteristics of silver nanoparticles synthesized using extracts of plants (Herskovitz*et al.*, 2016).

FTIR Analysis

The *Menthapiperita* extract was evacuated to generate FTIR spectra as follows: The extract gave peaks at 3284 cm−1, 2120 cm−1, 1637 cm−1, 1476 cm−1, and 1272 cm−1; which belongs to O-H, C=C=O, and C- H bend functional groups

respectively See (Figure 8). These groups are of importance in reducing the silver ions and in stabilizing the formed nanoparticles; herein, information on the chemical processes during green synthesis is revealed. These peaks can be explained as bonds and stretches characteristic for organic molecules within the precipitate interacting with Ag+ during nanoparticle formation. These interactions help in the reduction of Ag+ to Ag0 and significantly aids in stabilizing the nanoparticles by avoiding their agglomeration which is in accordance with the other works reported on the green synthesis involving plant extract. These functional groups give support to the part played by phytochemicals in the extract as efficient reagents in the synthesis process (Rodero&Khosrotehrani, 2010).

Transmission Electron Microscopy (TEM)

As observed from the TEM images, *Menthapiperita* based synthesized AgNPs were predominantly spherical in shape having size between 10-200 nm (Figure 9). It was also observed that the nanostructures' morphology and size increase as the concentration of the plant extract increases. Nano-size and shape of the nanoparticles determining the properties like optical properties as well as the antibacterial properties. Which makes sense when compared to prior research on plant-based synthesis, which shows that the morphology of the resulting nanoparticles actually depends on the concentration of the extract and the chemical content of the reducing agents thereof (Choi & Webster, 2012). This variability has shown that plant extracts are very effective when used in green synthesis methods.

Energy Dispersive X-ray (EDX) Analysis

Figure 10 demonstrates the EDX spectrum of the synthesized AgNPs wherein the presence of Ag-element with maximum peak at 3 keV and no other peak other than the silver element noticed that confirmed the birth and purity of the Silver nanoparticles. No peaks of other elements present demonstrated low level of impurities, which corroborated with the quality of synthesized nanoparticles. The low level of the presence of other elements demonstrates that the green synthesis process for the formation of AgNPs was successful in yielding samples with high purity and without the interference of impurities from the plant extract or the synthesis milieu. This finding is in concurrence with other works which have revealed similar purity of silver nanoparticles synthesized using plant extracts, which clearly substantiates the green synthesis technique as a means of procuring nanoparticles of acceptable quality (Ullah&Bussmann, 2017).

Antimicrobial Analysis of Silver Nanoparticles:

Menthapiperita derived AgNPs resulted the zone of inhibition against both the Gram positive and negative bacterial pathogens. These zones of inhibitions were determined to be 22 mm for *Bacillus subtilis*, 20 mm for *Staphylococcus aureus*, 22 mm for *Pseudomonas aeruginosa* and 20mm for *Escherichia coli* (Figure 11). These findings are quite similar to the reference antibiotic Gentamicin as evident by the high antibacterial efficacy of synthesized AgNPs. The ability to eradicate over ninety percent of bacteria strengthens the aspect of AgNPs as a replacement to the already fading antibiotics effective against antibiotic resistant bacteria. The large inhibition halos measured for *Menthapiperita* derived AgNPs against *Bacillus subtilis* (22 mm), *Staphylococcus aureus* (20 mm), *Pseudomonas aeruginosa* (22 mm), *Escherichia coli* (20 mm) showed the effectiveness of synthesized AgNPs. It is for this reason that nanoparticles are effective in their nanoscale distribution and size, which enhances their interaction with bacterial cell membranes. The antibacterial activity is mainly concern with the ions released from the nano-silver, which be taken into bacterial cell to interrupt metabolic process and induce oxidative stress and then lead to cell death (Frykberg& Banks, 2015).The active mechanism of antibacterial activity of nano-silver is associated with the reaction of silver ions with SH groups in bacterial proteins and DNA interfering with vital cell functions. It leads to alteration in the structural and membrane characteristic of the bacterial cell, increased permeability, and release of enzyme that degrades the bacterial cell wall and hence killing of the bacteria. Besides the mentioned impacts, it is reported that AgNPs induce the generation of ROS which in general boost them up their antibacterial aptitudes via inducing oxidative damage to the lipids, proteins, and DNA of the bacterial cell (Rai *et al.,* 2012). Further, the zones of inhibition evident against both the Gram-positive and the Gram-negative bacteria suggest that AgNPs have a broad spectrum activity that is desirable when developing drugs used in the management of infections produced by different bacterial genera. P. aeruginosa and E. coli are producers of biofilms and were shown to have an additional outer membrane which can be argued to have been overcome by the AgNPs considering that they are hard targets to the conventional antibiotics.

The reported broad-spectrum activity makes AgNPs to be very useful in combating MDR bacterial strains, which are some of the main challenges facing contemporary healthcare systems (Ahamed*et al.,* 2010).The findings are in support with other works that have recorded similar antibacterial effectiveness of silver nanoparticles that are prepared from plant extracts. For instance, Gurunathan et al. (2014) worked on AgNPs fabricated by using Azadirachtaindica and realized that the synthesized compound was as effective as the antibiotics as it formed equal zones of inhibition against several bacteria. This supports the prospect on plant synthesized AgNPs in combating bacteria through the research proposal by Gurunathan*et al.,* (2014).

***In Vitro* Cytotoxicity Assay**

In terms of cytotoxicity, Assay with Vero cells involves determination of cell viability with AgNPs that present cell viability between 89%, 93%, 97%, 98% at chosen concentrations of 20 µg/mL, 50µg/mL 75 µg/mL, 100 µg/mL respectively. From these results it is clear that at the given concentration of the biomolecules the synthesized AgNPs are biocompatible and therefore may be used for biomedical applications including; wound healing and drug delivery. This has an implication, in the context of their therapeutic application, with regard to the little or no harm which they are likely to inflict on normal cells (Badylak*et al.,* 2002). The high percentage of live cells indicated means that regardless of the cell type, silver nanoparticles indeed possess a high degree of biocompatibility which may further support for other applications in the biomedical fields. The maintained balance of the viability rates centrally that AgNPs do not lead to the disturbance of the vital processes under concentrations that may be useful for the medicinal purposes and owed to such, their effectiveness in wound healing and as drug delivery systems (Choi & Hu, 2008). Similar to Foldbjerg*et al.,* they affirm on the biocompatibility argument by showing that even at rather high concentrations, AgNPs has negligible impact on cytotoxicity of mammalian cells. This confirms the possibilities of safe use of AgNPs in biomedical applications for instance in drug delivery and tissue engineering since cell viability is very important (Foldbjerg*et al.,* 2009) (Figure 12 & Table 1).

Apoptotic Activity

AgNPs caused apoptosis in Vero cells by binding to DNA and showing green fluorescence with acridine orange and red fluorescence with propidium iodide for chromatin feature and apoptosis respectively as shown in Figure 13. Higher activation of caspase-3/9 supported the findings indicative of apoptosis induced by the AgNPs. This indicates that it can be useful in cancer treatment as well as in the process of healing of a body's wound because there is need to cause death of impaired of cancerous cells (Li *et al.,* 2007). Foldbjerg et al. (2011) have demonstrated that silver nanoparticles cause apoptosis in cancer cells through oxidative stress and the intrinsic pathway. This work established that there is a direct relationship between effects of AgNPs and ROS levels such that since ROS causes DNA damage the next effect is activation of apoptotic pathways such as caspase cascade. This correlates with the discover that AgNPs can cause apoptosis in Vero cells, possibly by the same pathways (Foldbjerg*et al.,* 2011). Gurunathan*et al.,* (2015) concluded that silver nanoparticles have the ability to kill leukemia cells through apoptosis by the generation of reactive oxygen species and activation of the intrinsic pro-apoptotic pathway. The study noted elevated caspase-3 levels, and condensed chromatin pattern, typical of apoptosis as seen in the present research (Gurunathan*et al.,* 2015).

***In-vitro* scratch wound healing assay**

Utilizing scratch assay, we looked at how well AgNPs plant extract healed wounds. To find out which chemicals have wound-healing properties, this is a common and easy way to do so. Fibroblasts & keratinocytes migrate and proliferate during this stage of wound healing, and they're connected. This test reproduces conditions under which cells migrate in body after wound heals. Figure 14 and Table 2 show that tested AgNPs were able to seal scratched gap more quickly.

CONCLUSION

The present investigation was able to synthesize successfully AgNPs using *Menthapiperita* extract and also encapsulated them with chicken collagen which showed enhanced antimicrobial activity and wound healing ability. Hence the encapsulation with collagen enhanced the solubility, stability and enhanced biocompatibility of the AgNPs leading to cell proliferation and migration without any toxic effects which enhanced the use of *Menthapiperita* in modern medicine. These studies reveal that collagen-encapsulated AgNPs can be used as effective wound healing agents that can improve the aspects of treatments now available on the market by combining the effects of natural extracts and nanotechnology. Thus, for the next steps of research, it is necessary to conduct experimental and clinical studies in vivo to confirm these initial findings and to investigate the possibility of the use of these nanoparticles in clinical practice, as well as to research specific guidelines on the application of these nanoparticles in the wound healing products. The findings of this study reveal a new way to fuse conventional comprehensive medicinal practice with modern nanotechnology, which provides a viable course for inventing adequate opportunities for wound management with the utilization of therapeutic silver nanoparticles during the healing process of the skin.

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Table 1: Table showing the cell viability test result

Concentrations (µg/mL)	Absorbance		Average	Cell viability (%)
	I	II		
Control	0.887	0.893	0.89	100
20	0.877	0.879	0.878	98.65168539
40	0.863	0.866	0.8645	97.13483146
60	0.852	0.847	0.8495	95.4494382
80	0.84	0.833	0.8365	93.98876404
100	0.799	0.8	0.7995	89.83146067

Table 2: Table showing the *in-vitro* scratch wound healing activities of AgNPs

S. No.	AgNPs		Control	
	Time (hr)	Healing (%)	Time (hr)	Healing (%)
1	0	0	0	0
2	24	30.41	24	27.91
3	48	49.58	48	43.33
4	72	63.33	72	58.33

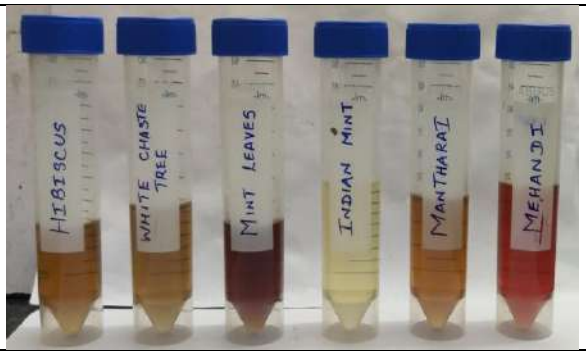


Fig-1: Image depicting phytochemical extracts from different plants

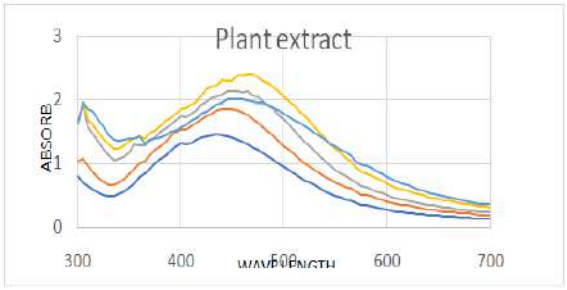


Fig-2: Photograph displaying UV-Vis peaks of various concentrations of plant extracts

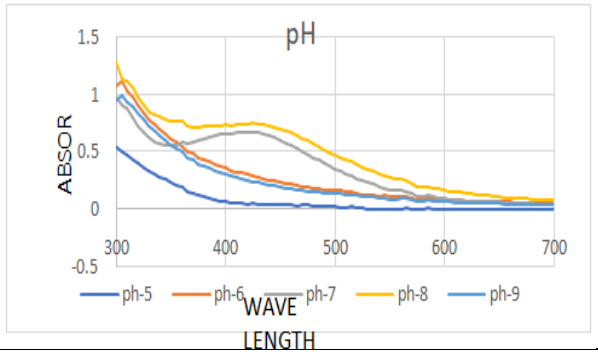


Fig-3: Image displaying UV-Vis peaks of extracts examined at various pH levels

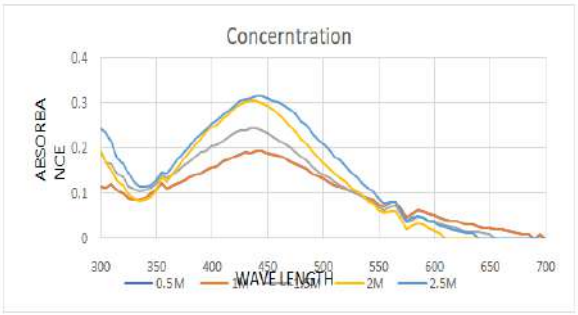


Fig-4: Pictorial representation of extract's UV-Vis peaks as a function of AgNo3 concentration

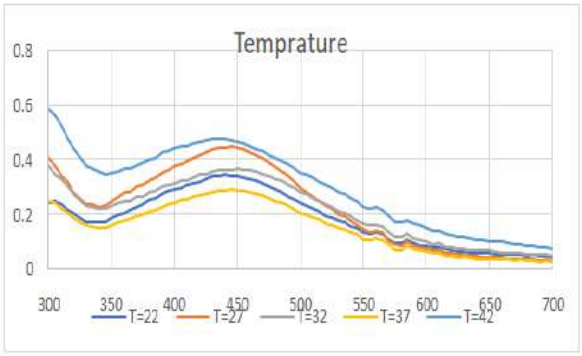


Fig-5: Photo displaying extract's UV-Vis peaks at various temperatures

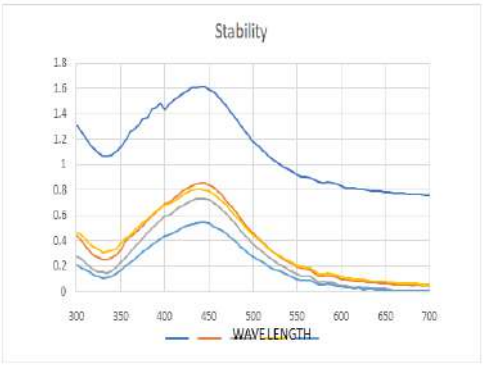


Fig-6: Image displaying extract's stability-testing UV-Vis peaks

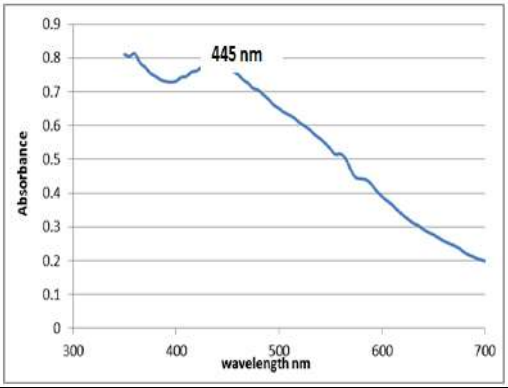


Fig-7: Photograph showing the UV-Vis peaks of the *Menthapiperita* L.extract

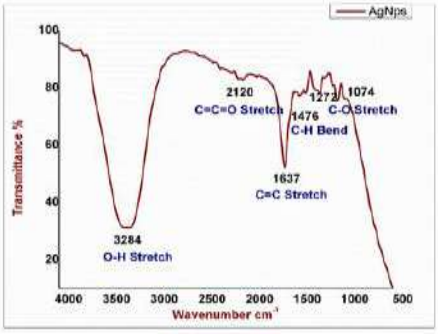


Fig-8: FTIR analysis of silver nanoparticles produced by *Menthapiperita* L.

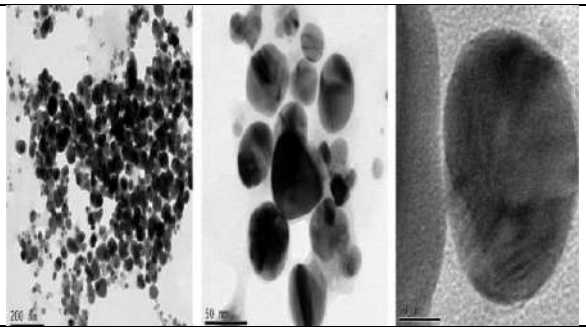


Fig-9: TEM images of the prepared AgNPs at three different sizes (20 nm, 50 nm, and 10 nm)

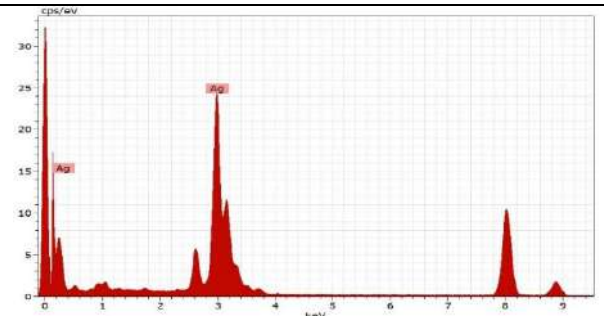


Fig-10: Energy dispersive X-ray (EDAX) spectrum of AgNPs

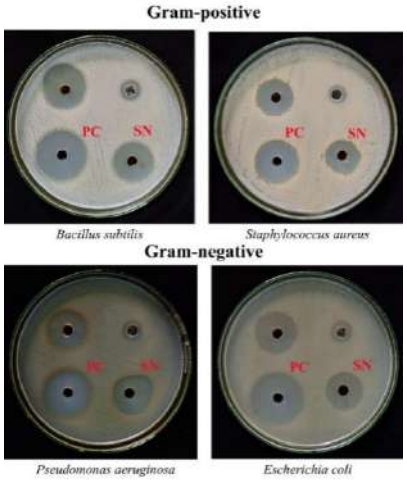


Fig-11: Antibacterial activity of synthesized silver nanoparticles (SN – Silver Nanoparticles & PC – Positive Control (Gentamicin))

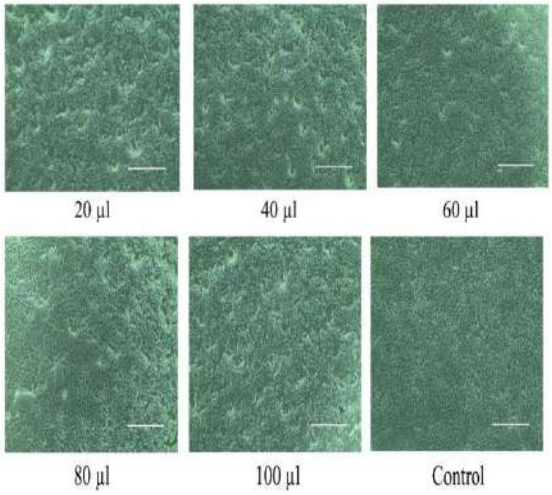


Fig-12: Images of cytotoxic capability of AgNPs at different concentrations

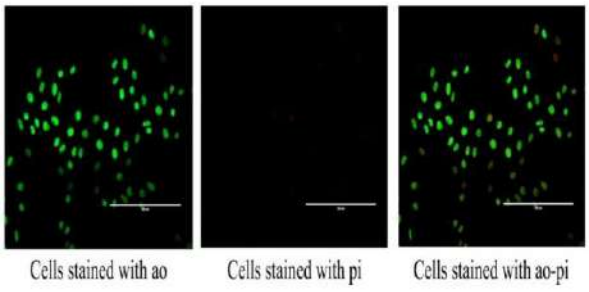


Fig-13: Photos displaying apoptotic processes of AgNPs using various dyes

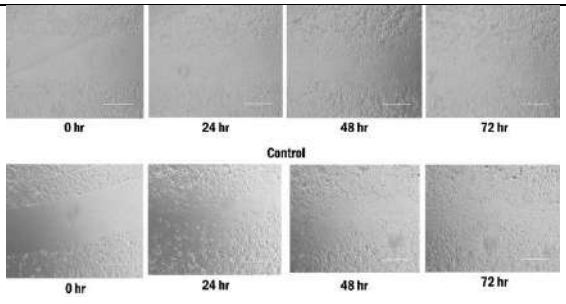


Fig-14: Photographs of in-vitro scratch wound healing activities of AgNPs

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RESEARCH ARTICLE

Qualitative and Quantitative Analysis of "Vellai Kungiliyam" In Various Purification Methods

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ABSTRACT

The Siddha system of medicine mainly emphasizes health as the perfect state of a person's physical, psychological, social, & spiritual well-being. One of the significant aspects of the Siddha system is the purification of raw drugs before using them to make medicines. The term *Suddhi* means to get rid of impurities. The *Vateria indica* is a tropical tree that is endemic to the Western Ghats of India & belongs to the family Dipterocarpaceae. The dammar resin obtained from the bark of the tree is used in wounds, leucorrhoea, swelling, cough, asthma, leprosy, & skin eruptions. *Vateria indica* resin regulates the *Tridosha*(*Vatham, pitham, kapham*) of the body. *Vellai Kungiliyam* is purified using a variety of purification methods, & the phytochemical analysis of separate three samples were evaluated. *Vellai Kungiliyam* is purified as per Siddha literature using three different methods. Physiochemical characterization such as loss on drying, ash values, extractive values, qualitative phytochemical screening, & TLC/HPTLC analysis were estimated as per Pharmacopoeia Laboratory for Indian Medicines (PLIM) guidelines. HPTLC fingerprinting of Sample I revealed the presence of five prominent peaks & the Rf value ranges from 0.02 to 0.90 whereas sample III showed the presence of seven prominent peaks & the Rf value ranges from 0.00 to 0.83. The present study revealed that the bioactive compounds were present in large amounts in purification by *Thiriphala kudineer* (Sample II). The phytochemical analysis confirms the presence of Alkaloids, Carbohydrates, Saponins, Phenols, Tannins, Flavonoids, & Diterpenes. The *Vellai*

kungiliyam purified with *Thiriphala kudineer* is known to have the highest therapeutic value in comparison to the other two samples.

Keywords: HPTLC, Physio-chemical analysis, Purification, *Vateria indica*.

INTRODUCTION

Nowadays, Herbal medicines are becoming a widely popular form of health care & it has witnessed a renaissance among consumers throughout the world. One of the oldest systems of medicine in the world that treats the body as well as the mind & the soul is Siddha medicine. The Tamil term *siddhi* means a goal to be achieved, perfection, or heavenly bliss [1].The recent upsurge of interest in the Siddha system can be seen in the large-scale manufacture of Siddha formulations. However, one of the impediments to the acceptance of the ancient systems of medical preparation is the lack of standard quality control profiles. The process of prescribing a set of standards or intrinsic qualities, constant parameters, & unambiguous qualitative & quantitative values that convey an assurance of quality, efficacy, safety, & repeatability is known as the standardization of herbal medicines.

Suddhi (Purification) of the raw drug is a process aimed at removing the impurities & toxic substances to some extent or potentiating their chemical transformation into nontoxic or comparatively less toxic chemicals, improving the potency, & efficacy, enhancing the synergistic effect of the drug [2]. No medicinal preparation can be done without prior *Suddhi muraigal* (Purification process). The three main phases in herb purification are drying, grinding, & sieving. The secondary purification process entails concentration, drying, & extraction using the appropriate solvents. Extensive separation & purification processes such as solvent-solvent extraction, solid-phase extraction, & liquid chromatography are needed for further purification to produce pure phytochemicals. In addition, thin-layer chromatography (TLC), high-performance liquid chromatography (HPLC), paper chromatography (PC), & gas chromatography (GC) were used in the separation & purification of the secondary metabolites[3].

According to the Indian system of medicine *Vateria indica* L. is used as a tonic, carminative, & expectorant. It is an important medicinal plant that is endemic to the western ghats of India & comes under the family *Dipterocarpaceae*. The resin obtained from this plant has the same uses as pine resin. Phytochemical analysis of *Vateria indica* L. stems revealed the occurrence of carbohydrates, tannins, phenols, & flavonoids in the aqueous & ethanolic extracts. The leaves & roots also have the presence of bergenin , hopeaphenol, stilbenoids, bergenin and benzophenone. The trees of the *dipterocarpaceae* family are primarily found in evergreen & semi-evergreen forests, near the streams of southern Western Ghats. *Vateria indica* was first described by Hook & Gamble in 1874 & 1915. Since then, many researchers have documented it from different sites in the southern western ghats of India, namely Kerala, Karnataka, & Tamilnadu. Traditional medicine & astrology also provide references that help us comprehend their ties to the national culture & heritage. Resins are usually mixtures of organic substances. Plants produce resins in response to injury because of their defensive properties. Resin is one type of secondary metabolite, that shields the plant from infections & insects.

In Siddha medicine, a resin called *vellai kungiliyam*, which is obtained from *Vateria indica* trees, has therapeutic properties. *Vellai kungiliyam* is a component of medicinal oils that are used to cure Vadha illnesses. It works better for disorders caused by *Vatham.* Resin is produced through the reaction of volatile oil & oxygen. They are primarily composed of hydrocarbons. Resins cannot be dissolved in water. They are soluble in both alcohol & ether. The ancient Egyptians coated food storage containers with resin to prevent food from rotting. Some resins are produced in the roots. Many of the resins come from families including *Dipterocarpacceae, Anacardiaceae, Burseracceae, Guttiferae, Fabacceae, Mimosaceae, Stryraceae, Umbelliferae, Liliaceae, Pinaceae*, etc.

Resins are generally categorized into three groups. They consist of hard resins, Oleo resins &, Gum resins. The hard resins are further divided into three categories. The three are lacquer, shellac, & damars. The word ' damar ' is a Malay word. It refers to burning material. 'Damars' refers to *kungiliyam* varieties in trade. The resin is obtained by scratching in the bark & phloem, after which it is obtained & collected. It appears to be white-colored fragments of marble [4]. *The Vellai kungiliyam* has a variety of pharmacological effects, including anticancer, antitumor, anti-inflammatory, & antiulcer properties [5-6].

As per Siddha system *Vellai kungiliyam* is purified by different methods, qualitative & quantitative analysis were done as per PLIM guidelines. Therefore, the purpose of the study is to purify the *Vellai kungiliyam* in three different methods & analyze the chemical changes that occurred during the purification process of *vellai kungiliyam* scientifically [7-8].

MATERIALS AND METHODS

Procurement of the raw drugs

The required drugs for the purification of *Vellai kungiliyam* were procured from a well-reputed country raw drug shop in Parrys Corner, Chennai. All the ingredients were purified in the *Gunapadam* laboratory at the National Institute of Siddha.

Identification & Authentication of the drug

The collected raw materials were identified & authenticated by the Assistant Professor, Department of Medicinal Botany, National Institute of Siddha, Tambaram Sanatorium.

Purification of *Vellai kungiliyam* - Process 1 (Sample 1)

Required ingredients

1. *Vateria indica L. (Vellai kungiliyam)*
2. *Citrus lemon (Elumichai)*

Method of Purification

The *Vellai kungiliyam* was soaked in lemon juice & dried.

Purification of *Vellai kungiliyam* : Process 2

Required ingredients

1. *Terminalia chebula* (*Kadukkai)*
2. *Phyllanthus emblica (Nellikkai)*
3. *Terminalia bellerica (thantrikkai*)

Method of Purification

The *Vellai kungiliyam* was packed in a cloth, soaked in *thiriphala kudineer* & then dried.

Purification of *Vellai kungiliyam* - Process 3 (Sample 3)

Required ingredients

1. Bark of *Azadirachta indica (Vembu pattai)*
2. Root of *Solanum Xanthocarpum (Kandankathiri ver)*
3. *Trichosanthes cucumerina (Peipudal)*
4. Leaf of *Justicia adathoda (Adathodai)*

Method of Purification

Veppampattai, Kandankathiri ver, Peipudal, Adathodai ilai each measuring 35 grams is added with 2 liters of water & boiled for a few hours till the water is reduced to 1/8th ratio. Then a cloth is tied up on the mouth of the vessel containing *Vellai kungiliyam* & is closed by the lid & ignited for a few hours till the *Vellai kungiliyam* reaches wax consistency. Following that *Vellai kungiliyam* is washed in water & dried.

Storage

The purified Vellai kungiliyam *was stored in a clean, dry, air-tight container & then it was sent to the laboratory for analysis.*

Qualitative & Quantitative analysis were carried out as per PLIM guidelines

Organoleptic properties

This provides first-step information regarding the identity, purity, & quality of the drug.

The organoleptic characters of the samples were evaluated which include their state, nature, odour, touch, flow property, & appearance. The results are shown in Table 1.

Physicochemical analysis

Physico-chemical studies of the plant drugs are necessary for standardization, as it helps in understanding the significance of physical & chemical properties of the substance being analysed in terms of their observed activities & especially for the determination of their purity & quality. The analysis includes the determination of Total ash, Loss on drying at 105ºC, acid-insoluble ash, water-soluble extractive, & alcohol-soluble extractive, which were carried out as per the procedures mentioned in standard references. Based on the AYUSH PLIM Guidelines, results are presented in Table 2.

The solubility profiles using various solvents were executed on different samples of *Vellai kungiliyam* & its results are depicted in Table 3.

The following analytical parameters were studied for *Vellai kungiliyam* which is purified by different methods:

Percentage loss on drying

The test drug was accurately weighed in an evaporating dish. The sample was dried at 105ºc for 5 hours & then weighed [9].

Determination of total ash

The test drug was accurately weighed in a silica dish & incinerated in the furnace at a temperature of 4000 ºc until it turned white in color which indicates the absence of carbon. The percentage of total ash was calculated with reference to the weight of the air-dried drug.

Determination of acid insoluble ash

The ash obtained by total ash test was boiled with 25 ml of dilute hydrochloric acid for 6mins. Then the insoluble matter is collected in a crucible & washed with hot water & ignited to constant weight. The percentage of acid-insoluble ash was calculated with reference to the weight of air-dried ash.

Determination of alcohol soluble extractive

The test sample was macerated with 100 ml of alcohol in a closed flask for twenty-four hours, shaking frequently for six hours, & allowed to stand for eighteen hours. Filter rapidly, taking precautions against loss of solvent, evaporate 25 ml of the filtrate to dryness in a tared flat-bottomed shallow dish, & dry at 105ºc, to constant weight & weigh. Calculate the percentage of alcohol-soluble extractive with reference to the air-dried drug.

Determination of water-soluble extractive

The test sample was macerated with 100 ml of chloroform water in a closed flask for twenty- four hours, shaking frequently for six hours, & allowed to stand for eighteen hours. Filter rapidly, taking precautions against loss of solvent, evaporate 25 ml of the filtrate to dryness in a tared flat-bottomed shallow dish, & dry at 105ºc, to constant weight & weigh. Calculate the percentage of water-soluble extractive with reference to the air-dried drug [10].

Biological & Pesticide Residue Screening

Sterility Test by Pour Plate Method

Objective

The pour plate techniques were adopted to determine the sterility of the product. Contaminated /unsterile sample (formulation) when coming in contact with the nutrition-rich medium it promotes the growth of the organism & after the stipulated period of incubation the growth of the organism was identified by a characteristic pattern of colonies. The colonies are referred to as colony-forming units (Cfus).

Methodology

The test sample was inoculated in a sterile petri dish to which about 15 ml of molten agar 45°c was added. Agar & sample were mixed thoroughly by tilting & swirling the dish. Agar was allowed to completely gel without disturbing it. (about 10 minutes). Plates were then inverted & incubated at 37° c for 24-48 hours & further extended for 72 hrs for fungal growth observation. Grown colonies of organisms were then counted & calculated for cfu.

Qualitative phytochemical analysis

Phytochemical screening of the plant gives a vast idea about the chemical constituents present in the drug. Key metabolites of Alkaloids, Carbohydrates, Flavonoids, Glycosides, Phytosterols, Tannins, Phenols, Saponins, Diterpenes, gum, & mucilage, & Quinones were carried out as per the procedures quoted in the standard organic book. The results obtained on each test are given in Table 5. Figure 5-7 shows the qualitative phytochemical investigation of *Vellai kungiliyam* purified by different methods.

Detection of alkaloids

Extracts were dissolved individually in dilute Hydrochloric acid & filtered.

Mayer's Test: Filtrates were treated with Mayer's reagent (Potassium Mercuric Iodide). The formation of a yellow colour precipitate indicates the presence of alkaloids.

Dragendroff's Test: Filtrates were treated with Dragendroff's reagent (Potassium Bismuth Iodide). The formation of a red precipitate indicates the presence of alkaloids.

Wagner's Test: Filtrates were treated with Wagner's reagent (Iodine in Potassium Iodide). The formation of a brown/reddish precipitate indicates the presence of alkaloids.

Detection of carbohydrates

Extracts were dissolved individually in 5 ml distilled water & filtered. The filtrates were used to test for the presence of carbohydrates.

Molisch's Test: To 2 ml of plant sample extract, two drops of alcoholic solution of α- naphthol are added. The mixture is shaken well & a few drops of concentrated sulphuric acid are added slowly along the sides of the test tube. A violet ring indicates the presence of carbohydrates.

Benedict's Test: Filtrates were treated with Benedict's reagent & heated gently. Orange red precipitate indicates the presence of reducing sugars.

Detection of saponins

Foam Test

0.5 gm of the extract was shaken with 2 ml of water. If the foam produced persists for ten minutes it indicates the presence of saponin

Detection of phenols Ferric Chloride Test

Extracts were treated with 3-4 drops of ferric chloride solution. The formation of bluish-black color indicates the presence of phenols.

Detection of tannins Gelatin Test

The extract is dissolved in 5 ml of distilled water & 2 ml of 1% solution of Gelatin containing 10% NaCl is added to it. White precipitate indicates the presence of phenolic compounds.

Detection of Flavonoids

Alkaline Reagent Test: Extracts were treated with a few drops of sodium hydroxide solution. The formation of an intense yellow colour, which becomes colorless with the addition of dilute acid, indicates the presence of flavonoids.

Lead acetate Test: Extracts were treated with a few drops of lead acetate solution. The formation of a yellow colour precipitate indicates the presence of flavonoids.

Detection of diterpenes Copper Acetate Test

Extracts were dissolved in water & treated with 3-4 drops of copper acetate solution. The formation of an emerald green color indicates the presence of diterpenes.

Test for Quinones

The extract was treated with sodium hydroxide blue or red precipitate indicating the presence of Quinones.

Test for Gum & Mucilage

To 1ml of extract add 2.5ml of absolute alcohol & stir constantly. Then the precipitate was dried in air & examined for its swelling properties. The swelling was observed which will indicate the presence of gum & mucilage.

TLC analysis

The test sample was subjected to thin layer chromatography (TLC) as per the conventional one- dimensional ascending method using silica gel 60f 254, 7x6 cm (Merck) was cut with ordinary household scissors. Plate markings were made with a soft pencil. Micro pipette was used to spot the sample for TLC applied sample volume 10-micro liter by using a pipette at 1 cm at 5 tracks. In the twin trough chamber with the specified solvent system after the run plates were dried & were observed using visible light short-wave UV light 254nm & light long-wave UV light 365 nm [11].

High-performance thin layer chromatography analysis

HPTLC method is a modern sophisticated & automated separation technique derived from TLC. Pre-coated HPTLC-graded plates & autosampler were used to achieve precision, sensitivity, & significant separation both qualitatively & quantitatively. High-performance thin layer chromatography (HPTLC) is a valuable quality assessment tool for the evaluation of botanical materials efficiently & cost-effectively. HPTLC method offers a high degree of selectivity, sensitivity, & rapidity combined with single-step sample preparation. thus, this method can be conveniently adopted for routine quality control analysis. It provides a chromatographic fingerprint of phytochemicals which is suitable for confirming the identity & purity of Phyto therapeutics.

Chromatogram development

It was carried out in camag twin trough chambers. Sample elution was carried out according to the adsorption capability of the component to be analyzed. After elution, plates were taken out of the chamber & dried.

Scanning

Plates were scanned under UV at 366nm. The data obtained from scanning were brought into integration through camag software. A chromatographic fingerprint was developed for the detection of phytoconstituents present in each sample & their respective rf values were tabulated [12].

RESULTS

Qualitative analysis

Table 1 : Organoleptic evaluation of *Vellai kungiliyam* purified by 3 different methods

Table 2: Physico-chemical evaluation of *Vellai kungiliyam* purified by 3 different methods

Table3: Solubility profile of *Vellai kungiliyam* purified by 3 different methods

Table 4: Sterility test analysis of *Vellai kungiliyam* purified by 3 different methods by pour plate method

Table 5: Phytochemical Analysis for Vellai kungiliyam purified by *3 different methods*

DISCUSSION

Vateria indica L. is an evergreen medicinal tree that grows up to 30m in height indigenous to the evergreen forests of western ghats from north Karnataka to Kerala. It is used for the treatment of respiratory disorders like chronic bronchitis, throat troubles, tubercular glands, boils, piles, diarrhoea, & rheumatism. Studies have shown that the resin of *Vateria indica* is a complex mixture of several triterpenes, hydrocarbons, ketones, alcohols, & acids along with small amounts of sesquiterpenes. On distillation, oleoresin yields essential oils (76%) with a stray balsamic odour. Dipterocarpaceous plants (*Vateria indica* L.) belong to the family Dipterocarpaceae) & are known to contain various resveratrol oligomers that exhibit a variety of biological activities such as antibacterial & antitumor effects. The organoleptic characters of *vellai kungiliyam* purified by three different methods are shown in Table no 1. All the samples were found to be solid in nature with non-free-flowing properties. Pharmaceutical powders may be classified as free-flowing or cohesive (non-free flowing). Frictional & cohesive forces (resistance to flow) are increased as the particle size is reduced.

In Physico-chemical parameters, the loss on drying test is to determine to measure the amount of water & volatile matter in a sample when the sample is dried under the specified conditions. Moisture is one of the major factors responsible for the deterioration of drugs & formulations. Thus, low moisture content could get maximum stability & better shelf life. The loss of drying at 105 ^{o}c was found to be 9.333 ± 0.210 % (sample I), 12.13±0.4453% (sample II), & 10.93±0.937% (sample III).

The Ash value is the residue remaining after incineration that determines the inorganic substances present in the sample. Similarly, it can also detect the nature of the material, whether it is adulterated or not. Hence, the determination of the ash value provides an idea for judging the identity & purity of the sample. The Ash values of *Vellai kungiliyam* were 0.3313± 0.03% (sample I), 0.5317±0.023 % (sample II), 0.64±0.039 % (sample III). Acid insoluble ash is the ash fraction that is insoluble in an acid & it is a measure of the index for siliceous impurities. The quality of the drug is better if the acid insoluble value is low. The Acid insoluble Ash values of *Vellai kungiliyam* were 0.017±0.003% (sample I), 0.03467±0.025% (sample II), 0.038±0.008% (sample III).

Extraction value determines the number of active constituents in each amount of the formulation when extracted with a solvent media such as water & alcohol. The water soluble & alcohol soluble extract values indicate the extent of polar & nonpolar compounds respectively. Usually, resins are insoluble in water but in these three samples, they show water-soluble extractive values. Both water & alcohol-soluble extractive value plays an important role in the evaluation of crude drugs. Water & alcohol-soluble extractive values of *Vellai kungiliyam* were 1.48± 0.216 %, 0.460±0.265 % (sample I), 2.373±0.308 %, 0.3272±0.188% (sample II), 3.51±0.476 %, 0.141±0.081 % (sample III) respectively. In the solubility test, all three samples were found to be soluble in ethanol. Increased ethyl alcohol extracts are suggestive of increased glycosides, flavonoids, & tannins. The ethyl alcohol extract of *Vateria indica* is found to be 1.014 % (w/w) as per previous studies . In the sterility test by pour plate method, there is no growth /colonies were observed in any of the plates inoculated with test samples I, II, & III.

In the phytochemical study of the Purified sample by Lemon juice, the bioactive compound present is alkaloids detected by Wagner's test. The purified sample by *Thriphala* decoction shows the presence of Alkaloids, Carbohydrates, Saponin, Phenols, Tannins, Flavonoids, & Diterpenes. The purified sample by the *pittaviyal* process shows the presence of Alkaloids detected by Wagner's test (Table 5). Table 7, summarizes the HPTLC analysis of *Vellai kungiliyam* purified by 3 different methods & Figure 8 shows the colour of spots visible in the TLC profiles of different samples of *vellai kungiliyam*. TLC & HPTLC are useful in the identification of individual compounds, & the clinical utility of *Vateria indica* resin & formulations based on this resin, especially in geriatrics & anti-tumor activities, can bring in newer horizons in the medicinal utility of this preparation & establish a firm phytochemical basis for its therapeutic properties. HPTLC analysis was performed & the study shed light on the active constituents present in *Vellai kungiliyam* which is depicted by the presence of 5 prominent peaks (sample I & II),7 Prominent peaks (sample

III) at 366nm & in which each peak corresponds to no of versatile components present within it. Sample I contain the Rf value of the peaks ranging from 0.02 to 0.90. Sample II contains the Rf value of the peaks ranging from 0.00 to 0.57. Sample III contains the Rf value of the peaks ranging from 0.00 to 0.83.

CONCLUSION

Vateria indica L. is purified using three different methods in this study. HPTLC fingerprinting analysis of purified sample III shows seven prominent peaks corresponding to the presence of five versatile phytocomponents present with it & it indicates that this purified sample will have higher efficacy in medicine preparations. *Vellai kungiliyam* purified by three different methods is soluble in ethanol, indicating the presence of glycosides, flavonoids, & tannins. The phytochemical screening provides additional evidence that sample II contains flavonoids, alkaloids, carbohydrates, saponins, phenols, & diterpenes. Therefore, it was concluded that samples II & III have the highest therapeutic value.

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Table 1 : Organoleptic evaluation of *Vellai kungiliyam* purified by 3 different methods

Organoleptic characters	Sample I	Sample II	Sample III
State	Solid	Solid	Solid
Nature	Slightly coarse	Fine powder	Coarse powder
Odour	Mild characteristic	Characteristic	Characteristic
Touch	Rough	Slightly coarse	Rough
Flow property	Non free flowing	Non free flowing	Non free flowing
Appearance	Pale whitish	Whitish	Pale whitish

Sample 1 – Purified *vellai kungiliyam* method I , Sample 2 - Purified *vellai kungiliyam* method II Sample 3- Purified *vellai kungiliyam* method III.

Table 2: Physico-chemical evaluation of *Vellai kungiliyam* purified by 3 different methods

S.no	Parameter	Sample I Mean (n=3) Sd	Sample II Mean (n=3) Sd	Sample III Mean (n=3) Sd
1.	Loss on drying at 105 ºc	9.333 ± 0.210	12.13±0.4453	10.93±0.937
2.	Total ash (%)	0.3313± 0.03	0.5317±0.023	0.64±0.039
3.	Acid insoluble ash (%)	0.017±0.003	0.03467±0.025	0.038±0.008
4.	Water soluble extractive (%)	1.48± 0.216	2.373±0.308	3.51±0.476
5.	Alcohol soluble extractive (%)	0.460±0.265	0.3272±0.188	0.141±0.081

Table 3: Solubility profile of *Vellai kungiliyam* purified by 3 different methods

S.no	Solvent used	Sample I	Sample II	Sample III
1.	Chloroform	Insoluble	Insoluble	Insoluble
2.	Ethanol	Soluble	Soluble	Soluble
3.	Water	Insoluble	Insoluble	Insoluble
4.	Ethyl acetate	Insoluble	Insoluble	Insoluble
5.	DMSO	Insoluble	Insoluble	Insoluble

Table 4: Sterility test analysis of *Vellai kungiliyam* purified by 3 different methods by pour plate method

Sample	Test	Result	Specification
I, II, III	Total bacterial count	Absent	Nmt 10^5cfu/g
	Total fungal count	Absent	Nmt 10^3cfu/g

Table 5: Phytochemical Analysis for Vellai kungiliyam purified by 3 different methods

S.no	Phyto chemicals	Test name	H_2O EXTRACT		
			Sample I	Sample II	Sample III
1.	Alkaloids	Mayer's test	-ve	-ve	-ve
		Wagner's test	+ve	+ve	+ve
		Dragendroff's test	-ve	-ve	-ve
2	Carbohydrates	Molisch' test	-ve	+ve	-ve
		Benedict's test	-ve	+ve(mild)	-ve
3	Saponins	Foam test	-ve	+ve	-ve
4	Phenols	Ferric chloride test	-ve	+ve	-ve
5	Tannins	Gelatin test	-ve	+ve(mild)	-ve
6	Flavonoids	Alkaline reagent test	-ve	+ve	-ve
		Lead acetate test	-ve	+ve(mild)	-ve
7	Quinones	NAOH + Extract	-ve	-ve	-ve
	Gum & Mucilage	Extract + Alcohol	-ve	-ve	-ve
8	Diterpenes	Copper acetate test	-ve	+ve(mild)	-ve

Table 6: HPTLC analysis of *Vellai kungiliyam* purified by 3 different methods

S.no	Sample 1 Max rf	Sample 2 Max rf	Sample 3 Max rf
1.	0.06	0.01	0.01
2.	0.19	0.26	0.06
3.	0.40	0.34	0.09
4.	0.68	0.42	0.23
5.	1.00	0.58	0.40
6.	-	-	0.67
7.	-	-	0.89



Fig 1: Purification method 1



Fig 2: Purification method 2



Fig 3: *Pittaviyal murai*



Fig 4: Wax-like consistency of *Vellai kungiliyam*

Purification method 3



Fig 5: sample I



Fig 6: sample II



Fig 7: sample III

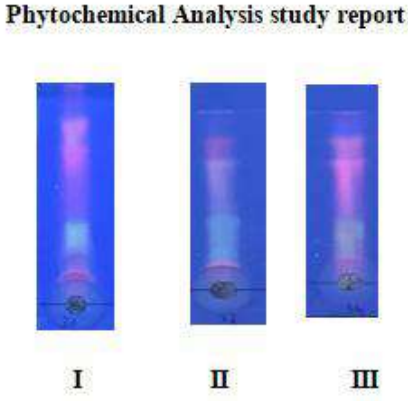
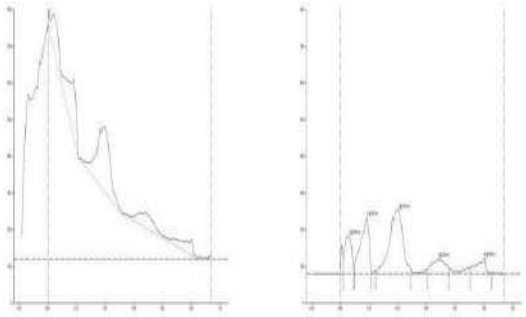
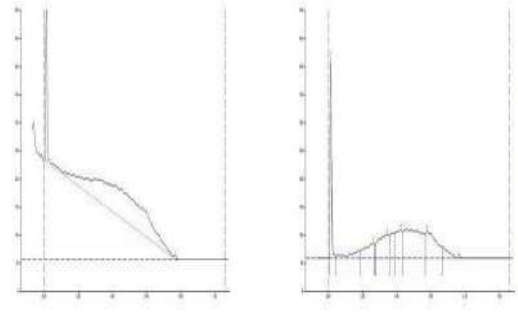


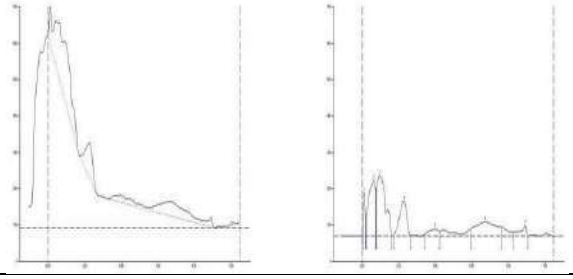
Fig 8: TLC Visualization of Sample I, Sample II, & Sample III at 366nm



Graph 1: Sample I



Graph 2: Sample II



Graph 2: Sample II

Fig 9 : High–Performance Thin-Layer Chromatography (HPTLC)

RESEARCH ARTICLE

Product Signed Domination in Corona Product of Graphs - II

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ABSTRACT

Graph theory, a branch of mathematics deals with network of vertices connected by edges. Domination in graphs is one of the important research areas in graph theory. The product signed dominating function assigns -1 or 1 to the vertices of a graph such that the product of functional values of the closed neighborhood of every vertex is one.This research paper studies the product signed dominating functions in the corona product of any simple undirected connected graph with complete graph on even number of vertices and deduce the exact values of their product signed domination number.

Keywords: Corona product of graphs, product signed dominating function, weight of a graph, minimum weight, product signed domination number.
AMS Subject Classification: 05C69.

INTRODUCTION

Domination in graphs is one of the important research areas in graph theory. It has applications in several fields. Signed domination was introduced by Dunbar and others [1-4].The concept of signed domination was studied in [5-9],[14]. The concept of product signed dominating function, PSDF [13], was introduced in [10]. In [11], PSDF for the corona product of path, cycle and star graph, with complete graph on odd number of vertices are discussed. PSDF for the corona product of complete graph and star graph is discussed in [12] and for probabilistic neural networks is discussed in [13]. Let G be any simple undirected connected graph on "a" vertices. This research paper includes the works which enumerates the values of product signed domination number of $G \circ K_b$ for different values of a and even b.Even b may or may not be divisible by 4. Hence there are two cases say $b \equiv 0(mod\ 4)$ and $b \not\equiv 0(mod\ 4)$. Hence the results are discussed in main cases relevant to b and correspondingly we consider 4 cases for a as $a < b$ (a is odd), $a \leq b$ (a is even), $a > b$ & $a = kb$ $(k > 1)$and $a > b$ & $a = kb + l$ $(k, l \geq 1)$. And finally it is proved that $\gamma^*_{sign}(G \circ K_b) \leq 4$ where G is any simple undirectedconnected graph on "a" vertices and $b \equiv 0(mod\ 2)$**.** Here $V(G) = \{v_1, v_2, \dots, v_a\}$. In $G \circ K_b$, at every vertex of G, there is a complete graph on $b+1$ vertices. Let ${K_{b+1}}^1, {K_{b+1}}^2, \dots, {K_{b+1}}^a$ be the complete graphs at $v_1, v_2, \dots, v_a$ respectively. For $i = 1$ to a, let $V(G \circ K_b) = \{v_i, v_{ij} | 1 \leq i \leq a, 1 \leq j \leq b\}$ and $E(G \circ K_b) = E(G) \cup \{v_i v_{ij} | 1 \leq i \leq a, 1 \leq j \leq b\} \cup \{v_{ij} v_{ik} | j \neq k,\ 1 \leq j, k \leq b,\ 1 \leq i \leq a\}$

PRELIMINARIES

Definition 2.1

Let $G = (V, E)$ be simple undirected connected graph. A function $f: V \to \{-1,1\}$ is a product signed dominating function[10], **PSDF** [13] if each vertex v in V satisfies the condition $f[v] = \prod_{u \in N[v]} f(u) = 1$ where $N[v]$ denotes the closed neighborhood of v. The weight of a graph G with respect to the function f is denoted by $w_f(G)$ [13],and defined as $w_f(G) = \sum_{v \in V} f(v)$. The product signed domination number of a graph G is the minimum positive weight of a PSDF and is denoted as$\gamma^*_{sign}(G)$.

Definition 2.2

The graph $G \circ H$ that results from taking one copy of G and $|V(G)|$ copies of H and connecting the ith vertex of G to every vertex in the ith copy of H is called the corona product of two graphs G and H.

Theorem 2.3

$For\ b \leq 4,\ \gamma^*_{sign}(K_b) = b$, the total number of vertices.

$$For\ b > 4,\ \gamma^*_{sign}(K_b) = \begin{cases} 1\ if\ b\ is\ odd\ and\ \dfrac{b-1}{2}\ is\ even \\ 2\ if\ b\ is\ even\ and\ \dfrac{b}{2}\ is\ odd \\ 3\ if\ b\ and\ \dfrac{b-1}{2}\ are\ odd \\ 4\ if\ b\ and\ \dfrac{b}{2}\ are\ even \end{cases}$$

MAIN RESULTS

Observation 3.1

(i) Let $f: V(G \circ K_b) \to \{-1,1\}$. At each v_i, $1 \leq i \leq a$, assigning-1 to zero or even number of vertices of ${K_{b+1}}^i$ with $f(v_i) = 1, 1 \leq i \leq a$ leads to a PSDF.

(ii) Since $b+1$ is odd, atleast one vertex in every ${K_{b+1}}^i$ where $1 \leq i \leq a$ should be assigned 1 in any PSDF.

Theorem 3.2

Let b be an even positive integer such that $b \equiv 0(mod\ 4)$ and $a < b$ be an odd integer. Then, $\gamma^*_{sign}(G \circ K_b) = \begin{cases} 3\ if\ b-(a+1) \equiv 0(mod\ 4) \\ 1\ otherwise \end{cases}$

Proof

Case 1: $b-(a+1) \equiv 0(mod\ 4)$

If $a = 1$, then $b-(a+1) = b-2 \not\equiv 0(mod\ 4)$ since $b \equiv 0(mod\ 4)$. Hence $a > 1$.

Define $f: V(G \circ K_b) \to \{-1,1\}$ by

$$f(v_i) = 1\ \forall\ i, 1 \le i \le a \text{ and } f(v_{ij}) = \begin{cases} -1\ if\ \begin{matrix} 1 \le i \le a-1,\ 1 \le j \le \frac{b}{2} \\ or \\ i=a,\ 1 \le j \le \frac{b+a-3}{2} \end{matrix} \\ 1\ otherwise \end{cases}$$

$b \equiv 0(mod\ 4)$ and $b-(a+1) \equiv 0(mod\ 4)$ implies $\frac{b+a-3}{2}$ is even.

Here $f[v] = 1\ \forall\ v \in V(G \circ K_b)$

Correspondingly, $w_f(G \circ K_b) = \sum_{v \in V(G \circ K_b)} f(v)$

$= 3$

Further f is defined such that in $a-1$ copies of ${K_{b+1}}^i$'s, $\sum_{j=1}^{b} f(v_{ij})$ vanishes for each i. Also $f(v_i) = 1\ \forall\ i, 1 \le i \le a$. In the remaining a^{th} copy of ${K_{b+1}}^i$, v_{aj}'s, $1 \le j \le b$ are assigned -1 and 1 in such a way to get minimum positive weight.

Case 2: $b-(a+1) \not\equiv 0(mod\ 4)$

When $a = 1$, $G \circ K_b \cong K_{b+1}$. Here $b+1$ is odd and $b \equiv 0(mod\ 4)$ implies $\frac{b}{2}$ is even. Then by **[2.3]**, $\gamma^*_{sign}(G \circ K_b) = 1$.

Let $a > 1$.

Define $f: V(G \circ K_b) \to \{-1,1\}$ by

$$f(v_i) = 1\ \forall\ i, 1 \le i \le a \text{ and } f(v_{ij}) = \begin{cases} -1\ if\ \begin{matrix} 1 \le i \le a-1,\ 1 \le j \le \frac{b}{2} \\ or \\ i=a,\ 1 \le j \le \frac{b+a-1}{2} \end{matrix} \\ 1\ otherwise \end{cases}$$

$b \equiv 0(mod\ 4), a+1 \equiv 0(mod\ 2)$ and $b-(a+1) \not\equiv 0(mod\ 4)$ implies $a+1 \equiv 2(mod\ 4)$ and $\frac{b+a-1}{2}$ is even.

Here $f[v] = 1\ \forall\ v \in V(G \circ K_b)$

Correspondingly, $w_f(G \circ K_b) = \sum_{v \in V(G \circ K_b)} f(v) = 1$

Obviously, $w_f(G \circ K_b) = 1$ is minimum.

Hence the theorem.

Theorem 3.3

Let b be a positive integer such that $b \equiv 0(mod\ 4)$ and $a \le b$ be an even integer. Then, $\gamma^*_{sign}(G \circ K_b) = \begin{cases} 4\ if\ b-a \equiv 0(mod\ 4) \\ 2\ otherwise \end{cases}$

Proof

Case 1: $a = b$

Then $b-a \equiv 0(mod\ 4)$

Define $f: V(G \circ K_b) \to \{-1,1\}$ by

$$f(v_i) = 1\ \forall\ i, 1 \le i \le a \text{ and } f(v_{ij}) = \begin{cases} -1\ if\ \begin{matrix} 1 \le i \le a-1,\ 1 \le j \le \frac{b}{2} \\ or \\ i=a,\ 1 \le j \le b-2 \end{matrix} \\ 1\ otherwise \end{cases} \quad \text{--- (A)}$$

Here $f[v] = 1\ \forall\ v \in V(G \circ K_b)$

Correspondingly, $w_f(G \circ K_b) = \sum_{v \in V(G \circ K_b)} f(v) = 4$

Here f is defined such that in $a-1$ copies of ${K_{b+1}}^{i}, \sum_{j=1}^{b} f(v_{ij})$ vanishes for each i. Also$f(v_i) = 1 \forall\, i, 1 \le i \le a$, $\sum_{i=1}^{a} f(v_i) = a$. And since $a = b$, if v_{aj}'s where $1 \le j \le b$ are assigned -1, then, it is also a PSDF but the weight would be zero. So in order to get positive weight, f is defined as in (A). Therefore, $w_f(G \circ K_b) = 4$ is minimum.

Case 2: $a < b$

Subcase 2a: $b - a \equiv 0 (mod\ 4)$

Define $f: V(G \circ K_b) \to \{-1,1\}$ by

$$f(v_i) = 1 \forall\, i, 1 \le i \le a \text{ and } f(v_{ij}) = \begin{cases} -1\ if & \begin{matrix} 1 \le i \le a-1,\ 1 \le j \le \frac{b}{2} \\ or \\ i=a,\ \frac{b-a+4}{2}+1 \le j \le b \end{matrix} \\ 1\ otherwise \end{cases} \quad \text{--- (B)}$$

$b \equiv 0(mod\ 4), a \equiv 0(mod\ 2)$ and $b - a \equiv 0(mod\ 4)$ implies $\frac{b+a-4}{2}$ is even.

Here $f[v] = 1 \forall\, v \in V(G \circ K_b)$

Correspondingly, $w_f(G \circ K_b) = \sum_{v \in V(G \circ K_b)} f(v) = 4$

Subcase 2b: $b - a \not\equiv 0 (mod\ 4)$

Define $f: V(G \circ K_b) \to \{-1,1\}$ by

$$f(v_i) = 1 \forall\, i, 1 \le i \le a \text{ and } f(v_{ij}) = \begin{cases} -1\ if & \begin{matrix} 1 \le i \le a-1,\ 1 \le j \le \frac{b}{2} \\ or \\ i=a,\ \frac{b-a+2}{2}+1 \le j \le b \end{matrix} \quad zz \\ 1\ otherwise \end{cases} \quad \text{---(C)}$$

$b \equiv 0(mod\ 4), a \equiv 0(mod\ 2)$and $b - a \not\equiv 0(mod\ 4)$implies $\frac{b+a-2}{2}$ is even.

Here $f[v] = 1 \forall\, v \in V(G \circ K_b)$

Correspondingly, $w_f(G \circ K_b) = \sum_{v \in V(G \circ K_b)} f(v) = 2$

In both the subcases 2a and 2b,f is defined such that in $a-1$ copies of ${K_{b+1}}^{i}$'s, $\sum_{j=1}^{b} f(v_{ij})$ vanishes for each i. Also $f(v_i) = 1 \forall\, i, 1 \le i \le a$. In the remaining a^{th} copy of ${K_{b+1}}^{i}$, v_{aj}'s, $1 \le j \le b$ are assigned -1 and 1 depending on the value of $\frac{b-a}{2}$ in order to get minimum positive weight.

Hence the theorem.

The following theorems discuss the cases when a $>$ b and b $\equiv 0 (mod\ 4)$.

Theorem 3.4

Let b be a positive integer such that $b \equiv 0(mod\ 4)$. Let $a > b$ be given by $a = kb$ where $k > 1$. Then, $\gamma^{*}_{sign}(G \circ K_b) = 4$.

Proof

Define $f: V(G \circ K_b) \to \{-1,1\}$ by

$$f(v_i) = 1 \forall\, i, 1 \le i \le a \text{ and } f(v_{ij}) = \begin{cases} -1\ if & \begin{matrix} 1 \le i \le k,\ 1 \le j \le b \\ or \\ k+1 \le i \le a-1,\ 1 \le j \le \frac{b}{2} \\ or \\ i=a,\ 1 \le j \le \frac{b-4}{2} \end{matrix} \\ 1\ otherwise \end{cases}$$

$b \equiv 0(mod\ 4)$ implies $\frac{b}{2}$ is even and $\frac{b-4}{2}$ is even and $f[v] = 1 \forall\, v \in V(G \circ K_b)$

Correspondingly, $w_f(G \circ K_b) = \sum_{v \in V(G \circ K_b)} f(v) = 4$

Here f is defined such that for k copies of ${K_{b+1}}^{i}$'s, $f(v_{ij}) = -1$ where $1 \le j \le b$ so that $(k)(b)(-1)$ vanishes with functional values of $(k)(b)$ vertices of v_i's and in another $a-k-1$ copies of ${K_{b+1}}^{i}$'s, the vertices v_{ij}'s, where $1 \le j \le b$, are assigned functional values such that its sum vanishes. And in the remaining one copy of ${K_{b+1}}^{i}$, v_{ij}'s, where $1 \le j \le b$, are assigned functional values which sums to 4 which is minimum.

Hence the theorem.

Theorem 3.5

Let b be a positive integer such that $b \equiv 0(mod\ 4)$ and $a = kb + l$ where k and l are positive integers such that $k, l \geq 1$. Then, $\gamma^*_{sign}(G \circ K_b) = \begin{cases} 4\ if\ l \equiv 0(mod\ 4) \\ 1\ if\ l \equiv 1(mod\ 4) \\ 2\ if\ l \equiv 2(mod\ 4) \\ 3\ if\ l \equiv 3(mod\ 4) \end{cases}$

Proof

Here f is to be defined such that for k copies of ${K_{b+1}}^{i}$'s, $f(v_{ij}) = -1$ where $1 \leq j \leq b$ so that $(k)(b)(-1)$ vanishes with functional values of $(k)(b)$ vertices of v_i's and in another $a - k - 1$ copies of ${K_{b+1}}^{i}$'s, the vertices v_{ij}'s, where $1 \leq j \leq b$, are assigned functional values such that its sum vanishes. And in the remaining one copy of ${K_{b+1}}^{i}$, functional values are to be assigned depending on the values of l.

Hence the weight would be $w_f(G \circ K_b) = \sum_{v \in V(G \circ K_b)} f(v)$

$$= \sum_{i=1}^{a} f(v_i) + \sum_{i=1}^{a}\sum_{j=1}^{b} f(v_{ij})$$

$$= a + \sum_{i=1}^{k}\sum_{j=1}^{b} f(v_{ij}) + \sum_{i=k+1}^{a-1}\sum_{j=1}^{\frac{b}{2}} f(v_{ij}) + \sum_{i=k+1}^{a-1}\sum_{j=\frac{b}{2}+1}^{b} f(v_{ij}) + \sum_{j=1}^{b} f(v_{aj})$$

$$= a + [(kb)(-1)] + \left[(a-1-k)\left(\frac{b}{2}\right)(-1)\right] + \left[(a-1-k)\left(\frac{b}{2}\right)(1)\right] + \sum_{j=1}^{b} f(v_{aj})$$

$$= a - kb + \sum_{j=1}^{b} f(v_{aj})$$

$= l + \sum_{j=1}^{b} f(v_{aj})$ since $a = kb + l$

$w_f(G \circ K_b) = l + x$ where $x = \sum_{j=1}^{b} f(v_{aj})$ --- (D)

The value of x depends on the value of l.

Case 1: $l \equiv 0(mod\ 4)$

Define $f: V(G \circ K_b) \to \{-1,1\}$ by

$$f(v_i) = 1\ \forall\ i, 1 \leq i \leq a \text{ and } f(v_{ij}) = \begin{cases} -1\ if\ \begin{matrix} 1 \leq i \leq k,\ 1 \leq j \leq b \\ or \\ k+1 \leq i \leq a-1,\ 1 \leq j \leq \frac{b}{2} \\ or \\ i = a,\ 1 \leq j \leq \frac{b+l-4}{2} \end{matrix} \\ 1\ otherwise \end{cases}$$ --- (E)

$b \equiv 0(mod\ 4)$ and $l \equiv 0(mod\ 4)$ implies $\frac{b}{2}$ and $\frac{b+l-4}{2}$ are even.

Also $f[v] = 1\ \forall\ v \in V(G \circ K_b)$

$w_f(G \circ K_b) = l + x$ where $x = \sum_{j=1}^{b} f(v_{aj})$ (by (D))

$= l + \sum_{j=1}^{\frac{b+l-4}{2}} f(v_{aj}) + \sum_{j=\frac{b+l-4}{2}+1}^{b} f(v_{aj})$ (by (E))

$$= l + \left(\frac{b+l-4}{2}\right)(-1) + \left(\frac{b-l+4}{2}\right)(1)$$

$$= 4$$

Since f in (E) is defined to satisfy (D), the obtained weight is minimum.

Case 2: $l \equiv 1(mod\ 4)$

Define $f: V(G \circ K_b) \to \{-1,1\}$ by

$$f(v_i) = 1\ \forall\ i, 1 \leq i \leq a \text{ and } f(v_{ij}) = \begin{cases} -1\ if\ \begin{matrix} 1 \leq i \leq k,\ 1 \leq j \leq b \\ or \\ k+1 \leq i \leq a-1,\ 1 \leq j \leq \frac{b}{2} \\ or \\ i = a,\ 1 \leq j \leq \frac{b+l-1}{2} \end{matrix} \\ 1\ otherwise \end{cases}$$ --- (F)

$b \equiv 0(mod\ 4)$ and $l-1 \equiv 0(mod\ 4)$ implies $\frac{b}{2}$ and $\frac{b+l-1}{2}$ are even.
Also $f[v] = 1\ \forall\ v \in\ V(G \circ K_b)$
$w_f(G \circ K_b) = l + x$ where $x = \sum_{j=1}^{b} f(v_{aj})$ (by (D))
$= l + \sum_{j=1}^{\frac{b+l-1}{2}} f(v_{aj}) + \sum_{j=\frac{b+l-1}{2}+1}^{b} f(v_{aj})$ (by (F))
$= l + \left(\frac{b+l-1}{2}\right)(-1) + \left(\frac{b-l+1}{2}\right)(1) = 1$
Clearly, the weight is minimum.

Case 3: $l \equiv 2(mod\ 4)$
Define $f: V(G \circ K_b) \to \{-1,1\}$ by

$$f(v_i) = 1\ \forall\ i, 1 \le i \le a \text{ and } f(v_{ij}) = \begin{cases} -1\ if\ \begin{matrix} 1 \le i \le k,\ 1 \le j \le b \\ or \\ k+1 \le i \le a-1,\ 1 \le j \le \frac{b}{2} \\ or \\ i=a,\ 1 \le j \le \frac{b+l-2}{2} \end{matrix} \\ 1\ otherwise \end{cases} \quad \text{--- (G)}$$

$b \equiv 0(mod\ 4)$ and $l-2 \equiv 0(mod\ 4)$ implies $\frac{b}{2}$ and $\frac{b+l-2}{2}$ are even.
Also $f[v] = 1\ \forall\ v \in\ V(G \circ K_b)$
$w_f(G \circ K_b) = l + x$ where $x = \sum_{j=1}^{b} f(v_{aj})$ (by (D))
$= l + \sum_{j=1}^{\frac{b+l-2}{2}} f(v_{aj}) + \sum_{j=\frac{b+l-2}{2}+1}^{b} f(v_{aj})$ (by (G))
$= l + \left(\frac{b+l-2}{2}\right)(-1) + \left(\frac{b-l+2}{2}\right)(1) = 2$
Since f in (G) is defined to satisfy (D), the obtained weight is minimum.

Case 4: $l \equiv 3(mod\ 4)$
Define $f: V(G \circ K_b) \to \{-1,1\}$ by

$$f(v_i) = 1\ \forall\ i, 1 \le i \le a \text{ and } f(v_{ij}) = \begin{cases} -1\ if\ \begin{matrix} 1 \le i \le k,\ 1 \le j \le b \\ or \\ k+1 \le i \le a-1,\ 1 \le j \le \frac{b}{2} \\ or \\ i=a,\ 1 \le j \le \frac{b+l-3}{2} \end{matrix} \\ 1\ otherwise \end{cases} \quad \text{--- (H)}$$

$b \equiv 0(mod\ 4)$ and $l-3 \equiv 0(mod\ 4)$ implies $\frac{b}{2}$ and $\frac{b+l-3}{2}$ are even.
Also $f[v] = 1\ \forall\ v \in\ V(G \circ K_b)$
$w_f(G \circ K_b) = l + x$ where $x = \sum_{j=1}^{b} f(v_{aj})$ (by (D))
$= l + \sum_{j=1}^{\frac{b+l-3}{2}} f(v_{aj}) + \sum_{j=\frac{b+l-3}{2}+1}^{b} f(v_{aj})$ (by (H))
$= l + \left(\frac{b+l-3}{2}\right)(-1) + \left(\frac{b-l+3}{2}\right)(1) = 3$
Since f in (H) is defined to satisfy (D), the obtained weight is minimum.
Hence the theorem.

Remark 3.6:
In theorem 3.5, the values of k and l may or may not be equal.

The following theorems discuss the cases when $\mathbf{b \not\equiv 0(mod\ 4)}$ is an even positive integer.
Theorem 3.7:
Let b be an even positive integer such that $b \not\equiv 0(mod\ 4)$ and $a < b$ be an odd integer. Then, $\gamma^*_{sign}(G \circ K_b) = \begin{cases} 3\ if\ b-(a+1) \equiv 0(mod\ 4) \\ 1\ otherwise \end{cases}$

Proof:

Here $b \not\equiv 0(mod\ 4)$ is an even integer implies $b \equiv 2(mod\ 4)$.

Let $f: V(G \circ K_b) \to \{-1,1\}$. f is to be defined such that f values of v_{ij}'s, where $1 \le j \le b$ at each i in $\frac{a-1}{2}$ copies of ${K_{b+1}}^{i}$'s vanishes with f values of v_{ij}'s, where $1 \le j \le b$ in another set of $\frac{a-1}{2}$ copies of ${K_{b+1}}^{i}$'s. in the remaining one copy, functional values are assigned depending on the value of $\frac{b-(a+1)}{2}$ --- (I)

Case 1: $b-(a+1) \equiv 0(mod\ 4)$

Subcase 1a: $a = 1$

When $a = 1$, $G \circ K_b \cong K_{b+1}$. Here $b+1$ is odd. $b \not\equiv 0(mod\ 4)$ is an even integer implies $\frac{b}{2}$ is odd. Then by 2.3, $\gamma^*_{sign}(G \circ Kb=3.$

Subcase 1b: $a > 1$

Define

$$f(v_i) = 1\ \forall\ i, 1 \le i \le a \text{ and } f(v_{ij}) = \begin{cases} -1\ if & 1 \le i \le \frac{a-1}{2},\ 1 \le j \le b \\ & or \\ & i=a,\ 1 \le j \le \frac{b+a-3}{2} \\ 1\ otherwise \end{cases}$$

$b \equiv 2(mod\ 4)$,$a \equiv 1(mod\ 2)$ and $b-(a+1) \equiv 0(mod\ 4)$ implies $\frac{b+a-3}{2}$ is even.

Also $f[v] = 1\ \forall\ v \in\ V(G \circ K_b)$

Correspondingly, $w_f(G \circ K_b) = \sum_{v \in V(G \circ K_b)} f(v) = 3$

Since f is defined in such a way to satisfy (I), the obtained weight is minimum.

Case 2: $b-(a+1) \not\equiv 0(mod\ 4)$

If $a = 1$, then $b-(a+1) = b-2\ \equiv 0(mod\ 4)$ since $b \not\equiv 0(mod\ 4)$ is an even integer. Hence $a > 1$.

Define

$$f(v_i) = 1\ \forall\ i, 1 \le i \le a \text{ and } f(v_{ij}) = \begin{cases} -1\ if & 1 \le i \le \frac{a-1}{2},\ 1 \le j \le b \\ & or \\ & i=a,\ 1 \le j \le \frac{b+a-1}{2} \\ 1\ otherwise \end{cases}$$

$b \equiv 2(mod\ 4)$, $a \equiv 1(mod\ 2)$ and $b-(a+1) \not\equiv 0(mod\ 4)$ implies $a+1 \equiv 0(mod\ 4)$ and $\frac{b+a-1}{2}$ is even.

f is defined to satisfy (I) and here $f[v] = 1\ \forall\ v \in\ V(G \circ K_b)$

Correspondingly, $w_f(G \circ K_b) = \sum_{v \in V(G \circ K_b)} f(v) = 1$

Clearly, the weight is minimum.

Remark 3.8:

From 3.2 and 3.7, if $b \equiv 0(mod\ 2)$ and $a < b$ is an odd integer, then $\gamma^*_{sign}(G \circ K_b) = \begin{cases} 3\ if\ b-(a+1) \equiv 0(mod\ 4) \\ 1\ otherwise \end{cases}$

Theorem 3.9:

Let b be an even positive integer such that $b \not\equiv 0(mod\ 4)$ and $a \le b$ be even. Then, $\gamma^*_{sign}(G \circ K_b) = \begin{cases} 2\ if\ b-a \equiv 0(mod\ 4) \\ 4\ otherwise \end{cases}$

Proof:

Here $b \not\equiv 0(mod\ 4)$ is an even integer implies $b \equiv 2(mod\ 4)$.

Case 1: $a = b$

Then $b-a \equiv 0(mod\ 4)$

Define $f: V(G \circ K_b) \to \{-1,1\}$ by

$f(v_i) = 1\ \forall\ i, 1 \le i \le a$ and $f(v_{ij}) = \begin{cases} -1\ if & \frac{a-2}{2}+1 \le i \le a-1,\ 1 \le j \le b \\ & or \\ & i=a,\ 1 \le j \le \frac{b-2}{2} \\ 1\ otherwise & \end{cases}$

Here$b \equiv 2(mod\ 4)$ implies $\frac{b-2}{2}$ is even. Also$f[v] = 1\ \forall\ v \in\ V(G \circ K_b)$

Correspondingly, $w_f(G \circ K_b) = \sum_{v \in V(G \circ K_b)} f(v) = 2$

Here f is defined such that f values of v_{ij}'s, where $1 \le j \le b$ at each i in one set of $\frac{a-2}{2}$ copies of ${K_{b+1}}^{i}$'s vanishes with f values of v_{ij}'s, where $1 \le j \le b$ in another set of $\frac{a-2}{2}$ copies of ${K_{b+1}}^{i}$'s and f values at each v_i, where $1 \le i \le a$ vanishes with f values at another one copy of ${K_{b+1}}^{i}$ in which v_{ij}'s are assigned -1. For the remaining one copy of ${K_{b+1}}^{i}$, functional values are assigned in order to get minimum weight that is positive. Hence, the weight obtained here is minimum.

Case 2: $a < b$

Subcase 2a: $b - a \equiv 0 (mod\ 4)$

Define $f: V(G \circ K_b) \to \{-1,1\}$ by

$f(v_i) = 1\ \forall\ i, 1 \le i \le a$ and $f(v_{ij}) = \begin{cases} -1\ if & 1 \le i \le \frac{a-2}{2},\ 1 \le j \le b \\ & or \\ & i=a-1,\ 1 \le j \le \frac{b-2}{2} \\ & or \\ & i=a,\ 1 \le j \le \frac{b+a}{2} \\ 1\ otherwise & \end{cases}$

$b \equiv 2(mod\ 4)$, $a \equiv 0(mod\ 2)$and $b - a \equiv 0(mod\ 4)$ implies $a \equiv 2(mod\ 4)$ and $\frac{b+a}{2}$ is even.

Also$f[v] = 1\ \forall\ v \in\ V(G \circ K_b)$

Correspondingly, $w_f(G \circ K_b) = \sum_{v \in V(G \circ K_b)} f(v) = 2$

Here f is defined such that f values of v_{ij}'s, where $1 \le j \le b$ at each i in one set of $\frac{a-2}{2}$ copies of ${K_{b+1}}^{i}$'s vanishes with f values of v_{ij}'s, where $1 \le j \le b$ in another set of $\frac{a-2}{2}$ copies of ${K_{b+1}}^{i}$'s and f values at each v_i, where $1 \le i \le a$ vanishes with f values of v_{aj}'s, $1 \le j \le a < b$ and the remaining v_{aj}'s are assigned 1 and -1 equal number of times so that it sums to zero. In the remaining one copy of ${K_{b+1}}^{i}$, v_{ij}'s are assigned functional values which adds 2 to the weight. Hence, the weight obtained here is minimum.

Subcase 2b: $b - a \not\equiv 0 (mod\ 4)$

Define $f: V(G \circ K_b) \to \{-1,1\}$ by

$f(v_i) = 1\ \forall\ i, 1 \le i \le a$ and $f(v_{ij}) = \begin{cases} -1\ if & 1 \le i \le \frac{a-2}{2},\ 1 \le j \le b \\ & or \\ & i=a-1,\ 1 \le j \le \frac{b-2}{2} \\ & or \\ & i=a,\ 1 \le j \le \frac{b+a-2}{2} \\ 1\ otherwise & \end{cases}$

$b \equiv 2(mod\ 4), a \equiv 0(mod\ 2)$ and $b - a \not\equiv 0(mod\ 4)$ implies $a \equiv 0(mod\ 4)$ and $\frac{b-2}{2}$ and $\frac{b+a-2}{2}$ are even.

Also$f[v] = 1\ \forall\ v \in\ V(G \circ K_b)$

Correspondingly, $w_f(G \circ K_b) = \sum_{v \in V(G \circ K_b)} f(v) = 4$

Here f is defined such that f values of v_{ij}'s, where $1 \le j \le b$ at each i in one set of $\frac{a-2}{2}$ copies of ${K_{b+1}}^{i}$'s vanishes with f values of v_{ij}'s, where $1 \le j \le b$ in another set of $\frac{a-2}{2}$ copies of ${K_{b+1}}^{i}$'s and f values at each v_i, where $1 \le i \le a$ vanishes with f values of v_{aj}'s, $1 \le j \le a < b$ and the remaining v_{aj}'s are assigned functional values so that it sums to 2. In the remaining one copy of ${K_{b+1}}^{i}$, v_{ij}'s are assigned functional values which adds 2 to the weight. Hence, the weight obtained here is minimum.

Theorem 3.10

Let b be an even positive integer such that $b \not\equiv 0(mod\ 4)$. Let $a = kb$ where $k > 1$ be any positive integer. Then, $\gamma^*_{sign}(G \circ K_b) = \begin{cases} 4\ if\ a - k \equiv 0(mod\ 2) \\ 2\ otherwise \end{cases}$

Proof

b which is an even positive integer such that $b \not\equiv 0(mod\ 4)$ implies $b \equiv 2(mod\ 4)$.

Since $a = kb$, f is to be defined such that f values of v_{ij}'s, where $1 \le j \le b$ at k copies of ${K_{b+1}}^{i}$'s vanishes with f values of v_i's where $1 \le i \le kb = a$. In the remaining $a - k$ copies of ${K_{b+1}}^{i}$'s, functional values for v_{ij}'s, where $1 \le j \le b$ are to be defined depending on the value of $a - k$. --- (J)

Case 1: $a - k \equiv 0(mod\ 2)$

Define $f: V(G \circ K_b) \to \{-1,1\}$ by

$$f(v_i) = 1\ \forall\ i, 1 \le i \le a \text{ and } f(v_{ij}) = \begin{cases} -1\ if & 1 \le i \le \frac{a+k-2}{2},\ 1 \le j \le b \\ & or \\ & a-1 \le i \le a,\ 1 \le j \le \frac{b-2}{2} \\ 1\ otherwise & \end{cases} \quad \text{--- (K)}$$

$b \equiv 2(mod\ 4)$ implies $\frac{b-2}{2}$ is even and $f[v] = 1\ \forall\ v \in V(G \circ K_b)$

$$w_f(G \circ K_b) = \sum_{v \in V(G \circ K_b)} f(v) = 4$$

Since (K) is defined to satisfy (J), the obtained weight is minimum.

Case 2: $a - k \not\equiv 0(mod\ 2)$

Define $f: V(G \circ K_b) \to \{-1,1\}$ by

$$f(v_i) = 1\ \forall\ i, 1 \le i \le a \text{ and } f(v_{ij}) = \begin{cases} -1\ if & 1 \le i \le \frac{a+k-1}{2},\ 1 \le j \le b \\ & or \\ & i = a,\ 1 \le j \le \frac{b-2}{2} \\ 1\ otherwise & \end{cases} \quad \text{--- (L)}$$

$b \equiv 2(mod\ 4)$ implies $\frac{b-2}{2}$ is even and $f[v] = 1\ \forall\ v \in V(G \circ K_b)$

$$w_f(G \circ K_b) = \sum_{v \in V(G \circ K_b)} f(v) = 2$$

Since (L) is defined to satisfy (J), the obtained weight is minimum.

Hence the theorem.

Theorem 3.11

Let b be an even positive integer such that $b \not\equiv 0(mod\ 4)$. Let $a = kb + l$ where $k \ge 1,\ l \ge 1$ be any integers. Let m_1 denote $\gamma^*_{sign}(G \circ K_b)$ when $a - k \not\equiv 0(mod\ 2)$ and m_2 denote $\gamma^*_{sign}(G \circ K_b)$ when $a - k \equiv 0(mod\ 2)$ Then,

$$m_1 = \begin{cases} m_{11} = 2\ if\ l \equiv 0(mod\ 4) \\ m_{12} = 3\ if\ l \equiv 1(mod\ 4) \\ m_{13} = 4\ if\ l \equiv 2(mod\ 4) \\ m_{14} = 1\ if\ l \equiv 3(mod\ 4) \end{cases} \text{ and } m_2 = \begin{cases} m_{11} + 2\ if\ l \equiv 0(mod\ 4) \\ m_{12} - 2\ if\ l \equiv 1(mod\ 4) \\ m_{13} - 2\ if\ l \equiv 2(mod\ 4) \\ m_{14} + 2\ if\ l \equiv 3(mod\ 4) \end{cases}$$

Proof

b which is an even positive integer such that $b \not\equiv 0(mod\ 4)$ implies $b \equiv 2(mod\ 4)$.

Case 1: $a - k \not\equiv 0(mod\ 2)$

f is to be defined such that f values of v_{ij}'s, where $1 \le j \le b$ in one set of $\frac{a-k-1}{2}$ copies of ${K_{b+1}}^{i}$'s vanishes with f values of v_{ij}'s, where $1 \le j \le b$ in another set of $\frac{a-k-1}{2}$ copies of ${K_{b+1}}^{i}$'s. And in another k copies of ${K_{b+1}}^{i}$'s,v_{ij}'s, where $1 \le j \le b$ are assigned -1 so that it vanishes with f values of v_i's where $1 \le i \le kb$. In the remaining one copy, v_{ij}'s, where $1 \le j \le b$ are assigned functional values depending on the value of l.

Correspondingly, the weight would be $w_f(G \circ K_b) = \sum_{v \in V(G \circ K_b)} f(v)$

$$= \sum_{i=1}^{a} f(v_i) + \sum_{i=1}^{a} \sum_{j=1}^{b} f(v_{ij})$$

$= a + \sum_{i=1}^{\frac{a-k-1}{2}} \sum_{j=1}^{b} f(v_{ij}) + \sum_{i=\frac{a-k-1}{2}+1}^{a-1} \sum_{j=1}^{b} f(v_{ij}) + \sum_{j=1}^{b} f(v_{aj})$

$= a + \left[\left(\frac{a-k-1}{2}\right)(b)(1)\right] + \left[\left(\frac{a+k-1}{2}\right)(b)(-1)\right] + \sum_{j=1}^{b} f(v_{aj})$

$= a - kb + \sum_{j=1}^{b} f(v_{aj})$

$= l + \sum_{j=1}^{b} f(v_{aj})$ since $a = kb + l$

$w_f(G \circ K_b) = l + x$ where $x = \sum_{j=1}^{b} f(v_{aj})$ --- (M)

Subcase 1a: $l \equiv 0(mod\ 4)$

Define $f: V(G \circ K_b) \to \{-1,1\}$ by

$$f(v_i) = 1\ \forall\ i, 1 \le i \le a \text{ and } f(v_{ij}) = \begin{cases} -1\ if & \frac{a-k-1}{2}+1 \le i \le a-1,\ 1 \le j \le b \\ & or \\ & i=a,\ 1 \le j \le \frac{b+l-2}{2} \\ 1\ otherwise & \end{cases} \quad \text{--- (N)}$$

$b \equiv 2(mod\ 4), l-2 \equiv 2(mod\ 4)$ implies $\frac{b+l-2}{2}$ is even and $f[v] = 1\ \forall\ v \in V(G \circ K_b)$

$w_f(G \circ K_b) = l + x$ (by (M))

$= l + \sum_{j=1}^{\frac{b+l-2}{2}} f(v_{aj}) + \sum_{j=\frac{b+l-2}{2}+1}^{b} f(v_{aj})$ (by (N))

$= l + \left[\left(\frac{b+l-2}{2}\right)(-1)\right] + \left[\left(\frac{b-l+2}{2}\right)(1)\right] = 2 = m_{11}$

Since (N) is defined to satisfy (M), the obtained weight is minimum.

Subcase 1b: $l \equiv 1(mod\ 4)$

Define $f: V(G \circ K_b) \to \{-1,1\}$ by

$$f(v_i) = 1\ \forall\ i, 1 \le i \le a \text{ and } f(v_{ij}) = \begin{cases} -1\ if & \frac{a-k-1}{2}+1 \le i \le a-1,\ 1 \le j \le b \\ & or \\ & i=a,\ 1 \le j \le \frac{b+l-3}{2} \\ 1\ otherwise & \end{cases} \quad \text{--- (O)}$$

$b \equiv 2(mod\ 4), l \equiv 1(mod\ 4)$ implies $\frac{b+l-3}{2}$ is even and $f[v] = 1\ \forall\ v \in V(G \circ K_b)$

$w_f(G \circ K_b) = l + x$ (by (M))

$= l + \sum_{j=1}^{\frac{b+l-3}{2}} f(v_{aj}) + \sum_{j=\frac{b+l-3}{2}+1}^{b} f(v_{aj})$ (by (O))

$= l + \left[\left(\frac{b+l-3}{2}\right)(-1)\right] + \left[\left(\frac{b-l+3}{2}\right)(1)\right] = 3 = m_{12}$

Since (O) is defined to satisfy (M), the obtained weight is minimum.

Subcase 1c: $l \equiv 2(mod\ 4)$

Define $f: V(G \circ K_b) \to \{-1,1\}$ by

$$f(v_i) = 1\ \forall\ i, 1 \le i \le a \text{ and } f(v_{ij}) = \begin{cases} -1\ if & \frac{a-k-1}{2}+1 \le i \le a-1,\ 1 \le j \le b \\ & or \\ & i=a,\ 1 \le j \le \frac{b+l-4}{2} \\ 1\ otherwise & \end{cases} \quad \text{--- (P)}$$

$b \equiv 2(mod\ 4), l \equiv 2(mod\ 4)$ implies $\frac{b+l-4}{2}$ is even and $f[v] = 1\ \forall\ v \in V(G \circ K_b)$

$w_f(G \circ K_b) = l + x$ (by (M))

$= l + \sum_{j=1}^{\frac{b+l-4}{2}} f(v_{aj}) + \sum_{j=\frac{b+l-4}{2}+1}^{b} f(v_{aj})$ (by (P))

$= l + \left[\left(\frac{b+l-4}{2}\right)(-1)\right] + \left[\left(\frac{b-l+4}{2}\right)(1)\right] = 4 = m_{13}$

Since (P) is defined to satisfy (M), the obtained weight is minimum.

Subcase 1d: $l \equiv 3(mod\ 4)$

Define $f: V(G \circ K_b) \to \{-1,1\}$ by

$$f(v_i) = 1\ \forall\ i, 1 \le i \le a \text{ and } f(v_{ij}) = \begin{cases} -1\ if & \frac{a-k-1}{2}+1 \le i \le a-1,\ 1 \le j \le b \\ & or \\ & i=a,\ 1 \le j \le \frac{b+l-1}{2} \\ 1\ otherwise & \end{cases} \quad \text{--- (Q)}$$

$b \equiv 2(mod\ 4), l \equiv 3(mod\ 4)$ implies $\frac{b+l-1}{2}$ is even and $f[v] = 1\ \forall\ v \in V(G \circ K_b)$

$w_f(G \circ K_b) = l + x$ (by (M))

$= l + \sum_{j=1}^{\frac{b+l-1}{2}} f(v_{aj}) + \sum_{j=\frac{b+l-1}{2}+1}^{b} f(v_{aj})$ (by (Q))

$= l + \left[\left(\frac{b+l-1}{2}\right)(-1)\right] + \left[\left(\frac{b-l+1}{2}\right)(1)\right] = 1 = m_{14}$

Clearly, the weight is minimum.

Case 2: $a - k \equiv 0(mod\ 2)$

f is to be defined such that f values of v_{ij}'s, where $1 \le j \le b$ in one set of $\frac{a-k-2}{2}$ copies of ${K_{b+1}}^{i}$'s vanishes with f values of v_{ij}'s, where $1 \le j \le b$ in another set of $\frac{a-k-2}{2}$ copies of ${K_{b+1}}^{i}$'s. And in another k copies of ${K_{b+1}}^{i}$'s,v_{ij}'s, where $1 \le j \le b$ are assigned -1 so that it vanishes with f values of v_i's where $1 \le i \le kb$. In the remaining two copies, v_{ij}'s, where $1 \le j \le b$ are assigned functional values depending on the value of l.

Correspondingly, the weight would be $w_f(G \circ K_b) = \sum_{v \in V(G \circ K_b)} f(v)$

$$= \sum_{i=1}^{a} f(v_i) + \sum_{i=1}^{a}\sum_{j=1}^{b} f(v_{ij})$$

$$= a + \sum_{i=1}^{\frac{a-k-2}{2}}\sum_{j=1}^{b} f(v_{ij}) + \sum_{i=\frac{a-k-2}{2}+1}^{a-2}\sum_{j=1}^{b} f(v_{ij}) + \sum_{j=1}^{b} f(v_{(a-1)j}) + \sum_{j=1}^{b} f(v_{aj})$$

$$= a + \left[\left(\frac{a-k-2}{2}\right)(b)(1)\right] + \left[\left(\frac{a+k-2}{2}\right)(b)(-1)\right] + \sum_{j=1}^{b} f(v_{(a-1)j}) + \sum_{j=1}^{b} f(v_{aj})$$

$$= a - kb + \sum_{j=1}^{b} f(v_{(a-1)j}) + \sum_{j=1}^{b} f(v_{aj})$$

$= l + \sum_{j=1}^{b} f(v_{(a-1)j}) + \sum_{j=1}^{b} f(v_{aj})$ since $a = kb + l$ Hence $w_f(G \circ K_p) = l + y$ where $y = \sum_{j=1}^{b} f(v_{(a-1)j}) + \sum_{j=1}^{b} f(v_{aj})$--- (R)

Subcase 2a: $l \equiv 0(mod\ 4)$

Define $f: V(G \circ K_b) \to \{-1,1\}$ by

$$f(v_i) = 1\ \forall\ i, 1 \le i \le a \text{ and } f(v_{ij}) = \begin{cases} -1\ if & \frac{a-k-2}{2}+1 \le i \le a-2,\ 1 \le j \le b \\ & or \\ & i=a-1,\ 1 \le j \le \frac{b-2}{2} \\ & or \\ & i=a,\ 1 \le j \le \frac{b+l-2}{2} \\ 1\ otherwise & \end{cases} \quad \text{--- (S)}$$

$b \equiv 2(mod\ 4), l \equiv 0(mod\ 4)$ implies $\frac{b+l-2}{2}$ and $\frac{b-2}{2}$ are even and $f[v] = 1\ \forall\ v \in V(G \circ K_b)$

$w_f(G \circ K_b) = l + y$ (by (R))

$= l + \sum_{j=1}^{\frac{b-2}{2}} f(v_{(a-1)j}) + \sum_{j=\frac{b-2}{2}+1}^{b} f(v_{(a-1)j}) + \sum_{j=1}^{\frac{b+l-2}{2}} f(v_{aj}) + \sum_{j=\frac{b+l-2}{2}+1}^{b} f(v_{aj})$ (by (S))

$$= l + \left[\left(\frac{b-2}{2}\right)(-1)\right] + \left[\left(\frac{b+2}{2}\right)(1)\right] + \left[\left(\frac{b+l-2}{2}\right)(-1)\right] + \left[\left(\frac{b-l+2}{2}\right)(1)\right]$$
$$= 4 = m_{11} + 2$$

Since (S) is defined to satisfy (R), the obtained weight is minimum.

Subcase 2b: $l \equiv 1(mod\ 4)$

Define $f: V(G \circ K_b) \to \{-1,1\}$ by

$$f(v_i) = 1\ \forall\ i, 1 \le i \le a \text{ and } f(v_{ij}) = \begin{cases} -1\ if & \frac{a-k-2}{2}+1 \le i \le a-2,\ 1 \le j \le b \\ & or \\ & i=a-1,\ 1 \le j \le \frac{b+2}{2} \\ & or \\ & i=a,\ 1 \le j \le \frac{b+l-3}{2} \\ 1\ otherwise & \end{cases} \quad \text{--- (T)}$$

$b \equiv 2(mod\ 4), l \equiv 1(mod\ 4)$ implies $\frac{b+l-3}{2}$ and $\frac{b+2}{2}$ are even and $f[v] = 1\ \forall\ v \in V(G \circ K_b)$

$w_f(G \circ K_b) = l + y$ (by (R))

$= l + \sum_{j=1}^{\frac{b+2}{2}} f(v_{(a-1)j}) + \sum_{j=\frac{b+2}{2}+1}^{b} f(v_{(a-1)j}) + \sum_{j=1}^{\frac{b+l-3}{2}} f(v_{aj}) + \sum_{j=\frac{b+l-3}{2}+1}^{b} f(v_{aj})$ (by (T))

$= l + \left[\left(\frac{b+2}{2}\right)(-1)\right] + \left[\left(\frac{b-2}{2}\right)(1)\right] + \left[\left(\frac{b+l-3}{2}\right)(-1)\right] + \left[\left(\frac{b-l+3}{2}\right)(1)\right] = 1 = m_{12} - 2$

Clearly, the weight is minimum.

Subcase 2c: $l \equiv 2(mod\ 4)$

Define $f: V(G \circ K_b) \to \{-1,1\}$ by

$$f(v_i) = 1\ \forall\ i, 1 \le i \le a \text{ and } f(v_{ij}) = \begin{cases} -1\ if & \frac{a-k-2}{2}+1 \le i \le a-2,\ 1 \le j \le b \\ & or \\ & i=a-1,\ 1 \le j \le \frac{b+2}{2} \\ & or \\ & i=a,\ 1 \le j \le \frac{b+l-4}{2} \\ 1\ otherwise & \end{cases} \quad \text{--- (U)}$$

$b \equiv 2(mod\ 4), l \equiv 2(mod\ 4)$ implies $\frac{b+l-4}{2}$ and $\frac{b+2}{2}$ are even and $f[v] = 1\ \forall\ v \in V(G \circ K_b)$

$w_f(G \circ K_b) = l + y$ (by (R))

$= l + \sum_{j=1}^{\frac{b+2}{2}} f(v_{(a-1)j}) + \sum_{j=\frac{b+2}{2}+1}^{b} f(v_{(a-1)j}) + \sum_{j=1}^{\frac{b+l-4}{2}} f(v_{aj}) + \sum_{j=\frac{b+l-4}{2}+1}^{b} f(v_{aj})$ (by (U))

$= l + \left[\left(\frac{b+2}{2}\right)(-1)\right] + \left[\left(\frac{b-2}{2}\right)(1)\right] + \left[\left(\frac{b+l-4}{2}\right)(-1)\right] + \left[\left(\frac{b-l+4}{2}\right)(1)\right]$

$= 2 = m_{13} - 2$

Since (U) is defined to satisfy (R), the obtained weight is minimum.

Subcase 2d: $l \equiv 3(mod\ 4)$

Define $f: V(G \circ K_b) \to \{-1,1\}$ by

$$f(v_i) = 1\ \forall\ i, 1 \le i \le a \text{ and } f(v_{ij}) = \begin{cases} -1\ if & \frac{a-k-2}{2}+1 \le i \le a-2,\ 1 \le j \le b \\ & or \\ & i=a-1,\ 1 \le j \le \frac{b-2}{2} \\ & or \\ & i=a,\ 1 \le j \le \frac{b+l-1}{2} \\ 1\ otherwise & \end{cases} \quad \text{--- (V)}$$

$b \equiv 2(mod\ 4), l \equiv 3(mod\ 4)$ implies $\frac{b+l-1}{2}$ and $\frac{b-2}{2}$ are even and $f[v] = 1\ \forall\ v \in V(G \circ K_b)$

$w_f(G \circ K_b) = l + y$ (by (R))

$= l + \sum_{j=1}^{\frac{b-2}{2}} f(v_{(a-1)j}) + \sum_{j=\frac{b-2}{2}+1}^{b} f(v_{(a-1)j}) + \sum_{j=1}^{\frac{b+l-1}{2}} f(v_{aj}) + \sum_{j=\frac{b+l-1}{2}+1}^{b} f(v_{aj})$ (by (V))

$= l + \left[\left(\frac{b-2}{2}\right)(-1)\right] + \left[\left(\frac{b+2}{2}\right)(1)\right] + \left[\left(\frac{b+l-1}{2}\right)(-1)\right] + \left[\left(\frac{b-l+1}{2}\right)(1)\right]$

$= 3 = m_{14} + 2$

Since (V) is defined to satisfy (R), the obtained weight is minimum.

Hence the theorem.

Remark 3.12:

In theorem 3.11, the values of k and l may or may not be equal.

CONCLUSION

From the above results, it is clear that $\gamma^*_{sign}(G \circ K_b) \leq 4$ where G is any simple undirected graph on "a" vertices and $b \equiv 0(mod\ 2)$.

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RESEARCH ARTICLE

Understanding Flunitrazepam : A Concise Review on Action Pathways and Adverse Effects

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ABSTRACT

Benzodiazepines (BZD) can cause a variety of adverse effects, ranging from nausea and vomiting to mental impairment and memory disturbances. Whereas none of the side effects are small enough to be neglected, memory deficiency, motor impairment and vasorelaxation are of utmost importance as they aid the abusers for its utilization as a date-rape drug. These adverse effects take place through action pathways that are yet to be completely uncovered. This review provides the highlights of three main pathways and their crucial roles for the above-mentioned adverse effects, respectively. The studies are based on the pathways of NO:cGMP, L-arginine NO:cGMP and Endothelial NO-dependent and endothelium-independent, which are found to regulate memory deficiency, motor impairment and vasorelaxant effects caused by FNZ, respectively. The common findings of these research studies indicate that NO-related mechanisms could be involved in FNZ produced motor and memory failure in rodents. Nitric oxide (NO), a key bioregulatory molecule, is produced from L-arginine through a reaction catalyzed by nitric oxide synthase (NOS) and is thought to be essential in regulating neuronal excitability, synaptic plasticity, anxiety, seizure activity, and drug tolerance. Moreover, FNZ has showed to have a clear vasodilatory effect in isolated rat thoracic aortas through both endothelial-NO-mediated and endothelium-independent pathways. This review aims to help in discovering a strategical method in blocking or reversing the mentioned adverse effects and terminating the use of flunitrazepam as date-rape drug. Hence, getting a better understanding of FNZ action pathways can be helpful in building tolerance towards its adverse effects and increasing its therapeutic efficacy.

Keywords: Benzodiazepines, flunitrazepam, nitric oxide, date-rape drug.

INTRODUCTION

Flunitrazepam(FNZ), commonly known by the brand name Rohypnol, is a potent sedative-hypnotic drug belonging to the benzodiazepine class. It is a sedative–hypnotic benzodiazepine that is used for the short-term treatment of insomnia, for premedication in surgical procedures, and for inducing anesthesia[1].FNZ is one of the most commonly abused benzodiazepines; nevertheless, it is unclear if BZD abuse is recreational in character or an abnormal drug use related with the drug's therapeutic utility[2]. BZD can cause a variety of adverse effects, such as nausea, vomiting, drowsiness, confusion, dizziness, shaking, poor balance, and memory disturbances. Memory deficiency and motor impairment are one of the many side effects of BZD along with vasorelaxant effects.

Flunitrazepam is frequently misused in social environments mostly involving bars, clubs, etc., often to render individuals helpless for the purpose of sexual assault.It is typically slipped into a person's drink without their knowledge. When used as a roofie, flunitrazepam can cause sedation, confusion, impaired coordination, and anterograde amnesia, making it difficult for victims to remember what happened while under its influence[3-5].FNZ can induce anterograde amnesia, which prevents the patient from recollecting any memories of the past events that have occurred after ingestion of the drug. This feature lends itself to its use as a "date-rape drug," which is frequently delivered in a bar or party ("club drug"), where it is unknowingly put into the beverages of victims who will then have little or no recall of the assault[6].Detecting the presence of flunitrazepam in a person's system can be challenging, as it is rapidly metabolized and eliminated from the body. However, specialized toxicology tests can detect its presence in urine or blood samples.

FNZ acts on the central nervous system (CNS) by enhancing the effects of gamma-aminobutyric acid (GABA), a neurotransmitter that inhibits brain activity. The mechanism of action of FNZ involves its binding to the type A-aminobutyric acid receptor (GABAA-R), an intrinsic membrane protein. Allosteric binding of another medication or modification of lipid phase dynamics near a receptor can lead to the structural changes of its binding site. Thus, knowledge of the modulation of FNZ–membrane binding, including binding to GABAA-R, is required for proper development of functional methods to evaluate FNZ quantity and function simultaneously.

GABA ligands, such as barbiturates, can allosterically regulate FNZ binding depending on the subunit composition of the receptor. For example, pentobarbital and etomidate inhibit $\alpha 1\gamma 2$ receptor binding of FNZ, while the same compounds stimulate $\alpha 1\beta 3\gamma 3$ receptor binding[7]. Perhaps more concerning is the finding that FNZ can act as an inverse agonist on $\alpha 6\beta 2\gamma 2$ receptors, causing insomnia instead of sedation and anxiety instead of anxiolysis, respectively[8]. The paradoxical effects of FNZ, such as hyperactivity, insomnia, aggression, hallucinations, and anxiety, may be explained by this inverse agonist pharmacology. These subtle variations can explain why certain benzodiazepines, such as FNZ, are more likely to be abused or trigger a stronger amnestic effect, more potent anxiolysis, or a strong sedative effect.

To certain extent, all benzodiazepines potentiate GABA binding to their receptor and cause CNS depression, which is clinically manifested as sedative, anxiolytic, and amnesic actions (Griffin et. al, 2013). Flunitrazepam, a high-potency benzodiazepine,can be used as a hypnotic to produce anesthesia and have a stronger anterograde amnesia effect. This property attributes an individual's failure to memorize the events from the moment of administration (parenteral) or after enough absorption of the drug (oral). Small therapeutic dosages of FNZ administered either intravenously or orally can obviously cause memory impairment, however, this effect is transient and appears to fade within 30 minutes of drug administration. $GABA_A$ receptor activation has been found to affect memory formation in the hippocampus formation. Long-term potentiation (LTP) involving the N-methyl-D-aspartate (NMDA) receptor involve the excitatory amino acid transmitters glutamate and aspartate in plastic changes in neurons of this cerebral. FNZ induced LTP induction can be blocked by pre-administration of flumazenil, benzodiazepine receptor antagonist[9]. FNZ also has considerable vasodilatory characteristic, viz. the vascular smooth muscle relaxation, blood pressure reduction and a reflex rise in heart rate. The above characteristic is unique

to this benzodiazepine. According to a clinical investigation, it was found that 2 mg of FNZ causes pleasurable feelings in healthy people[10].

In addition to its illicit use, flunitrazepam can also lead to dependence and addiction when used recreationally or in high doses. Chronic use of the drug can result in tolerance, where higher doses are needed to achieve the same effects, as well as withdrawal symptoms upon discontinuation.Withdrawal from benzodiazepines, including FNZ, is marked by rebound anxiety or sleeplessness, which may be accompanied by headaches, nausea, vomiting, and muscletremors[11-14].

CLINICAL USES

Flunitrazepam is sometimes used in the short-term management of severe anxiety or agitation. However, due to its sedative effects and potential for abuse, it is generally not recommended as a first-line treatment for anxiety disorders[15]. In some medical procedures, it is given as a sedative, such as endoscopy or minor surgery, to induce relaxation and reduce anxiety. It is administered under strict medical supervision due to its potential for misuse[16].Flunitrazepam is primarily indicated for the short-term treatment of severe insomnia. It is used when other treatments have failed or are not suitable, and its use is limited to a few weeks due to the risk of tolerance and dependence[17]. It also has muscle relaxant properties which can be utilized in the management of muscle spasms or stiffness. However, its use is generally limited to short-term treatment due to the risk of adverse effects and dependence[18].Flunitrazepam may be used as a pre-anesthetic medication to induce sedation and reduce anxiety before surgery. It is often administered intravenously or orally in this setting[19, 20].In some cases of status epilepticus (a life-threatening condition characterized by prolonged seizures), flunitrazepam may be used as an adjunctive treatment to help control seizures. However, other medications are typically preferred for this indication. Due to its anticonvulsant properties,it may be used in the management of certain types of seizures, however, this is not always advised seeing the risks associated with it, and is only used when all the other options have been exhausted[21]. In cases where the use of FNZ is inevitable, a risk-benefit ratio assessment can be done.

MISUSE OF FLUNITRAZEPAM

The misuse of flunitrazepam, is a significant public health concern due to its potent sedative effects and potential for abuse. Moreover, flunitrazepam exhibits characteristics of central nervous system depressants by inducing relaxation, sedation, and amnesia.

One of the most notorious aspects of flunitrazepam misuse is its association with drug-facilitated sexual assault (DFSA). Due to its potent sedative effects and amnesia-inducing properties, flunitrazepam is often used by perpetrators to incapacitate victims, making them vulnerable to sexual assault[22]. The drug is typically slipped into drinks without the knowledge of victim, leading to loss of consciousness, memory impairment, and difficulties in recalling events, which can hinder the victim's ability to report the assault [23, 24].One of the key factors contributing to flunitrazepam's notoriety as a date rape drug is its potency and rapid onset of action. When mixed with alcohol or other beverages, flunitrazepam can intensify the sedative effects, leading to a quick and profound impairment of cognitive and motor functions[25, 26].

FNZ is also misused for recreational purposes, particularly in settings where individuals seek to enhance the effects of alcohol or other drugs. Some individuals misuse flunitrazepam to experience some euphoric effects associated with it, which can induce feelings of relaxation and tranquillity. However, recreational use of flunitrazepam is associated with a high risk of dependence, tolerance, and overdose, especially when combined with other substances [27, 28].

Chronic misuse of FNZ can lead to the development of dependence, characterized by physical and psychological reliance on the drug to function normally[29]. Individuals who misuse flunitrazepam may experience withdrawal symptoms when attempting to reduce or discontinue its use, including anxiety, insomnia, tremors, seizures, and hallucinations[30, 31].

If taken in high doses or combined with other central nervous system depressants such as alcohol or opioids FNZ can cause overdose. This may lead to severe respiratory depression, coma, and even death.The risk of dependence,

withdrawal and overdose underscores the importance of careful prescribing practices and monitoring of flunitrazepam use [32-35].

ACTION PATHWAYS FOR FLUNITRAZEPAM

L-Arginine:NO:cGMP Pathway

According to Talarek S. et. al., they conducted some rotarod and chimney experiments using mice to assess the motor impairing effects of FNZ.It was found that both a non-selective nitric oxide synthase (NOS) inhibitor, NG-nitro-L-arginine methyl ester (L-NAME), and an unselective neuronal NOS inhibitor, 7-nitroindazole (7-NI), blocked the development of tolerance to the motor impairing effects of FNZ. Additionally, L-arginine, a precursor of nitric oxide (NO) and a potent inhibitor of phosphodiesterase 5 (PDE5), did not affect the development of tolerance to FNZ-induced motor dysfunction in mice, as evidenced by sildenafil's lack of impact[36, 37].

Nitric Oxide

Nitric oxide (NO) is a key bioregulatory molecule produced from L-arginine through a reaction catalyzed by nitric oxide synthase (NOS) as seen in Fig. 1. Since 2010, research has further elucidated the diverse roles of NO in neuronal function. NO is considered essential in regulating various aspects of neuronal activity, including excitability, synaptic plasticity, anxiety, seizure activity, and drug tolerance[38].

NO mediates its effects by increasing the expression of cyclic guanosine 3′,5′-monophosphate (cGMP) and modulating cGMP-dependent signaling. Upon synthesis, NO allosterically interacts with soluble guanylyl cyclase (sGC), leading to the production of cGMP. This molecule then regulates various downstream effectors, including cGMP-dependent kinases, cGMP-gated ion channels, and cGMP-regulated phosphodiesterases (PDE).[38] The modulation of these effectors by cGMP plays a crucial role in mediating the diverse effects of NO in neuronal physiology[39, 40].

L-arginine:NO:cGMP and GABA:

There is compelling evidence supporting a link between L-arginine: GABA-mediated transmission and the nitric oxide (NO):cGMP pathway in the central nervous system (CNS). Neurotransmitters such as nitric oxide (NO) and gamma-aminobutyric acid (GABA) play crucial roles in neuronal communication and are intricately interconnected. Studies have shown that neuronal nitric oxide synthase (NOS)-positive neurons are co-localized with GABA-positive neurons in various regions of the CNS, including the cerebral cortex and spinal cord, as revealed by histochemical mapping[41-43]. Activation of GABAergic neurotransmission has been shown to result in the production of NO in the animal cortex, highlighting the close relationship between these two systems[44]. Furthermore, NO has been shown to modulate GABA release and uptake in the CNS, suggesting a regulatory role for NO in GABAergic neurotransmission[45, 46]. This intricate interplay between L-arginine: GABA-mediated transmission and the NO:cGMP pathway underscores the complexity of neuronal signaling in the CNS.

Flunitrazepam has been shown to modulate the L-arginine:NO:cGMP pathway in the CNS. Studies have demonstrated that flunitrazepam can alter NO production and cGMP levels in the brain, suggesting a potential interaction with this pathway[47]. Flunitrazepam's effects on the L-arginine:NO:cGMP pathway may contribute to its pharmacological actions, including sedative-hypnotic and anxiolytic effects, by modulating neurotransmission and synaptic plasticity[48, 49].

According to a study conducted by Talarek et. al., using animal models, it was noticed that tolerance to motor impairment can be blocked with the use of nitro-L- arginine methyl ester (L-NAME) and 7-nitroindazole, both being indirect and direct inhibitors of nitric oxide synthase, respectively[50, 51]. Chronic administration of NOS inhibitors and FNZ is thought to prevent GABA-A receptor inhibition, thus helping manage symptoms related to cognition.
The activation of N-methyl-D-aspartate (NMDA) receptors help to synthesize more amounts of NO[52, 53].Drugs that function on the GABA-A receptors, (such as benzodiazepines, barbiturates, and alcohol) cause motor impairing

effects. When NMDA receptor antagonists,(such as amantadine, ketamine and dextromethorphan) are given along with these drugs, the development of tolerance to their motor impairing effects is reduced. Hence, the investigation conducted by Talarek et. al.,has gathered some behavioral evidence from animal models that the L-arginine:NO:cGMP pathway can play a key role in the development of FNZ tolerance.

NO-cGMP Pathway

BZDs can cause a variety of adverse effects, such as emesis, disorientation, confusion, dizziness, shaking, poor balance, and memory disturbances. Memory deficiency is one of the many side effects of BZDs, which restricts their use in conditions like anxiety, insomnia, and seizures[54]. These medications inhibit episodic memory, which allows people to remember experiences that they have personally witnessed. There are three primary forms of memory viz., sensory memory, short-term memory, and long-term memory. Amongst which it is the short-term memory which seems to sustain the most damage from FNZ[55]. Short-term memory, often referred to as working memory, is a crucial component of cognitive function responsible for temporarily storing and manipulating information.

Memory and $GABA_A$ receptors:

Memory consists of three stages: acquisition, consolidation, and retrieval[56]. FNZ interferes namely with the initial stage of memory process which enables it to start the pathway of anterograde amnesia. This in turn leads to activation of GABA-A receptors which facilitate the amnesic effect of FNZ. Any new information that a person wants to learn is not possible if some certain new connections in neurons and memory are not made. Thus, this is also one of the ways that FNZ affects development of any new memory. Apart from these, some modifications in the synapse transmission of hippocampus region have also been documented to trigger amnesic effects of FNZ. This is enabled as the hippocampus region has binding sites for the GABA-A receptors to bind on. Another one of the mechanisms, that FNZ is known to interfere with is the long-term potentiation which is thought to lead to learning and memory processes[55].

Nitric oxide (NO) is a vital signaling molecule which is produced from the amino acid L-arginine by the enzyme nitric oxide synthase (NOS)[54]. NO is particularly important in the nervous system, where it regulates neuronal excitability and synaptic plasticity, which are crucial for learning and memory. Furthermore, NO is thought to contribute to drug tolerance, affecting how the body responds to certain medications over time. There are four isoforms of NOS out of which the neuronal, nNOS is predominantly found in neurons and is involved in neurotransmission[57]. NO is believed to play a key role in LTP, influencing learning and memory processes. In various rodent memory models, it has been discovered that inhibiting NOS behavior impairs cognitive reactions. NO donors, L-arginine and molsidomine may help to counteract these negative effects[58]. The fluctuation in levels of NO in the body are also caused by some neurological disorders such epilepsy and anxiety. These fluctuations have been linked to impair the process of memory formation. Here, some drugs which are also donors of NO, such as sodium nitroprusside and molsidomine can be used to counteract the impairment of cognition[59].

NO helps in production as well as reuptake of many neurotransmitters including even GABA[60, 61]. For instance, the release of GABA in the cerebral cortex, hippocampus, and striatum is positively correlated to great amounts of NO concentration in the CNS[62]. The authors Orzelska et. al., have conducted a research study in animal models comparing the effects of diazepam and flunitrazepam in a novel object recognition (NOR) task. Here two different memory models NOR and mEPM were used. Wherein, the NOR is a behavioral test that is used to model human amnesia in animals. It takes advantage of rodents' natural desire to investigate new items and assesses their ability to remember what they have seen. mEPM, which is a rodent spatial memory model, is another animal model of amnesia.It takes advantage of their inherent aversion to open, elevated spaces.In the mEPM procedure, memory impairments were verified whereas, in the NOR test anterograde amnesic effects were seen. Adding to this a similar study was conducted recently which showed that flunitrazepam enhances memory consolidation in the object recognition task, potentially through modulation of the NO-cGMP pathway[63].

In behavioral studies it has been noticed that sildenafil, a phosphodiesterase (PDE-5) inhibitorand methylene blue, a soluble guanyl cyclase inhibitor, reduces memory damage due to FNZ. Here it showed that memory impairment due

to FNZ can be reversed by using methylene blue. Many recent behavioral studies have found that the cGMP levels improve learning and memory processes by inhibiting PDE, especially PDE-5[64-66]. It acts as a cognitive enhancer by interfering with transduction of signal in the NO:cGMP pathway. The selective behavior of methylene blue or sildenafil on particular GABA-A receptor subunits may be a reason forthe divergent effects of both the drugs. It is worth noting that in this analysis, both sildenafiland methylene blue did not show any significant difference in NOR and mEPM models when given alone; as opposed to when they were administered along with FNZ. Based on the findings, we can deduce that NO-related mechanisms could be involved in FNZ-induced memory failure in rodents and perhaps in humans too.

Endothelial-NO-mediated and endothelium-independent pathways

Direct Vasorelaxant Action:

The endothelial NO-mediated pathway refers to the production of nitric oxide (NO) by endothelial cells in response to various stimuli, including shear stress and neurotransmitters. NO, in turn, plays a crucial role in vasodilation and neurotransmission. Endothelium-independent pathways involve the direct effects of drugs on vascular smooth muscle cells, bypassing the need for endothelial NO production. These pathways can be activated by exogenous NO donors or by drugs that directly activate guanylate cyclase, leading to the production of cyclic guanosine monophosphate (cGMP) and subsequent smooth muscle relaxation[67]. It can be understood with the help of Fig. 2.
Flunitrazepam's effects on endothelial cells may involve oxidative stress[68].Flunitrazepam has been implicated in endothelial dysfunction, a condition characterized by impaired NO production and vascular dysfunction. Research has shown that flunitrazepam can modulate NO production in rat cavernous tissue by down-regulating nitric oxide synthase (NOS) and phosphodiesterase type 5 (PDE5) expressions, leading to increased NO levels and enhanced smooth muscle relaxation[47]. The involvement has been clearly noticed in all the three pathways (Fig 3).

According to a study flunitrazepam when given orally at night for four weeks, resulted in a substantial reduction in nighttime blood pressure in healthy volunteers aged 21 to 30[69]. It was observed that in healthy volunteers that there were reduced levels of systolic as well as diastolic blood pressure[70]. In a few studies, it has been observed that BDZs such as diazepam[71], flunitrazepam[72], flurazepam[71], midazolam[74] and tetrazepam[73] show a direct action on arteries in animal models and cause vasodilation. Studies have also suggested that chronic use of flunitrazepam may contribute to endothelial dysfunction and cardiovascular risk[75].

A study by Zhang et al., investigated whether NO from vascular endothelium is involved in the relaxation induced by four benzodiazepines all of which are known for their vascular relaxing effects. The study found that the arterial relaxation induced by these drugs, as well as by L-NAME (Nω-Nitro-L-arginine methyl ester), a NO synthase inhibitor, was significantly inhibited after endothelium denudation, suggesting the involvement of endothelial NO in the vasorelaxant effects of these drugs[76]. Other study reports found that treatment with BDZs increased NO production in endothelial cells, suggesting a potential mechanism for the vascular relaxing effects of these drugs[77]. Hence, if this vasodilatory action of FNZ is interrupted then the side effects, such as dizziness and palpitation can also be inhibited.

CONCLUSION

Despite its beneficial applications, FNZ remains predominantly utilized for its adverse effects. NO, the key bioregulatory molecule, contributes to all the main pathways through which flunitrazepam induces its primary adverse effects.NO is particularly important in the nervous system, where it regulates neuronal excitability and synaptic plasticity, which are crucial for learning and memory. Flunitrazepam's effects on the L-arginine:NO:cGMP pathway contribute to its sedative-hypnotic and anxiolytic effects, by modulating neurotransmission and synaptic plasticity. The studies included in this review have demonstrated that flunitrazepam can alter NO production and cGMP levels in the brain.In behavioral studies it has been noticed that sildenafiland methylene blue reduce memory damage due to FNZ and thus, it can be used to reverse the memory impairment due to FNZ. Also, it has been

observed in the endothelial pathways that production of increased levels of NO due to modulation cause enhanced smooth muscle relaxation which eventually lead to drowsiness. Hence, all the findings from different studies give us an understandable perspective towards the workings of FNZ and its adverse effects. In conclusion, we would like to suggest that further study is required to find a possible way to interrupt the interaction of FNZ with the pathways of NO combined with L-arginine, cGMP and endothelial tissues which can help minimize or even alter the adverse effects of FNZ.

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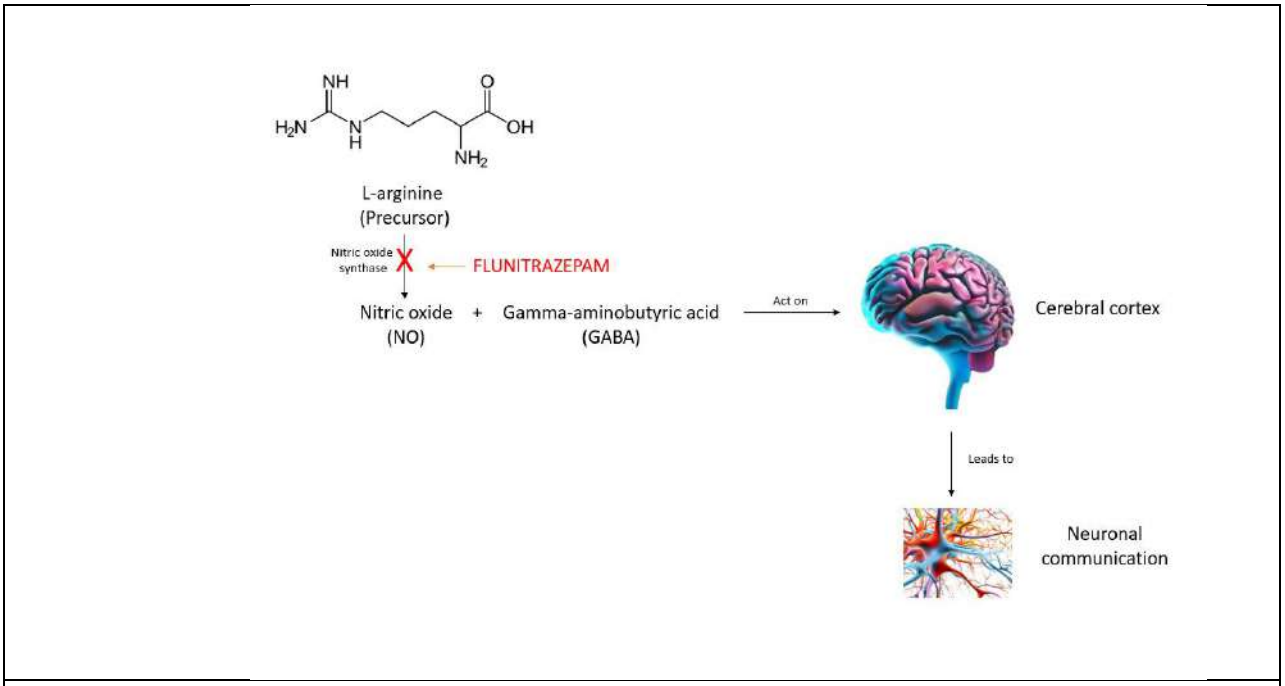


Fig. 1: Flunitrazepam disrupts the production of nitric oxide from L-arginine

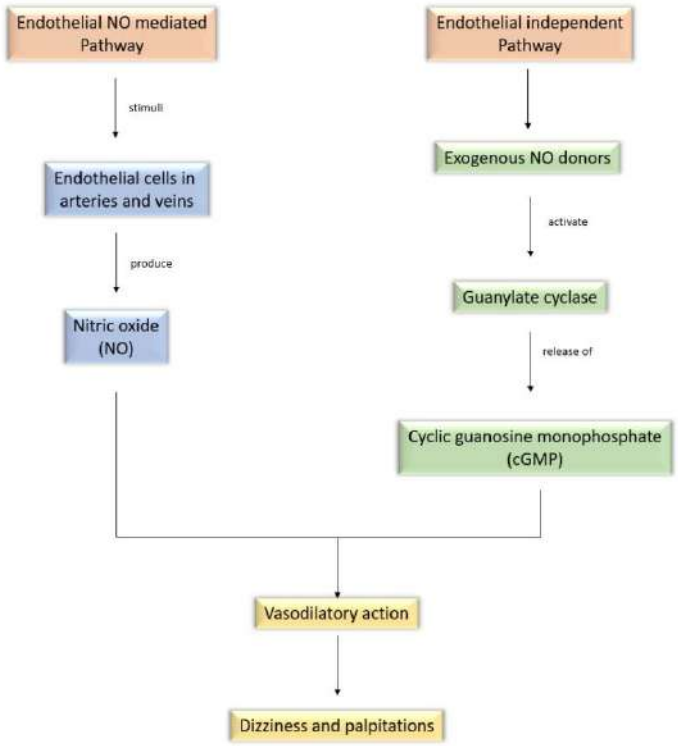


Fig. 2: Mechanisms of endothelial NO mediated and endothelial independent pathways

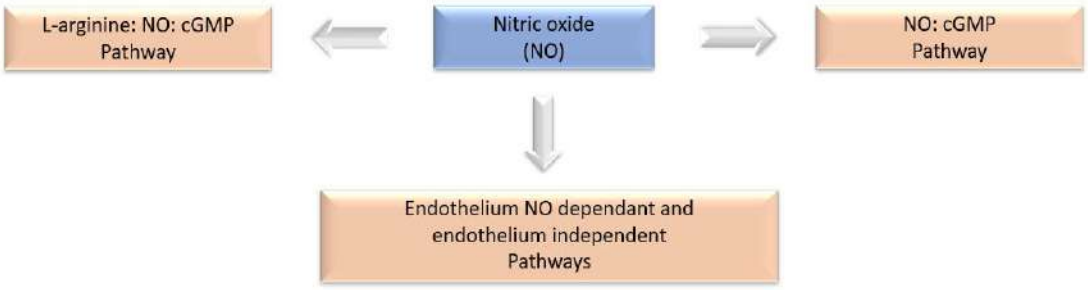


Fig. 3: Involvement of nitric oxide in L-arginine: NO: cGMP, NO-cGMP and endothelial NO mediated and endothelium independent pathways

RESEARCH ARTICLE

A Model for Efficient Media Dependent Resource Utilization Techniques for Massive Data Learning using Clustering in Grid Computing

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ABSTRACT

The primary goal of this proposed work is to enhance the synchronization of media parameters by optimizing grid process running time. The work is divided into four main tasks: estimating grid process running time, optimizing loading harmonization, clustering media parameters based on instructional and media factors, and improving load balancing. The aim is to ensure that a shared media object can be efficiently delivered to a large number of users simultaneously through effective harmonization and clustering. This approach is designed to reduce grid process running time for the same media object, even with a high number of users accessing it at the same time. The clustering in this study is categorized into Instructional Parameters and Media Parameters, with a primary focus on media parameters, particularly in the context of massive clusters. The subsequent category involves load harmonization based on Poisson distribution, where the average and actual numbers of successes from experiments are analyzed. This approach aims to understand and optimize massive clusters within learning grids.

Keywords: harmonization, e-content, grid, load balancing.

INTRODUCTION

Information Technology has advanced significantly over the past twenty five years, leading to a gradual rise in the use of online courses. These courses are typically divided into instructional and media categories. When a single file (a shareable object) is accessed by many users simultaneously, the loading time for that file can increase. To address

this issue, the proposed work focuses on reducing loading times through harmonization and clustering techniques[1]. The proposed work is shown in the following Figure 1. Initially when the user searches the appropriate documents for learning through Electronic-content developments.

PROPOSED WORK

E-content is becoming a standard due to its flexibility in terms of time, location, and pace of learning. It encompasses all types of content created and delivered through various electronic media and is available across a wide range of subjects and educational levels. E-content caters to diverse learners with different needs, backgrounds, and levels of experience and skill. It can be easily and quickly shared among a vast number of users globally. Both teachers and students benefit from the use of simple and advanced e-content, which offers significant advantages to educational institutions by making their programs accessible in various settings such as fields, homes, and community learning centers. This has profound implications for open and distance learning institutions.

E-content development has seen substantial growth over recent decades, leading to a surge in online learners and the rise of platforms like MOOCs (Massive Open Online Courses) ,NPTEL (National Programme on Technology Enhanced Learning) and Coursera, which offer unrestricted participation and open access via the internet. Besides traditional materials such as recorded lectures and problem sets, many courses on these platforms now incorporate interactive elements like user forums for community interaction and instant feedback on quizzes to enhance the learning experience. NPTEL, introduced in 2006 and gaining popularity in 2012, initially focused on open-access principles, including open licensing to encourage the reuse of resources, though some courses have since adopted closed licenses while maintaining free access. Similarly, Coursera, launched in 2012, provides a wide range of courses from top universities and institutions, often featuring a mix of open and proprietary content[4]. Today, online courses from platforms like MOOC's, NPTEL and Coursera are increasingly utilized by schools, colleges, companies, and individuals seeking certifications. A major challenge for these platforms is efficiently distributing content to a large number of users, which involves managing one-to-many or many-to-many interactions. To address this, the concept of shareable common objects has been introduced.

Shareable Common Object (SCO)

A Shareable Content Object (SCO) represents the fundamental unit of learning within the SCORM framework. Depending on the context, it may be called a module, chapter, or page. The defining feature of an SCO is its diverse range in size and content. As per the SCORM (Shareable Content Object Reference Model) standard, an SCO should be the smallest unit of content that is both reusable and self-contained[3]. In a Learning Management System (LMS), an SCO is individually listed in the table of contents and tracked separately from other content. It includes its own marker, score, and completion status, as illustrated in Figure 2. A significant challenge with Shareable Content Objects is managing the delivery of content from multiple servers to a large number of clients. This issue can be addressed through Load Balancing. Load Balancing is a method used to distribute tasks or requests across several computers. For example, if many users are seeking e-content on C-Programming, specifically about while loops, Load Balancing ensures that the content is provided to all users promptly. Regardless of whether there are tens, hundreds, thousands, or even millions of users, optimizing Load Balancing for Shareable Content Objects helps manage the distribution effectively. The figures illustrating Load Balance's are shown below.

Load Balancing can be enhanced through the use of clustering. In the realm of e-content development, clustering is a key approach. A cluster typically consists of multiple servers running the same application. This setup serves two main purposes: to distribute the load across different servers and to provide redundancy and fail-over mechanisms[2]. Within a cluster, tasks are evenly distributed among the servers. This method is most effective when all servers have the same capabilities and each task requires a similar amount of effort. The sample e-content are classified into four ways as shown in Figure 4. First it includes normal languages used in the real world environment; second, e-content is related to the mechanical studies; Third, e-content is related to the business management people and Fourth, e-contents are categorized into programing languages used in the computer programming



By analyzing the Shareable Content Object file and its memory usage, you can determine its performance in a grid processing environment using GridSim 5.0. Grid computing technology is increasingly used to deploy e-learning content over the internet, as e-learning environments often require substantial computing resources to support a large number of simultaneous users. Consequently, both software and hardware need to be frequently updated or upgraded to accommodate these demands[1]. Large learning grid could be a machine cooperative setting for effectively endeavor massive pools of e-learners of the online that is turning into vogue the. One among the basic problem in such grid environments is job programming, that is required for achieving higher performance As grid setting is mostly suburbanized and it consists of heterogeneous systems, economical programming technique would be noticeably required for sound acceptable resources for relevant e-content; say massive or little or the e-content.

Load harmonization based on grid process running time has been applied to media parameters in large-scale learning grids. For massive open online courses (MOOCs), load harmonization for media parameters is estimated using a Poisson distribution. The proposed work is categorized into four areas: grid process running time, harmonization, clustering, and load balancing. The size and memory usage of each Shareable Content Object can be determined through Java programming. When many users access the same Shareable Content Object, these metrics can be calculated for each experimental trial using the Poisson distribution.[3]

Find out the chances of occurrence of a number of events in some given time interval or given space conditionally that the value of the average number of occurrence of the event is known. In a dynamic learning grid environment with a vast amount of knowledge and numerous users, virtual warehousing can be utilized for storing and retrieving data. Virtual warehousing, a crucial technology in e-commerce, offers flexibility in managing large datasets. One of its main benefits is cost reduction, as it eliminates the need to structure individual data sets for many concurrent users, allowing multiple learners to access a single data source. Additionally, using independent and Poisson probabilities to minimize redundant computations within learning grid clusters can conserve computational resources for thousands of simultaneous users.

EXPERIMENT AND RESULT

The following shows the instructional objects based on the file size and the memory utilization and the processing times are calculated using GridSim 5.0. File size and Memory are measured in terms of Kilo Bytes. Grid processing time is measured in terms of milliseconds.

- The file size of the 'definable' instruction object in storage is 188KB; and its size in memory is 186.6KB; processing time by the GridSim 5.0 would be around 2300 ms (excluding user retention time).
- The file size of the 'demonstrable' instruction object in storage is 654KB; and its size in memory is 651KB; processing time by the GridSim 5.0 would be around 14300 ms.
- The file size of the 'solvable' instruction object in storage is 362KB; and its size in memory is 660.7KB; processing time by the GridSim 5.0 is around 8600 ms.
- The file size of 'perceivable' instruction object in storage is 160KB; and its size in memory is 158.8KB; processing time by the GridSim 5.0 would be around 1800 ms.
- The file size of the same content integrated into a single document is about 1346KB; size the same in memory is 1340KB; processing time by the GridSim 5.0 would be around 28350 ms (excluding user retention time).
- With authorized research support [Kaladevi 2013], the average computational ratio of Definable , Demonstrable , Solvable , Perceivable has been empirically worked out to be about: 1.00 , 4.00,,3.00 , 0.75 (i.e 11.5% : 46% : 34.5% : 8%), which is more or less matching with size and computational time.
- In a similar empirical study on media categories with authorized research support [Jagadeesan, B 2014], the average empirical computational ratio of Textual: Graphical: Animation is about 1.00 , 1.10 , 1.30 (i.e 28% : 33% : 39%) respectively.

The above Table 1 shows the summarized the specification, trials and range for the samples and inputs for the proposed experimental setup. Tasks of massive users take 10, 50, 100, 200 and 400 experimental trials of tasks. Clusters or Resources for creation of task for massive
users takes trial ranges from 1000 to 10000. Massive clusters that would be grouped into resources that can be varied different ranges and will be decided through first experiments. Parameters for selection of clusters for experimental trials are trust based performance based and to remove the redundancy.
The above table 2 shows the grid processing time of Instructional parameter. For Each category of instructional parameters the experimental trials of tasks are taken from 1000 to 10000. Instructional Parameters are Definable, Demonstrable, Solvable and Perceivable.
Definable cluster or task ratio is 4,
Demonstrable cluster or task ratio is 8,
Solvable cluster or task ratio is 5
Perceivable cluster or task ratio is 7
Based on the cluster or task ratio and experimental trials of task average grid processing time are calculated by using GridSim 5.0

Above table 3 shows the grid processing time for Media parameter. For Each category of media parameters the experimental trials of tasks are taken from 1000 to 10000. Media parameters are Textual, Graphics, and Animations.
Textual cluster or task ratio is 8,
Graphics cluster or task ratio is 9,
Animations cluster or task ratio is 11

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Table 1. Experimental Setup for Grid Resources

Specification	Trials & range
Tasks for massive users (Experiment 1).	10, 50, 100, 200 and 400
Clusters (resources) requested for creation of tasks for massive users (Experiment 2).	1000 – 10000 in steps of 100
Massive clusters that would be grouped into resources.	Varies and will be decided through first experiments
Parameters for selection of clusters (Experiment 1)	Trust, performance, redundancy removal

Table 2 Grid Processing Time for Instructional Parameter

TRIALS	DEFINABLE (CLUSTER 4)	DEMONSTRABLE (CLUSTER 8)	SOLVABLE (CLUSTER 5)	PERCEIVABLE (CLUSTER 7)
1000	2858	15865	8740	1867
2000	2846	15020	8904	1845
3000	2818	16980	8965	1898
4000	2840	17030	9083	1904
5000	2878	16820	9154	2065
6000	2903	16092	9258	2037
7000	2840	17896	9474	2176
8000	2880	17670	9787	2297
9000	2895	18005	9937	2303
10000	2816	18875	9956	2455

Table 3. Grid Processing Time For Media Parameter

TRIALS	TEXTUAL (CLUSTER 8)	GRAPHICAL (CLUSTER 9)	ANIMATION (CLUSTER 11)
1000	5002	5980	6379
2000	5976	6258	6904
3000	5620	6984	7408
4000	6278	7158	7923
5000	6128	8003	8509
6000	6503	8823	8165
7000	6400	9043	8964
8000	7078	8978	9472
9000	7587	9539	9946
10000	8198	9912	10027

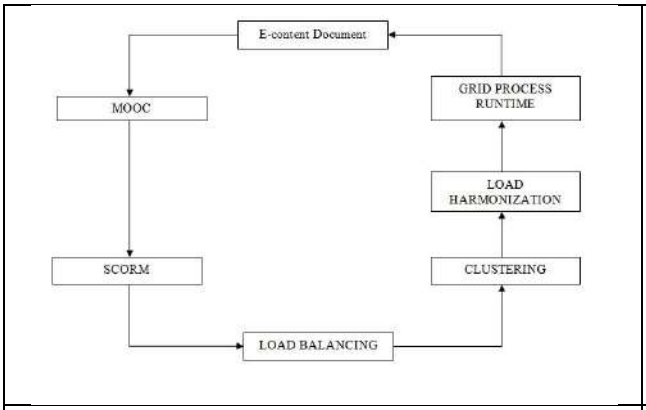


Figure 1 Proposed Work

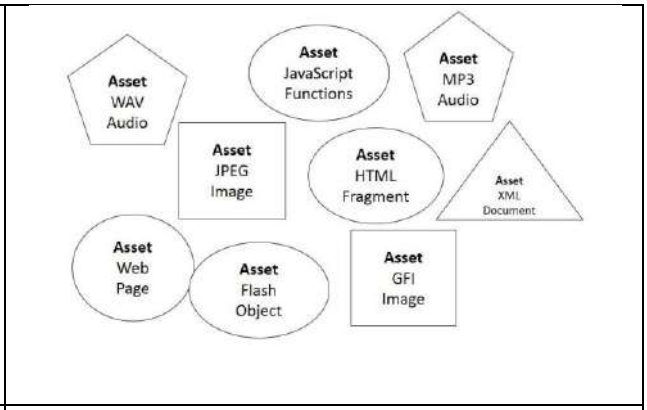


Figure 2 Shareable Content Object Reference Model.

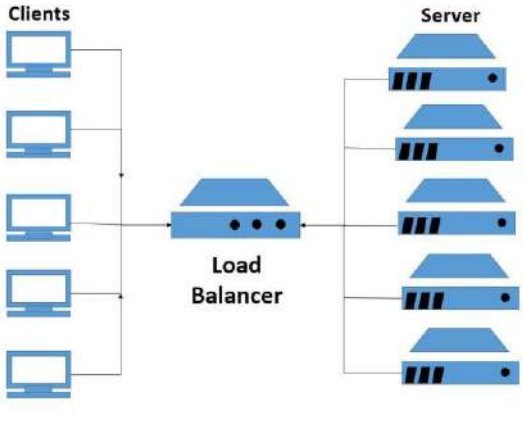


Figure 3. Load Balancing

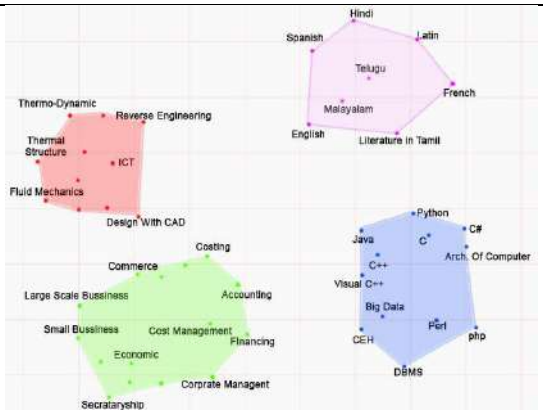


Figure 4 : Sample Categorization of E-Content

RESEARCH ARTICLE

Machine Learning Algorithms for Predicting Pregnancy Risks : a New Frontier

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ABSTRACT

Pregnancy, a significant life event, poses dangers for both the mother who is carrying the child and the developing fetus. Machine learning (ML) is essential in the medical field, specifically for healthcare diagnosis, assessment, and therapy. Conventional diagnostic methods may encounter difficulties in accurately diagnosing high-risk pregnancies, leading to potential complications and adverse outcomes for both the mother and the fetus. Recent advancements in machine learning (ML) algorithms have demonstrated remarkable efficacy in detecting and predicting high-risk pregnancies by analyzing a range of clinical, physiological, and behavioral data. This review study describes the supervised and unsupervised learning approaches used to identify high-risk pregnancies. Machine learning algorithms offer benefits in identifying high-risk pregnancies. Some of the advantages include prompt action, enhanced precision, and tailored treatment approaches. Implementing machine learning can lower the expenses associated with costly medical interventions.

Keywords : Machine Learning; fetus; high-risk pregnancies; Algorithms;

INTRODUCTION

Pregnancy, a significant life event, poses dangers for both the mother who is carrying the child and the developing fetus. Machine learning (ML) is essential in the medical field, specifically for healthcare diagnosis, assessment, and therapy. Conventional diagnostic methods may encounter difficulties in accurately diagnosing high-risk pregnancies, leading to potential complications and adverse outcomes for both the mother and the fetus. Recent advancements in machine learning (ML) algorithms have demonstrated remarkable efficacy in detecting and predicting high-risk pregnancies by analyzing a range of clinical, physiological, and behavioral data. This review study describes the supervised and unsupervised learning approaches used to identify high-risk pregnancies. Machine learning algorithms offer benefits in identifying high-risk pregnancies. Some of the advantages include prompt action, enhanced precision, and tailored treatment approaches. Implementing machine learning can lower the expenses associated with costly medical interventions [1]. While technological developments in obstetrics and gynecology have been considerable, it is crucial to realize that not all dangers can be entirely removed [2].

According to World Health Organization in 2020, around 800 women died during pregnancy due to different risk factors involved during pregnancy. Every day in 2020, about 800 women died from pregnancy and childbirth-related causes that may have been avoided. In 2020, a mother's death apparently happened every two minutes. Between 2000 and 2020, the global maternal mortality ratio (the number of pregnancy - related deaths per 100,000 live births) lowered by approximately 34% [3]. Numerous machine learning methods and technology is used for pregnancy related diseases. Stress detection of working lady during pregnancy by using neural network .In a recent studies a semi-supervised machine learning to predict pregnancy related risks in Philippines [4]. A supervised learning was used to detect pregnancy risk due to hypertension, in this study, graph-based SSL was used to simultaneously incorporate labeled and unlabeled data in order to predict pregnancy-related HTN [5]. In 2022, a research was done on creation of a cerebral infarction (CI) threat prediction using machine learning techniques to mine huge data from common test results [6]. Preeclampsia is an anomaly of pregnancy that appears after 20 weeks of pregnancy and is characterized by proteinuria and hypertension and research as done on algorithms for detection of these risks using deep learning and neural network [7].

The study by [8]examined the effectiveness of three classification algorithms: the logistic regression classifier, rule-based classifier, and RF classifier [9]. They made use of the PhysioNet [10] Term-Preterm EHG database. With a sensitivity of 97%, specificity of 86% AUROC of 94%, a mean square error rate of 14%, the RF classifier performed the best. There was no reported accuracy rate, false positive rate (FPR), or false negative rate (FNR). Another study shows the potential of utilizing machine learning techniques to forecast the lifetime of preterm children based on clinical & demographic factors. The creation of the PISA predictor may enable healthcare professionals to make better choices regarding the preterm newborns they treat and care for, thereby improving their patients' outcomes [11]. Another study used graph-based semi-supervised learning to create a prediction model for pregnancy-related hypertension. In comparison to the most recent clinical recommendations and a predictive biomarker, the model had a greater predictive accuracy. The best average model parameters was demonstrated by the top 11 variables chosen by feature selection, with a mean AUC of 0.89 with training dataset & 0.81 in the test set. Using common clinical characteristics, the suggested model may successfully predict the onset of hypertension associated in pregnancy in the early stages of pregnancy [12].

In an effort to enhance prenatal care in remote areas of low- and middle-income nations, the paper suggests adopting portable ultrasound devices, blood and urine testing to identify high-risk pregnancies and send them. In order to care for 10,108 pregnant women over the course of two years and three months, the Healthy Prenatal project, a case study, trained migratory nurses and provided them with mobile ultrasound systems and tests. The findings demonstrated that nursing personnel may quickly identify and refer the majority of obstetric concerns, helping to lower maternal mortality, with the right tools, training, and supervision. The study emphasizes the strategy's potential to enhance maternity care in rural low- and middle-income nations [13].

Another study with an objective to examine the outcomes of both Deep Learning & Neural Network models in order to predict the risk of preeclampsia in pregnant women. A particle swarm optimization (PSO) algorithm was used to minimize the number of features from 17 to 9, using the study's 1077 patient data as input. In comparison to the original data, the results indicated that Deep Learning executed more quickly and had an accuracy of 95.12% while using the raw data and 95.68% when using the smaller dataset. The variety of attributes could be greatly reduced with PSO while preserving and enhancing precision. Deep Learning has been demonstrated that it's an effective edge framework that does not need sophisticated systems or in-depth data analysis [7]. The study was conducted in rural India, where the prevalence of preterm delivery is high and there are little resources available to support pregnant women and new babies. The authors want to create a model that could forecast the likelihood of preterm birth and help with intervention decision-making. Several machine learning models, such as logistic regression, decision trees and support vector machines, were developed and tested by the authors. Accuracy, specificity, and sensitivity are used to evaluate the classifiers' performance. Finally, compared to the other learning classifiers utilized in this study, the SVM classifier provides an accuracy of 90.9%[14].

A systematic review was conducted to evaluate the entire artificial intelligence model in pregnancy related risks and labor after conducting a thorough search of numerous databases. A total of nine categories of AI applications were discovered, including pregnancy risk evaluation, prenatal diagnosis, pregnant hypertensive problems, stillbirth, foetal growth, premature deliveries, delivery route, and others. The best artificial intelligence application for evaluating medical issues, in accordance with this systematic review, is ANN approaches. It has been determined that ANN approaches typically have an accuracy of 80–90%. The authors have included papers that apply AI-based algorithms for forecasting adverse affects during pregnancy. The notion that this publication offers a critical examination of the many research is one of its advantages [15]**.** A random forest regression technique was used in the study discussed in the content to create a prediction models for GDM in pregnant women. Around 4800 pregnant women's data were gathered, and the researchers used a literature review, expert discussion, and 67 indications of GDM to identify them. According to the study, the generated model performed well, with overall predictive accuracy for the F1 data set of 93.10% as well as an AUC of 0.66 and overall predictive accuracy for the F2 data set of 88.70% and 0.87 respectively [16]. The literature on the application of affective computing and artificial intelligence to pregnancy health was examined in this scoping review, which covered the years 2008 through 2020. Although the study revealed that emotional well-being can be a substantial risk factor throughout pregnancy, there is currently a dearth of research on automated emotion analysis. According to the review, future studies should concentrate on creating AI & affective computing-based products to improve the health and wellbeing of expectant mothers [17]. Another study was designed in order to reduce the danger of multiple pregnancies and maintain the best pregnancy odds, the goal of this study was to build artificial intelligence algorithms that could forecast the pregnancy result and repeated pregnancy risk after IVF-ET. Among the six machine learning techniques employed for model development, XGBoost performed the best. The dataset includes 1507 fresh embryo transfer cycles. The accuracy, sensitivity, specificity, and AUC values for the pregnant women prediction model were 0.716, 0.711, 0.719, and 0.787, respectively. With an accuracy of 0.711, specificity of 0.740, sensitivity of 0.649 and AUC of 0.732, the multiple pregnancy prediction method performed well. According to the study, using AI models to reduce the probability of multiple pregnancies following IVF-ET is a promising strategy [18].

DISCUSSION

A number of studies have revealed that the use of Machine learning can reduce high-risk during pregnancy. A decision tree method was employed in one study to predict preterm birth using information on the mother's demographics, previous health history, and foetal growth. In terms of predicting preterm birth, the algorithm has a sensitivity of 79.4% and a specificity of 81.6% [19]. Another study was conducted considering maternal health and demographic information using a random forest algorithm to forecast gestational diabetes. The system successfully predicted gestational diabetes with an area under the curve (AUC) of 0.77 [20].

Deep learning-based neural networks have been utilized to solve a variety of challenges in several disciplines in recent years. Deep neural networks learn complicated relationships between variables using layered design. A well precise decision support system is required to obtain accurate outcomes from the diagnosis procedure while minimizing costs. Classification of diseases based on multiple characteristics is a difficult work for human professionals, but AI can help to detect and handle such risks. Several AI techniques are currently being applied in the field of medicine to accurately diagnose illnesses. AI is a component of computer science that allows computers to become more intelligent [21].

Initially, rule-based decision-making was the main component of AI techniques that was commonly utilized in healthcare. Because they can perfectly mimic the physicians' own decision-making process, AI solutions that use rule-based decision-making fit in with the clinical setting organically. MYCIN was one of the initial rule-based decision-making algorithms. MYCIN was created in 1974 to forecast the best course of treatment for certain bacterial illnesses. It was created as "expert system" that would use a sequence of if-then statements to direct therapists towards the best course of action. It would take another 20 years for these "expert" rule-based systems to be used for the first time, in 1994, when a rule-based predictor of the risk of preterm birth was created. An application of AI known as machine learning (ML) permits learning without explicit programming. An artificial neural network (ANN), a common ML technique, is created to approximate how biological neural networks process data. We identified three main areas where applying AI techniques could help us better understand the pharmacological impacts of pregnancy, including: Acquiring significant and trustworthy information from clinical records; establishing efficient animal experiments to test particular ideas; designing decision-support tools that guide decisions [22].

It has been 25 years since the first AI tool for a woman's health issue—preterm birth—was created, and 45 years since the creation of the first AI system with a health focus. Recently, two studies published in the New England Journal of Medicine brought attention to the critical need for novel approaches to study pharmaceutical effects in both pregnant and lactating women [23]. 90 percent of pregnant women take a pharmacologic at some point during their pregnancy, according to Eke et al. and Mitchell et al., and between 70 and 80 percent of pregnant women gain a pharmacologic during the first trimester of their pregnancies, which is the most dangerous due to congenital anomalies and unfavorable foetal outcomes [24]. We have seen previous work done on utilizing different machine learning algorithms in pregnancy related risk analysis. We can differentiate these models on the bases of their sensitivity, accuracy and precision. We can use these factors to check which model is best for risk detection.

Types of machine learning

We broadly classify machine learning into three categories [25] and in some papers they are classified in four categories [26].

- **Supervised learning:** This kind of machine learning entails using labeled data to train the algorithm. It makes use of a dataset where every observation has a corresponding label or result. Then the model uses this information to make predictions on unseen data. Image recognition, speech recognition, and home price forecasting utilizing factors like location, bedroom count, and square footage are all common uses for supervised learning [27].
- **Unsupervised Learning:** The algorithm is trained with unlabeled data in this sort of machine learning. It looks for patterns or clusters in the dataset without knowing what the results should be in advance. Unsupervised learning frequently uses clustering, in which the algorithm groups together data points with similar characteristics [27].
- **Semi-Supervised Learning:** Unsupervised and supervised learning are combined in semi-supervised learning, a kind of machine learning. It entails putting the algorithm through training on a dataset containing both labeled and unlabeled data. While making predictions, the algorithm applies the patterns it has learned from the labeled data to the unlabeled data. When labeled data is expensive or challenging to collect, semi-supervised learning is advantageous [28].
- Reinforcement Learning: With this kind of machine learning, a decision-making algorithm is trained to take into account mistakes and previous decisions [29]. By acting and getting rewards or penalties for such behaviors, the

algorithm operates from its surroundings. Throughout time, the aim is to increase the benefits and decrease the penalties. Robotics, video games, and autonomous cars frequently use reinforcement learning [28].

Analysis of machine learning algorithms

From different researches papers we observed different parameters that were mostly used for the analysis of machine learning algorithms. Following are some of the parameters

Accuracy

One of the most often applied evaluation measures in machine learning is accuracy. It calculates the proportion of accurate predictions of a model on a specific dataset makes. Accuracy is specifically determined by the proportion of the number of correct predictions to the sum of all the predictions [30].

It can be calculated by the formula: AC = T P + T N / T P + T N + F P + F N

Precision

The proportion of true positives, or instances of a particular class that are properly identified, among all positive predictions that are made by a model, is measured by precision, an extensively used evaluation metric in machine learning [31]. It can be calculated by the formula: P =T P/ T P + F P

Recall

Recall is a metric that is used to measure how well a model performs at correctly identifying every relevant instance in a dataset. Out of all positive cases in the dataset, it calculates the proportion of real positive instances that the model properly detected [32].

It can be calculated by the formula: P =T P/ T P + F N

1. F represents the equilibrium in between P and R values. Since we care more about labour data in our results, a higher F value indicates a stronger classifier.

It can be calculated by the formula: F = 2 ∗ P ∗ R / P + R

2. F1 score

F1 score is a parameter that is frequently used in data analysis along with machine learning to assess how well a classification algorithm is performing. It refers to the harmonic mean of recall and precision, two additional often employed measures. A higher score on the F1 scale, which spans from 0 - 1, indicates superior performance. Using different algorithms for machine learning in pregnancy-related risk analysis has been the focus of past research. These models can be distinguished based on their sensitivity, accuracy, and precision. These elements enable us to assess which model is the most effective at identifying risks.

FINDINGS

Algorithms used in pregnancy related risk

The degree to which a person can accurately predict the result of a model that has been well-accepted by the clinical team is referred to as the applicability of ML models. From the previous papers I came across, the support vector machine, neural networks [33], decision tree, Naive Bayes, logistic regression, deep learning and random forest [34]. ML techniques were most frequently employed to predict pregnancy related problems. In which it was noticed that the highest AUC value was 0.95 for SVM [2].

Model validation methods

Validation procedures are approaches used in machine learning (ML) to assess how well a trained model performs on incoming, unknown data. These techniques measure a model's ability to generalize and generate precise predictions on data that it has never seen before. Three widely used techniques for validating Machine learning algorithms are cross-validation, testing, and training.

- **Training:** When a model is trained, its parameters are adjusted to reduce error on a particular collection of data known as the training set. Usually, an optimization algorithm like gradient descent is used for this.
- **Testing:** Testing is the process of assessing the model's performance using a unique data that it has never seen before. The testing data is used to calculate the model's generalization error, or how well it can predict outcomes using brand-new, untested data.
- **Cross validation:** By dividing the given data into numerous subsets, or "folds," cross-validation is a method for assessing the efficacy of a model. A subset of the data is used to train the model, while the remaining subset is used to test it. Several subsets are employed for training and validation during the course of this process's repetition. To estimate the model's performance, the results are averaged.

Predictive aspects

Studies outline the key aspects of pregnant women that may be important in predicting risk. High-ranking factors for the prediction of premature births include the mother's age, the presence of chronic arterial hypertension, gestational diabetes,Preeclampsia [35], heart disease [36], underlying illnesses, gestational hypertension disorders, Fetal growth restriction(FGR)and the father's nationality. It is also crucial to distinguish between provider-initiated spontaneous preterm births and unplanned preterm births [22].

Pre-labor rupture, placenta praevia, and an unspecified antepartum haemorrhage were among the obstetric problems. Preeclampsia, rupture of membranes, threatened miscarriage, preterm birth, infection of the urinary tract, gestational hypertension, and gestational diabetes are some conditions that may occur [37].

Generalized methodology

Machine learning algorithms use technique to evaluate large datasets in order to identify patterns that may be used to build a model that can be used in future for prediction. In the realm of perinatal care, these algorithms can be trained on enormous quantities of data relating to prenatal care, foetal development, and neonatal outcomes to detect potential risks and forecast future concerns. Methodology was divided into six sequentially steps

1. Data gathering and preprocessing: Gather information that is pertinent to your work and prepare it for the model by cleaning, converting, and normalizing it.
2. Model selection: Based on the type of information, the quantity of data, and the difficulty of the task, selects a suitable machine learning algorithm.
3. Model training: Apply the chosen algorithm to the preprocessed data to train the model.
4. Model evaluation: Measure the trained model's accuracy, precision, recall, and some other metrics by applying it to a different dataset (the test set). Metrics including accuracy, precision, recall, F1 score, and area under the receiver operating characteristic (AUC) curve will be used to assess the model's performance.
5. Model tuning is the process of modifying the model's hyperparameters and parameters to enhance performance.

CONCLUSION

We can conclude that machine learning algorithms are used to identify high-risk pregnancies based on this review paper. The analysis and evaluation of several research and methodologies are utilized in the risk factors involved in pregnancy and provided a process that comprises data gathering, risk analysis, data splitting, developing a deep learning-based model, and prediction made by this model. Overall, the outcomes for maternal and foetal health may be improved by the adoption of algorithms based on machine learning for high-risk pregnancy diagnosis. Yet, it is crucial to make sure that the data is gathered and used ethically, and that the algorithms are accurate, objective, and understandable. In order to advance this subject and guarantee its safe and efficient application, more study and cooperation between physicians, data scientists, and ethicists are imperative. There are still research gaps in need of being filled despite the substantial breakthroughs in using algorithms for machine learning to forecast pregnancy-related hazards. To verify that the methods are generally applicable across diverse populations, for instance, larger datasets including a range of population groupings and demographic data are required. Also, adding additional pertinent parameters, such social and environmental ones, could increase the predictive models' precision. To fill up

the gaps in the existing data and create more precise and generally applicable models for predicting hazards associated with pregnancy, more study is required.

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Table 1. Classification of potential risk factors in pregnancy

Current health conditions	Hypertensive disorders, polycystic ovary syndrome, diabetes, kidney disease, autoimmune diseases, thyroid disease, infertility, obesity, HIV/AIDS
Lifestyle factors	Use of alcohol, tobacco and illegal drugs
Pregnancy conditions	Multiple pregnancy, gestational diabetes, preeclampsia and eclampsia
Age	Adolescent pregnancies, first pregnancy after the age of 35

Table 2. Types of machine learning

MACHINE LEARNING			
Supervised learning	Unsupervised learning	Semi -supervised - learning	Reinforcement learning
1. Classification	1. Clustering	1. Classification	1. Positive
2. Regression	2. Association	2. Clustering	2. Negative

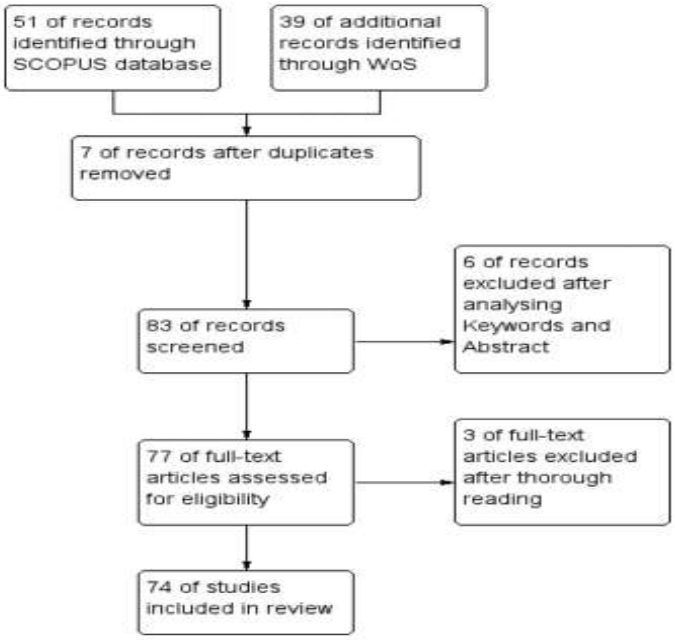


Fig.1 Flow Chart

RESEARCH ARTICLE

In Vitro Anti-Arthritic Activity of *Piper betel* Flower Extract along with Antioxidant Activity and its *In silico* Molecular Docking Study

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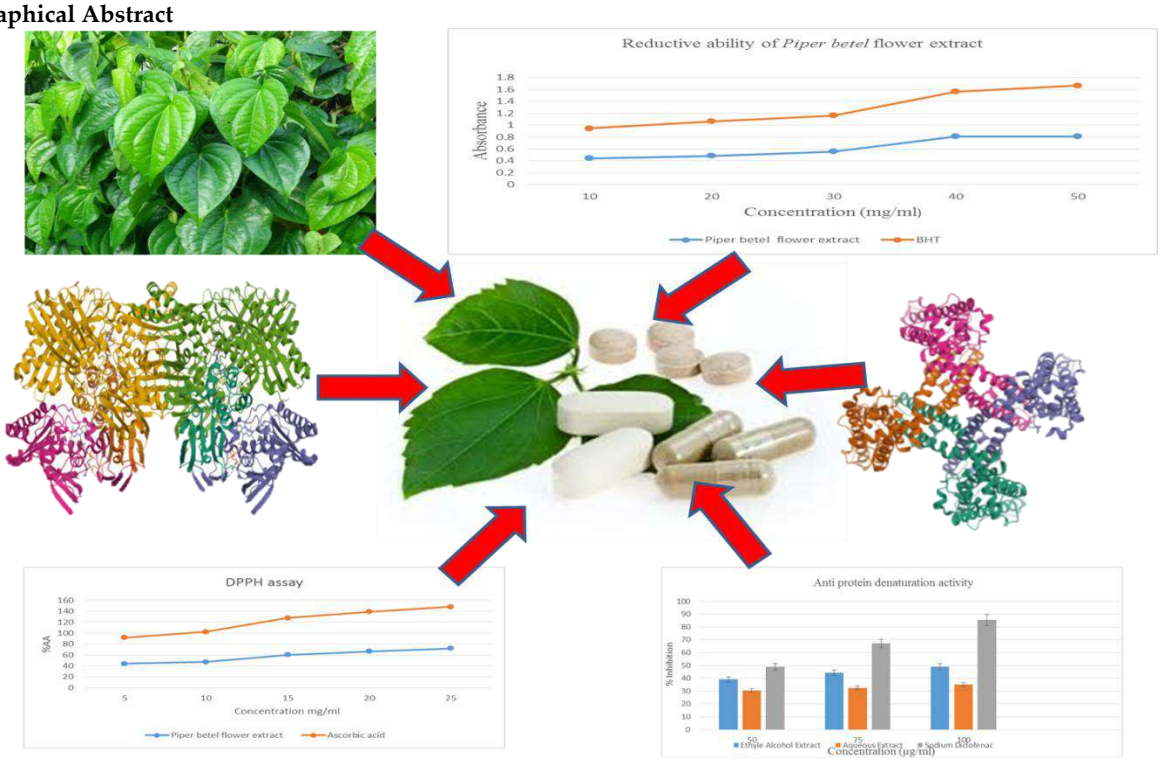
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ABSTRACT

Rheumatoid Arthritis is a chronic, inflammatory, and systemic autoimmune disease, it affects elders worldwide. Herbal medicines have been used for the treatment of various ailments from ancient times. Betelvine (*Piper betle*L.) leaves have long been used in Asian countries as a medicine to relieve pain and some metabolic diseases. The present study of methanolic extract of phytochemical analysis confirms the presence of alkaloids, tannins, terpenoids, saponins, steroids, total flavonoids and total phenols. The long-term condition known as rheumatoid arthritis is marked by joint inflammation that progresses to cause bone loss. According to its important qualities such as antioxidant, anticancer, and anti-allergic, extracts from the *Piperbetel* plant have been used for centuries to treat a wide range of illnesses. *Piper betel* flower extract's antioxidant properties was investigated in this study, and also molecular docking study. To virtually screen a large number of tiny molecules in an attempt to find possible hits, molecular docking of compounds across different databases is helpful. By including distinct molecular scaffolds into the discovery process, these predictions save expenses and save time. Molecular docking was done by using Capsaicin receptor protein 3J9J and3EUB PDB.

Keywords: Rheumatoid Arthritis, bone, antioxidant, Molecular docking, phytochemical.

Graphical Abstract



INTRODUCTION

Rheumatoid arthritis (RA) is a systemic autoimmune disease that is persistent and causes degeneration of the joints and bones [1]. Pain, edema, and cartilage degradation are the main signs and symptoms of RA. When the condition progresses, it gradually destroys bone and cartilage, resulting in permanent bone impairment. The World Health Organization estimates that between 0.3% and 1% of people worldwide suffer from RA, with women three times more likely than males to get the illness. One chronic, systemic autoimmune disease is rheumatoid arthritis (RA).[2]As a component of the intricate biological reaction of vascular tissues to damaging stimuli such as infections, injured cells, and allergens, inflammation occurs. The symptoms include discomfort, fever, redness, swelling and loss of function. It is an intrinsic immune mechanism [3].

Protein denaturation was the primary source of inflammation in rheumatoid arthritis. Sites of inflammation are where protein denaturation takes place, and denatured proteins may be more prone to glycation, a known mediator of inflammation [11]. Denaturation can happen as a result of heating, being near acids or bases, or even from vigorous physical activity. Rheumatoid arthritis inflammation leads to excruciating swelling of joint tissues, which may cause malformed joints and bone loss. Prior studies carried out by Ahmed and his colleagues have indicated that the primary cause of this inflammation is a cytokine protein called interleukin-1 beta (IL-1 beta).[12]

Since denatured proteins are frequently insoluble, they precipitate more frequently, which raises the activity of the macrophase at the tissue's protein de-naturation site and can cause inflammatory and neurodegenerative illnesses.[13]Because conventional drugs have significant adverse effects when used over an extended period of time, managing disorders connected to protein de-naturation presents a significant problem for medical professionals.[14]The clinician attempts to think that using herbal or alternative medication will help with this severe problem. Many modern human drugs are derived from natural resources, which have been a major source of

medicinal medicines for thousands of years. So, the main goal for researchers going forward is to produce novel plant-based medications with improved bioactive potential and little to no negative effects [15].

Since ancient times, plants have been used as powerful biochemical factories and as components of phytomedicine. Man can extract an amazing variety of industrial chemicals from plants [13]. Plants based natural constituents can be obtained from any part of the plant, meaning that any portion of the plant may contain active ingredients. Examples of plant parts include bark, leaves, flowers, roots, fruits, and seeds. The last three decades have seen the emergence of antioxidant-based drugs and formulations for the inclusion, prevention, and treatment of complicated illnesses like as cancer, diabetes, Alzheimer's disease, stroke, and atherosclerosis [4].

Oxidative stress, which is a major contributor to numerous diseases like cancer, cardiovascular disease, neurodegenerative disease, rheumatoid arthritis, atherosclerosis, hypertension, and AIDS, is brought on by an imbalance between reactive oxygen species (ROS) and the anti-oxidative defense systems [12]. The potential of antioxidants to prevent or postpone oxidative damage by obstructing the start and spread of oxidizing chain reactions has led to the exploration of antioxidant therapy for cellular degenerations. Because of this imbalance, which can cause damage to cellular components including lipids, proteins, and DNA, our bodies produce more reactive oxygen species than antioxidant species when under stress.

A heart-shaped, shiny, white cat can be found on the evergreen betel leaf creeper. Throughout the world's tropical and subtropical climates, the genus Piper (Piperaceae) is still abundant. Growing countries for *piper betel* include East Africa, the Philippines, Malaysia, Indonesia, and Sri Lanka. It tastes harsh and has a faint yellow scent from the essential oils.[4] In the world, betel vines come in over 90 species, with nearly 45 of those being found in India and 30 of those being in West Bengal. It is cultivated in tropical and subtropical regions due to its evergreen leaves, which are utilized as a chewing stimulant and in pooja sessions and other religious events [5].

In the Ayurvedic medicine system, the properties of *Piper betel* are described below[6]

- Guna (Quality): Laghu, Ruksha, Tikshan
- Rasa (Nambitha): Tikt
- Vipak (Metabolism): Katu
- Virya (Power): Ushan
- Prabhav (Impact): Hridya

The *Piper betel* flower is composed of long terminal spikes. A single spike can consist of all staminate flowers, almost all hermaphrodite flowers, or partially or entirely pistillate flowers with sporadic staminociia. This is less common.[7]About two millimeters in diameter, the full staminate flowers diameter and a minimum length of five centimeters. When mature, the female and hermaphrodite spikes measure ten to twelve millimeters in thickness and length, matching that of the male counterparts [8]. There could be as many as 500 or 600 blossoms on a spike.Long terminal spikes make up the *Piper betel* flower. All staminate flowers, nearly all hermaphrodite flowers, or partially or fully pistillate flowers with intermittent staminociia can all be found in one spike. This is not as typical.[9]The complete staminate flower's diameter is approximately two millimeters, and its minimum length is five centimeters. The adult female and hermaphrodite spikes are the same length and thickness as their male counterparts, measuring ten to twelve millimeters. On a spike, there could be 500 or 600 flowers [10].

MATERIALS AND METHODS

Collection and Preparation of Extract

Fresh *Piper betel* flowers were gathered from Tanaji Kharat's personal farm. Fresh flowers were twice washed under running tap water, then distilled water and allowed to air dry. The flowers were mixed into a fine powder after they had properly dried. For later use, the flower powder that had been shade-dried was kept at room temperature. Two

separate pre-labeled conical flasks were filled with one gram of the dried powdered flower, 40 milliliters of de-ionized double-distilled water, and ethanol. The mixes were incubated overnight at 30°C and 120 rpm in a BOD shaker incubator. The mixture was run through Whatman filter number one the next day.Every time, newly made alcoholic and aqueous extracts were employed in the anti-protein de-naturation experiment.

Preparation of Extract- for antioxidant assay

Fresh flowers were gathered, then allowed to air dry at room temperature in the shade. Using a mesh screen, dried flowers were mechanically ground into powder. Seventy percent alcohol was used to extract 100 grams of freshly powdered flowers that had been evenly packed in a soxhlet apparatus. After then, the solvent evaporated at a low temperature and with less pressure.

Chemicals

DPPH (2, 2-diphenyl1-picrylhydrazyl), gallic acid, and catechin are standard chemicals used to measure radical scavenging activity. These compounds were acquired from Sigma-Aldrich Fine Chemicals (St. Louis, MO). The supplier of TPTZ (2,4,6-tripyridyl-striazine) was Sisco Research Laboratories Pvt. Ltd. (Mumbai, India), while Merck (Darmstadt, Germany) provided the Folin-Ciocalteu reagent, methanol, ethanol, ethyl acetate, acetone, acetic acid, and hydrochloric acid. The antioxidant (PHOTOCHEM) kit that was utilized was purchased from Analytikjena (Konrad-Zuse-Strasse 1, Germany). We bought potassium per sulfate, ferric chloride, hydrochloric acid, anhydrous sodium acetate, acetate buffer, and ferrous sulphate from Central Drug House (Pvt.) Ltd. (New Delhi, India).

METHODS

Phyto-chemical Screening

A fresh betel extract was evaluated for bioactive substances such as terpenoids, saponin, sterols, alkaloids, flavonoids, tannin, carbohydrates, amino acids, and proteins. The usual procedure was used to complete the qualitative analysis.

***In Vitro* - Protein Denaturation Assay**

In this experiment, 2.8 ml of phosphate buffered saline (PBS, pH 6.4) and 2 ml of various concentrations of the test extract (50 µg/ml, 75 µg/ml, and 100 µg/ml alcoholic and aqueous extract of *Piper betel* flower) were mixed to prepare the assay mixture. Additionally, 0.2 ml of egg albumin (from fresh hen's egg) was used as their protein source. The control was an equivalent volume of double-distilled water. After being heated to 70ºC for five minutes in a water bath, the mixtures were incubated for fifteen minutes at 37±2ºC in a BOD incubator. The vehicle was used as a blank to test their absorbance at 660 nm after cooling. To determine absorbance, diclofenac sodium was utilized as a reference medication at final concentrations of 50µg/ml, 75µg/ml, and 100µg/ml and handled in a comparable manner [16].

Calculations

We used the following formula to get the percentage inhibition of protein de-naturation.

% inhibition = 100 × [Vt / Vc – 1]

where

Vc = absorbance of the control sample and

Vt = absorbance of the test sample

***In vitro*- Antioxidant Activity**

DPPH photometric assay

When the 2, 2-diphenyl-1-picrylhydrazylhydrate (DPPH) radical was present, the capacity of *Piper betel* extract to donate hydrogen was tested. In ethanol, it yields a violet-colored solution. [14]. A stock solution of the extract (1.0

mg/ml) was diluted in ethanol to reach a final concentration of 5, 10, 15, 20, and 25 mg/ml. 2.5 ml of sample solution with varying concentrations was mixed with 1 ml of 0.3 mM DPPH ethanol solution, and the mixture was left to react at room temperature. The absorbance readings at 518 nm were recorded after 30 minutes. As a blank, 1.0 ml of ethanol and 2.5 ml of plant extract solution were utilized. As a negative control, DPPH solution (1.0 ml: 0.3 mM) with 2.5 ml of ethanol was employed. Those utilizing the standard solutions (ascorbic acid) served as the positive control.[8]

Using the following formula, the percentage Antioxidant Activity (%AA) was determined:

$AA\% = 100 - \{ Abs\ Sample\ -\ Abs\ blank / Abs\ control \times 100\}$

The concentration needed at 50% to block or alter absorbance. (IC50) was computed as well.

Measurement of the reductive ability

The Fe^{3+}-Fe^{2+} transition in the presence of the extract was examined in order to quantify the reductive ability.[15] 2.5 milliliters of 0.2M phosphate buffer (pH 6.6), 2.5 milliliters of 1% potassium fericynide [K3 Fe (CN) 6], and one milliliter of plant extract (1 mg/ml) were incubated at 50 degrees Celsius for 20 minutes. After the liquid was mixed with 2.5 cc of 10% Trichlo acetic acid (TCA), it was centrifuged for 10 minutes at 3000 rpm. A 1.5 ml solution of freshly made 0.1% ferric chloride was added to 2.5 ml of the supernatant, which was then agitated. A 700 nm measurement was made of the absorbance. In place of extract, water was added to the reference solution, which was made similarly to the previous one. A reaction mixture's enhanced absorbance suggests a higher reducing power.[7]

Scavenging of Superoxide anion radical

Xanthine oxidase and hypoxanthine were used in vitro to produce the superoxide anion radical.[16]A reaction mixture containing 1 mM EDTA and 50 mM $KH_2\ PO_4$ – KOH pH 7.4 was produced, with a final volume of 1 ml per tube. 100 mM NBT and 100mM hypoxanthine. 0.066 U of xanthine oxidase per tube, diluted in 100 ml of phosphate buffer, and 10 ml of saline for the PBLE. The penultimate addition was xanthine oxidase. After five minutes of incubation at 25°C, the absorbance of the reaction mixture was measured at 560 nm.The activity of superoxide anion scavenging increases when the absorbance of the reaction mixture decreases. The findings are given as the percentage inhibition of the NBT decrease rate in comparison to the reaction mixture that contains only saline (no flower extract).[9]

Inhibition of reaction mixture was calculated by using following formula:

$I\ \% = 100\ X\ \{A_o\text{-}A_t/A_o\}$

where At is the absorbance of the test substance and

Ao is the absorbance of the control.

Molecular Docking

The use of molecular docking in computer-aided drug design and structural molecular biology is essential. An objective of ligand-protein docking is to forecast the main binding mode(s) between a ligand and a protein with a known three-dimensional structure.Many software programs have been created over the past few decades; some of the more well-known ones include AutoDock, AutoDockVina, DockThor, GOLD, FlexX, and Molegro Virtual Docker. Getting the target structure is the initial step in a docking calculation, and it often comprises of a big biological molecule (a protein, DNA, or RNA). The Protein Data Bank (PDB), which offers access to 3D atomic coordinates acquired through experimental techniques, makes the structures of these macromolecules easily retrievable. That the target's experimental 3D structure is unavailable is, nevertheless, not unusual. To get over this problem, the three-dimensional structure of proteins can be obtained using computer prediction techniques including comparison and ab initio modeling.

Method

Molecular docking has been an essential part of in-silico drug research in recent years. With this approach, the atomic-level1 interaction between a small molecule and a protein is predicted. This enables researchers to study the behavior of small molecules, such as nutraceuticals, within the binding area of a target protein and to understand the fundamental metabolic process underlying this interaction. The structure-based method requires a high-resolution 3D model of the target protein, which can be obtained by nuclear magnetic resonance spectroscopy, X-ray crystallography, or cryo-electron microscopy3-5.Both free and paid computational tools and molecular docking techniques are available.

The molecular docking of active constituent was conducted by using V life MDS 4.6 to evaluate *in silico* Antiarthritic activity of the isolated metabolites the X-ray crystal structure of active Capsaicin receptor protein 3J9Jas proposed molecular target, was obtained from the RCSB protein data bank (PDB DOI: https://doi,org/10.2210/pdb3J9J/pdb) .
In silico Antioxidant activity of the isolated metabolites was evaluated by using X-ray crystal structure of protein PDB 3EUB was obtained from the RCSB protein data bank (PDB DOI: https://doi.org/10.2210/pdb3EUB/pdb).
Water molecules and ligands which are not involved in the binding were removed. The protein was prepared using Protonate 3D protocol in MOE with default options. And then molecular docking was carried out by obtaining docking score of two active constituents present in *Piper betel* Flower extract.

- Hydroxychavichol
- Eugenol

Formula for binding affinity of ligand and protein:
$BindingAffinity\Delta G =$
$Totalenergyofcomplex - (\ UncomplexedΔG.\ protein + UncomplexedΔGligand)$

RESULTS

In the current investigation, Table 1 showed the existence of several bioactive compounds in the *Piper betel* extract, and Table 2 showed the aqueous and ethanolic extracts' anti-protein denaturation properties. The same table also included information on the concentrations of the experimental samples and the reference medication.

DPPH assay

The addition of the *Piper betel* flower extract decreased DPPH in a concentration-dependent manner. In terms of IC50, the extract's free radical scavenging activity was 12.0 mg/ml, surpassing the standard drug's ascorbic acid concentration of 5.35 mg/ml. This suggests that the extract may have antioxidant properties.

Measurement of reductive ability

Comparing the*Piper betel* flower extract to the standard, it exhibited the greatest capacity to decrease Fe3+ ions and reductive ability (Table.2). A higher reducing power is shown by a higher absorbance of the reaction mixture.

Scavenging of Superoxide anion radical

Ascorbic acid at 50 mg/ml and the alcoholic extract of *Piper betel* flower decreased NBT reduction by 66% and 77%, respectively. Table 3 indicates that the extract's IC50 values were 20 mg/ml and the standard's IC50 values were 22 mg/ml. This indicates that xanthine oxidase activity was suppressed by the extract.

Molecular Docking

Table 6. Comparative scores obtained from molecular docking responces of 2 active constituents (ligand) showing interaction with optimized PDB.

DISCUSSION

The structural isomers of denatured proteins are incredibly diverse and usually lack the biological activity that were intended for them. Structural and functional characterization of denatured proteins has commonly been viewed as an intimidating and fruitless endeavor due to the intricate structure and absence of biological function. Denatured protein characterization has become more crucial, though, as it has been shown that many inflammatory and neurological illnesses are caused by conformational changes in proteins. A thorough analysis of the various isomers of disease-associated proteins would be necessary in any effort to clarify the cause of these illnesses. Furthermore, it is possible that one of the richest sources of biomolecules that has not yet been utilized for the detection and treatment of disease is conformational isomers of denatured proteins. Animal models are used in pharmaceutical research nowadays, however this has its drawbacks, including ethical concerns and altered bodily homeostasis mechanisms under stressful conditions. We search for alternate approaches from the perspective of fundamental mechanisms as a result of this issue [13]. Therefore, in order to evaluate Piper betel's in vitro anti-inflammatory properties, the protein de-naturation assay methods were chosen for this work. A well-established cause of inflammation-related diseases like arthritis is protein de-naturation, which is one of the main characteristics of inflammatory tissue. It is thought that an agent with anti-protein denaturetion properties may one day be employed as a highly effective anti-inflammatory medication.

In India, thousands of tonnes of crop are lost due to lack of exploration in the agro-economy of this crop, particularly in the post-harvest phase. The industrial promise of producing anti-inflammatory drugs and other nutraceuticals from *Piper betel* is therefore promising. The current study assessed *Piper betel's* in vitro protein denaturation activity in comparison to heat-induced protein denaturation. The chosen plant flower extract exhibits concentration-dependent anti-protein denaturation, according to the current data. Denatured proteins from lysosomal contents were released, triggering an inflammatory reaction that resulted in extracellular release of proteases and neutrophil activation. A qualitative study of the *Piper betel* flower extract indicated the presence of many phytochemicals, including alkaloids, flavonoids, polyphenols, steroids, carbohydrates, and tannins. Many of these bioactive substances have well-established potential biological characteristics. These bioactive substances may be the cause of Paan's or *Piper betel* flower ability to inhibit protein denaturation. Instead of a single effect, there can be a synergistic one.

Piper betel flower extract has the potential to scavenge free radicals on DPPH, as demonstrated by its in vitro antioxidant activity. Rich reductive ability is exhibited by the extracts, which reduced the majority of the Fe3+ ions. In comparison with various standards, including ascorbic acid and BHT, the extract exhibited robust scavenging properties against superoxide anion and hydroxy radicals. Free radical scavenging and reduction of free radical-induced cell damage are presumably the antioxidant roles played by *Piper betel* flower extract. The natural antioxidants found in medicinal plants are helpful in reducing or avoiding the harmful effects of oxidative stress. The DPPH free radical scavenging assay and the reducing power assay were used in this study to assess the scavenging abilities of ethanolic extracts of Piper betle flowers.Any substance's ability to reduce really depends on the existence of reductants, which have the ability to exhibit anti-oxidative properties by donating an atom of hydrogen to break the free radical chain. In this approach, the ferric (Fe)/ferricyanide complex was reduced to the ferrous form (Fe) by the presence of reductants or antioxidants in ethanolic extracts. The ferrous form (Fe) is thus reached by the concentration procedure. Consequently, Prussian blue from Perl at a wavelength of 700 nm.

Hydroxychavicol and Eugenol Binding Affinity (ΔG) are -74.13 and -54.04, respectively, with a docking score of -4.6639 and -4.1768 when matched with antiarthritis activity. Hydroxychavicol contains one hydrogen bond, but ethanol contains none. A single active molecule, hydroxychavichol, has a docking score of -5.0856, its binding affinity (ΔG) is -99.18, and there are two hydrogen bond interactions, according to molecular docking research on antioxidant activity.

CONCLUSION

There have been reports that a number of non-steroidal anti-inflammatory medications can prevent protein denaturation. Thus, it can be inferred from the results of this exploratory experiment that *Piper betel* flowers ethanolic and aqueous extract significantly reduced protein denaturation in vitro, but Ethanolic extract reduces more protein denaturation than Alcoholic extract. Thus, additional research should be done to assess this plant's anti-inflammatory properties in the search for newer.

The current studies have so established the antioxidant activity of ethanolic flower extracts of the *Piper betle* plant. From the DPPH assay IC50 value of the extract of *Piper betel* flowers free radical scavenging activity 12.0 mg/ml and Scavenging of Superoxide anion radical IC_{50} values 20 mg/ml. According to the results of the current research, *piper betel* flowers may be utilized as a natural antioxidant source. We can conclude from in silico studies that hydroxychavicol, a major antioxidant active constituent found in *Piper betel* flower extract, has a major binding affinity, and that eugenol has an affinity for optimized PDB 3J9J. These studies also demonstrate that hydroxychavicol and eugenol have an inhibitory action on COX1 and COX2, which leads to antiarthritic activity.

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Table 1: Extraction of *Piper betel* extract bioactive compound found

Particulars	Observation
Alkaloids	+++
Flavonoids	+++
PolyPhenols	+++
Tannin	+++
Carbohydrate	+++
Saponin	-
Carbonyls	+++
Terpenoids	-
Proteins	+++
Sterols	+++
Triterpensess	+++
Anthraquinon	-

Table 2: *In vitro* anti protein denaturation activity of aqueous and ethanolic extract of *Piper betel*(flower)

Treatment	Concentration(µg/ml)	% Inhibition
Ethanolic Extract	50	39.05
	75	44.17
	100	48.95
Aqueous Extract	50	30.28
	75	32.50
	100	35.04
Sodium Diclofenac	50	49.00
	75	67.14
	100	85.33

Table. 3. Measurement of DPPH assay

Treatment	Concentration (mg/ml)	%AA	IC_{50}
Piper betel flower extract	05	44.07 ± 1.44	12.00mg/ml
	10	47.05 ± 3.59	
	15	60.34 ± 5.20	
	20	66.50 ± 2.90	
	25	72.02 ± 3.86	
Ascorbic acid	05	47.60 ± 9.84	5.35mg/ml
	10	55.39 ± 14.4	
	15	67.42 ± 7.07	
	20	72.81 ± 5.33	
	25	76.20 ± 6.50	

The three parallel measurements' mean ± SD is shown as the result. %AA is the antioxidant activity percentage. 50% inhibitory concentration, or IC50.

Table. 4. Measurement of Reductive ability of *Piper betel* flower extract

Treatment	Concentration (mg/ml)	Absorbance
Blank		0.4279 ± 0.18
Piper betel flower extract	10	0.4403 ± 0.23
	20	0.4831 ± 0.42
	30	0.5570 ± 0.12
	40	0.8087 ± 0.78
	50	0.8092 ± 0.65
BHT	10	0.5071 ± 0.24
	20	0.5823 ± 0.31
	30	0.6068 ± 0.28
	40	0.7535 ± 0.35
	50	0.8562 ± 0.29

The three parallel measurements' mean ± standard deviation are the results.

Table. 5 Scavenging of Superoxide anion radical (NBT)

Treatment	Concentration (mg/ml)	%AA	IC_{50}
Piper betel flower extract	10	28.01 ± 3.16	20mg/ml
	20	50.77 ± 7.70	
	30	57.01 ± 5.50	
	40	60.50 ± 4.72	
	50	66.24 ± 3.57	
Ascorbic acid	10	34.72 ± 7.43	22mg/ml
	20	48.44 ± 4.05	
	30	56.12 ± 12.5	
	40	68.28 ± 4.96	
	50	77.82 ± 9.89	

The three parallel measurements are combined to get the mean ± SD

Table 6. Comparative scores obtained from molecular docking responces of 2 active constituents(ligand) showing interaction with optimized PDB.
Antiarthritis activity

Sr. no.	Compoundname	Dockingscore	BindingAffinity (ΔG)	Interaction
1	Hydroxychavichol	-4.6639	-74.13	1 Hydrogen Bond(TYR175A)
2	Eugenol	-4.1768	-54.04	No Hydrogen bond

Table 7.Comparative scores obtained from molecular docking responces of 1 active constituents(ligand) showing interaction with optimized PDB.

Sr. no.	Compoundname	Dockingscore	BindingAffinity (ΔG)	Interaction
1	Hydroxychavichol	-5.0856	-99.18	2 Hydrogen Bonds (SER1082C)



Fig. 1 *Piper betel* plant



Fig. 2 *Piper betel* Flower

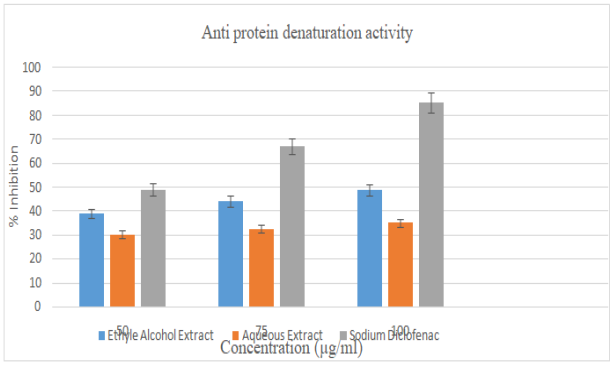


Fig no.3 Comparative analysis of inhibition percentage of protein denaturation in different extract of *Piper betel* flower.

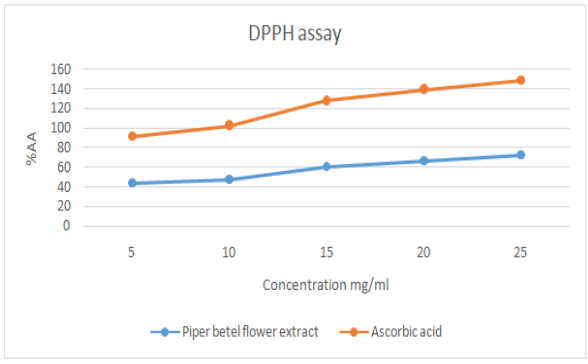


Fig. no. 4 DPPH assay results

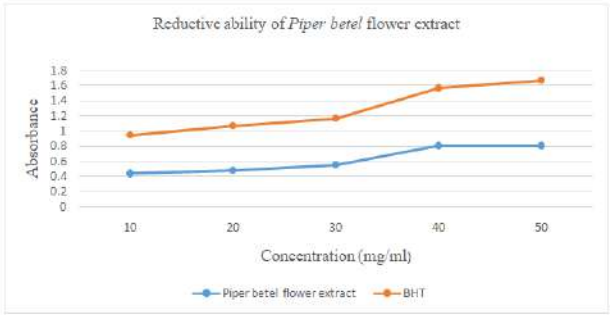


Fig.no .5 Reductive ability of *Piper betel* flower extract Results

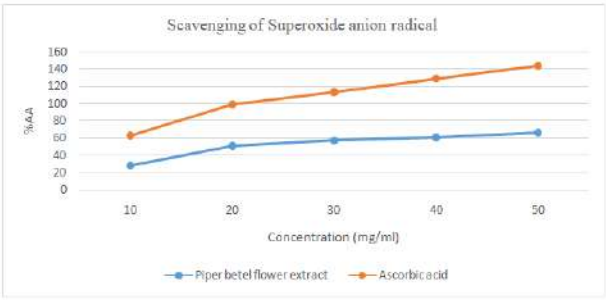


Fig.no.6 Scavenging of Superoxide anion radical results

Anti- Arthritis Activity

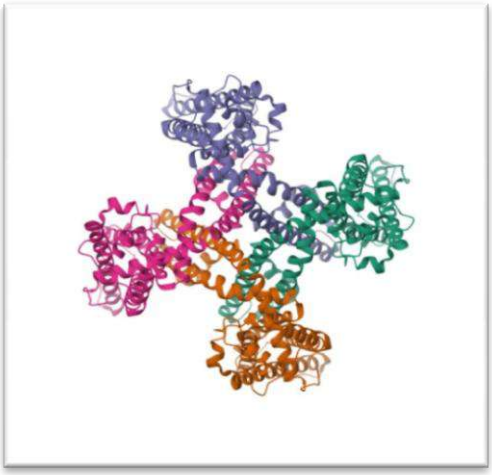


Fig.no. 7 Structure of 3J9J obtained from RCSB protein data bank

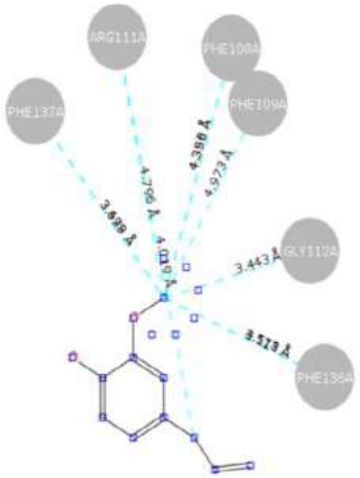


Fig.no.8 Structure showing interactions of Eugenol with 3J9J PDB

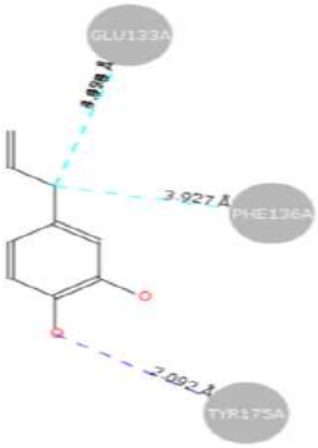


Fig.no. 9 Structure showing interactions of Hydroxychavichol with 3J9J PDB

Antioxidant Activity

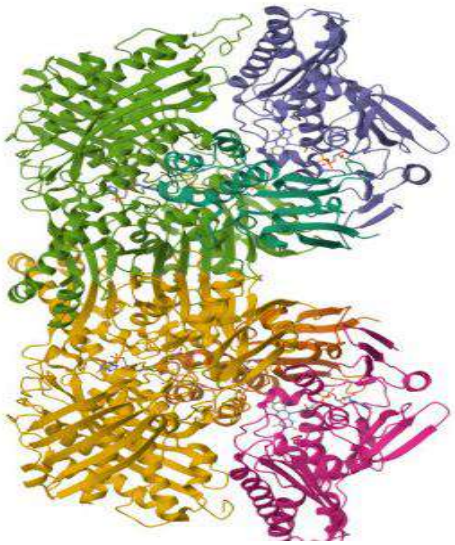


Fig.no. 10 Structure of 3EUB obtained from RCSB protein drug bank

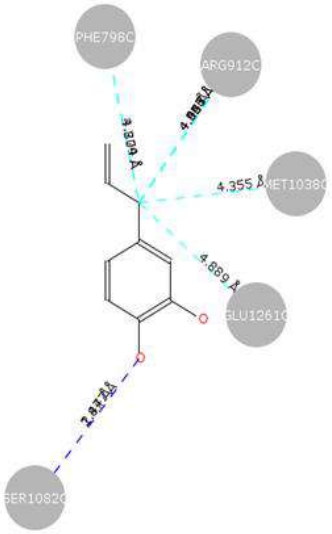


Fig.no. 11 Structure showing interaction of Hydroxychavichol with 3EUB PDB

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RESEARCH ARTICLE

A Study to Determine Gender Variation of Maxillary Sinus Dimensions by 3D CT in Adult Population of Western Uttar Pradesh Region

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ABSTRACT

The Maxillary sinus is one of the four pairs of paranasal sinuses located in the skull. The maxillary sinus is situated within the maxillary bone, which is the large bone of the upper jaw. There is two MS, one on each side of the nose. The size of the MS can vary among individuals, and it tends to enlarge as a person grows. MS are particularly sensitive to sexual dimorphism in terms of dimensions including volume, length, width and height. Understanding how MS varies by gender has applications in numerous fields such as in radiology, dentistry, clinical diagnosis, surgical planning, gender determination in forensic and earlier disease detection are all possible because to an appreciation of these differences. In cases involving pathology or anatomical anomalies of MS it can increase the accuracy of diagnosis.The significance of this knowledge in disease screening and early management is further emphasised by the possible link between sinus dimensions and systemic disorders. Computed tomography (CT) imaging is a revolutionary way for determiningMS dimensions and accurate measurements of sinus. CT scan guarantee excellent accuracy and precision in measurements due to their three-dimensional characters.

Keywords: Maxillary Sinus (MS), Computed Tomography (CT).

INTRODUCTION

Each side of human skull contains air filled chambers called maxillary sinus or maxillary antra. Due to their diagnostic and forensic importance, sinus is increasingly being examined with imaging methods such as three-dimensional computed tomography (3D CT) scans. Several anatomical structures are found in close proximity to maxillary sinus (Joe Ivanga *et al.,* 2019). Due to their convenient anatomic placement, 3D CT imaging of the maxillary sinus has proven to be of great value in investigations at identifying a person`s gender (Gulec *et al.,* 2020). Many anatomical changes, including hypoplasia, antral septa, and bone exostosis, can be seen in the maxillary sinus (Naroa Lozano *et al.,* 2017). The possibility of membrane perforation during sinus floor elevation is increased in patients having maxillary sinus septa (A.Hungerbuhler *et al.,* 2019). Anatomical structures which are commonly found include maxillary sinus septa (M.E. Toprak *et al.,* 2021). The maxillary sinus septum formed with the evolution of the middle face region of the skull and is largely developed in all maxillary sinus regions (Young *et al.,* 2011). The volume of the maxillary sinus is correlated with specific characteristics such side, gender, lack of posterior teeth, thickening of the sinus membrane, bony septa, and sagittal and vertical skeletal patterns (Anne Maria *et al.,* 2022). Septa with a transverse orientation are most prevalent in the middle section of the sinus (Henriques *et al.,* 2022).

The ethmoid, sphenoid, frontal, and maxillary sinuses are the four complicated anatomical structures that together make up the paranasal sinuses (Sophie Lee *et al.,* 2022). To distinguish between normal development and unusually massive, hypoplastic, or deformed sinuses, one must be aware of the stages of sinus growth (Adam *et al.,* 2021). There is also a relation between headache and smaller paranasal sinus volume (Levent *et al.,* 2019). The maxillary sinus has two postnatal period at which it grows rapidly 0–3 is the first period's age range, and 7–12 is the second.After the age of twelve, it proceeds to develop slowly until it reaches full maturity. The maxillary sinus became fully mature at the ages between 18-20. After this age any changes in the measurement of maxillary sinus will be sign of pathology and variation of sinus. The shape and size of sinus are affected by many factors including environment, genetics or any kind of infections. A routine implant procedure or tooth extraction could have complications that can affect the craniofacial anatomy.Therefore, it is essential to have a solid understanding of the anatomy and measurements of the maxillary sinus (M. Gulec et al 2020).

Computed Tomography: Basics

Computed Tomography (CT), also referred to as Computerized Axial Tomography (CAT) scan, stands as a pivotal medical imaging technique that has transformed diagnostic medicine by delivering intricate cross-sectional images of the body's internal structures. This imaging modality relies on X-ray technology to generate comprehensive and highly detailed images, empowering healthcare professionals with the capability to observe and scrutinize various anatomical regions with exceptional precision. The advent of CT scans has significantly enhanced diagnostic capabilities, allowing for more accurate and detailed assessments in the field of medical imaging (Seeram. E 2010). X-ray computed tomography (CT) is a non-destructive technique which can disclose an object inside details in three dimensions (Philip *et al.,* 2021). Accurate tissue/organ separation between the various body compartments, such as adipose tissue, skeletal muscle, bones, and organs, is made possible by the high-resolution CT imaging (Michalis *et al.,* 2016). Recent developments in CT technology include extreme multidetector CT, iterative reconstruction methods, dual-energy CT, cone-beam CT, portable CT, and phase-contrast. These advancements are anticipated to have, a substantial therapeutic impact (Daniel Thomas *et al.,*2014). These developments might be analyzed in terms of how they affect clinical practice, how they enhance performance (Jiang *et al.,* 2021). Due to the rise in CT exams conducted globally, radiation dosage in x-ray computed tomography (CT) has drawn a lot of attention. Patient dosage assessment is still an area in need of progress and global consistency (Willi 2014). Furthermore, with positive results, fresh image reconstruction methods that lower radiation exposure have been developed recently (Stephen *et al.,* 2016). The capacity to collect data in various energy bins is suggested by recent developments in the use of energy-resolving, photon-counting detectors for CT imaging. This is anticipated to further improve the signal-to-

noise ratio for material-specific imaging (Cynthia *et al.,* 2015). When suitable scan lengths within each imaging procedure are strictly followed, whenever possible, there is great opportunity for dosage optimization (Mohamed *et al.,* 2015). Several technical methods can be used to obtain dual-energy information in computed tomography (Nils *et al.,* 2020). Computed tomography makes it feasible to take measurements with high precision (Saccucci *et al.,* 2015).

Development of Maxillary Sinus

The intricate anatomy of the paranasal sinuses exhibits individual variance. Normative values for the size of the paranasal sinuses and how they vary with age may be useful in determining whether certain disorders affecting the sinonasal area are present (Degermenci *et al.,* 2016). Different maxillary sinus diameters experience development spikes at various Intra Uterine Life phases. Anteroposterior diameter values grow from the start of intrauterine life to the end. Throughout life, male maxillary sinuses stay comparatively larger (Ghaus *et al.,* 2006). Males have larger width of maxillary sinus when compared with females,which is useful in determining gender dimorphism (Franciellen et al 2022).

Pathology of Maxillary sinus

The dental and otolaryngology communities both admit the existence of a well-known disorder called odontogenic maxillary sinusitis (Kasikcioglu *et al.,*2016). There might be an underlying dental pathology in about 30% of cases of unilateral maxillary sinusitis (George Psillas *et al.,* 2021). The etiology of persistent odontogenic maxillary sinusitis (OMS) was examined using histopathology of the maxillary sinus mucosa, and the significance of endoscopic sinus surgery (ESS) was elucidated (Sato *et al.,* 2020). For individuals with recurrent and refractory sinusitis, functional endoscopic sinus surgery is a successful treatment option. Radiologists can use preoperative computed tomography (CT) to prospectively identify anatomic variants that put patients at risk for significant surgical problems (William *et al.,* 2016). Maxillary sinus mucosal cysts (MMC) are often found during imaging examinations. It has been found that their prevalence can reach 35.6%. Although quantitative study is lacking, it is known from personal knowledge that numerous procedures are carried out to treat isolated MMC in the absence of symptoms (Evangelos I. Giotakis *et al.,* 2013). Mucous retention cysts (MRCs), sometimes referred to as antral or maxillary sinus pseudocysts, are one of the most frequent pathological observations of the maxillary sinus. They typically manifest as a radiopaque soft-tissue mass that is dome-shaped and linked to the sinus's bony walls (Kuofeng *et al.,* 2021). The variants of maxillary sinuses involve hypoplasia and aplasia, maxillary sinus septae, ethmomaxillary sinus, superior meatus-draining maxillary sinus, and over-pneumatization. Hypoplasia of the maxillary sinus is an exceptional disorder. Most people don't have any symptoms, although occasionally they experience facial pain and headaches (Banu Atalay 2021). Many of the maxillary sinus pathology can cause severe symptoms which lead to admit patients in departments like dentistry, Surgery, ENT (Adin Selcuk *et al.,* 2008). For otolaryngologists, rhinologists, oral and maxillofacial surgeons, dental and maxillofacial radiologists, the knowledge of maxillary sinus dimensions is crucial (Whyte *et al.,*2019). As one of the most prevalent congenital craniofacial defects, cleft lip and palate (CLP) can alter the morphology of the maxillary sinus, skull, and face because it disrupts the fusion of the palatal shelves (Yassaei *et al.,* 2023). Neurilemmoma, also known as Schwannoma, is a benign tumor that develops from Schwann cells that surround the nerve sheaths of the autonomic or peripheral nervous systems, particularly the sympathetic nervous system (Bader *et al.,* 2018). The most frequent sinonasal tumors are polyps and mucocele, while schwannoma is infrequently discovered in the paranasal sinuses (R.S.Minhas *et al.,* 2013). Under general anesthesia, a combination of endoscopic medial maxillectomy with Caldwell-Luc operation can be performed to eliminate the encapsulated mass entirely (Turgut *et al.,* 2022).

The majority of incidental findings don't need to be treated, but some will need the treatment plan to be adjusted. Consequently, anatomical variances and incidental findings should be known to dental practitioners. If these findings are correctly identified, fewer needless additional diagnostic evaluations can be performed, and more suitable treatment options can be chosen (Hakan *et al.,* 2018). Before any treatments that involve close approach to the sinus floor, like tooth extraction, implant insertion, and sinus floor elevation, it is crucial to visualize and evaluate the maxillary sinus (Andy *et al.,*) 20

Clinical Applications of dimensions

Anatomic variability across genders has been found by maxillary sinus measurements, and this methodology can be used as a supplementary tool for human identification in forensics. (Nikolas*et al.,* 2023). By evaluating dimensions of maxillary sinus, gender can be identified (Oguzhan *et al.,* 2014). A trustworthy method for determining gender is the morphometric examination of the maxillary sinus (Tanya *et al.,* 2017). Maxillofacial and oral surgery heavily relies on accurate measurements of the maxillary sinus. Sinus dimensions might vary by gender, which can affect preoperative planning. To avoid difficulties during sinus floor elevation or implant insertion, surgeons must be aware of variances in the size and position of the maxillary sinus. Since septa are frequently present and are detected in one-third to roughly half of the investigated cases, a thorough inspection is necessary before doing any surgical procedures in order to prevent any potential consequences (Amani *et al.,*2023). Before doing any maxillary sinus augmentation, a thorough assessment of various anatomic anomalies must be carried out, especially in elderly individuals (Mohammed *et al.,*2020). Accurate and risk-free surgical procedures are made possible by the anatomical insights provided by 3D CT scans. The posterior maxilla is a typical area for dental implant insertion. The importance of knowing the maxillary sinus's size cannot be overstated. Gender differences can affect how long implants are and where they're placed. For men with larger maxillary sinuses, for instance, the implant may need to be longer or the sinus floor elevated. However, women with narrower sinuses may have to adjust how their implants are placed (Mathew *et al.,* 2020).

DISCUSSION

To get a complete picture of the range of maxillary sinus volume, the study included participants of varying ages and sexes. Cone beam computed tomography (CBCT), which provides high-resolution, three-dimensional imaging, was the principal technique used to record the maxillary sinuses' anatomical structure. The data was analysed to reveal potential differences in maxillary sinus size across the sexes and age groups. Ex differences in maxillary sinus size were validated by the research. In every three-dimensional CBCT analysis, males were found to have larger maxillary sinuses than females. Consistent with prior investigations, this one found that maxillary sinus diameters differ by gender. The consistency of the results across age groups demonstrates the validity and strength of the study. The use of CBCT enabled more accurate measurements, strengthening the reliability of the results. This research underlined the precision and potential of CBCT in determining maxillary sinus architecture. It demonstrated the value of this imaging method for comprehending differences between the. sexes along these lines. Clear evidence of sexual dimorphism in maxillary sinus dimensions was found in the study by Aktuna Belgin and her colleagues, who used CBCT for three-dimensional evaluation. Consistency in findings across age groups demonstrates the validity and versatility of this approach. This study's use of CBCT demonstrates the reliability and promise of this imaging modality for determining gender based on maxillary sinus morphology (Aktuna Belgin *et al.,* 2019).

Researchers in Oral Radiology look at the posterior maxillary region, which is hard for dentists to work with because of its intricate architecture. Cone beam computed tomography (CBCT) scans from 212 patients will be analyzed in this study in order to ascertain the average diameters and frequency of maxillary sinus abnormalities by age and gender. This information is clinically important for surgery; hence the study also looks at how changes are influenced by maxillary sinus sizes. 77.8% of the time, at least one anatomical variation occurs; the most frequent variant is the auxiliary ostium. The investigation examines whether gender, age, and variations impact maxillary sinus morphometry using chi-square, independent t, and one-way Anova. The conclusion emphasizes comprehensive pre-surgical screening to prevent problems because of usual anatomical variances. The study by Ayyildiz and Akgunlu highlights the three-dimensional evaluations of CBCT. This enhances the precision and security of challenging maxillary posterior dental procedures (Ayyildiz & Akgunlu, 2023).

All of the maxillary sinus measurements were taken using computed tomography (CT) scans, a non-invasive and extremely precise imaging method. The study's major aim was to look into whether or not there is a difference in the size of the maxillary sinuses between sexes, hence it included both males and females in its cohort. In order to get

precise measurements, Sharma and his group used 3D CT scans to get detailed images of the maxillary sinuses. Maxillary sinus diameters differed significantly between sexes, as demonstrated by this study. The maxillary sinuses of males were measured and found to be significantly larger than those of females. The existence of sexual dimorphism along these dimensions was therefore highlighted. The maxillary sinuses were studied for their volume, length, width, and height, all of which contributed to the reliable separation of the sexes. This study highlighted the importance of maxillary sinus measurements outside of the forensics field. Maxillofacial surgery, orthodontics, and even general medical imaging can all benefit from a deeper understanding and quantification of these differences. The therapeutic importance of the study was further emphasised by the exact measurements obtained by 3D CT scans, which increased the dependability of these findings (Sharma *et al.,* 2014).

A study was conducted on maxillary sinus development in children up to 18 years old, published in the International Journal of Paediatric Otorhinolaryngology. Clinically, understanding how the maxillary sinus changes in size and volume with age helps evaluate radiographs and discover irregularities. The research of CT scans from 170 participants across 17 age groups shows a continuous maxillary sinus growth trajectory from birth to 18 years. Changes are noticeable in horizontal, vertical, and antero-posterior dimensions. Although bilateral dimorphism is absent, gender differences appear in children above 8. According to the study, most growth occurs in the first eight years, and all diameters and volumes peak by the sixteenth year. The study shows that CT scans may reliably assess age-related maxillary sinus changes. This wealth of developmental data helps us comprehend sinus growth, which enhances early sinus anomaly diagnosis and clinical evaluations in children (Lorkiewicz-Muszyńska *et al.,* 2015).
Maxillary sinus sexual dimorphism is investigated in a study with cone beam computed tomography (CBCT). CBCT measurements were made of the bilateral maxillary sinus width, length, height, area, perimeter, and volume in 100 patients (50 males and 50 women). For most measures, there are no significant gender differences according to the statistical analysis's unpaired t-tests. Nonetheless, the left side maxillary sinus width of the female group displayed statistically significant greater values, suggesting that it may, with 60% accuracy, determine gender. In forensic anthropology, discriminative analysis reveals that the maxillary sinuses more precisely, its width—can predict gender 71% of the time. (Urooge& Patil, 2017).

A study was done to look at how children's maxillary sinus volumes changed with age. 150 children, ages 0 to 18, had their height, width, and depth measured by CT. The investigation reveals noteworthy patterns of maxillary sinus growth. In every age group, maxillary sinus height increases gradually from birth to age 18. Children under the age of six and those beyond the age of twelve have markedly broader and deeper maxillary sinuses, which indicate distinct phases of growth expansion. The maxillary sinus does not enlarge in width, depth, or volume after 12. This makes the finding puzzling. The complex dynamics of the maxillary sinus during childhood are clarified by this work. Age-specific development patterns are useful to researchers and physicians because they highlight typical disparities. The work of Bhushan et al. highlights the significance of taking into account a variety of elements in order to comprehend the complex development of the maxillary sinus during childhood (Bhushan *et al.,* 2016).

Using CT scans, the study evaluated children ages 0 to 18 for potential sexual dimorphism of the maxillary sinus. The study involved the retrospective examination of 170 patients, aged 0-18 (85 females and 85 males), whose CT scans of the head were deemed normal by radiologists. All the patients had their maxillary sinuses measured bilaterally in three planes. The maximum vertical diameter (the maxillary sinus height, MSH); maximum anteroposterior diameter (the maxillary sinus length, MSL); and maximum transverse (horizontal) diameter (the maxillary sinus width, MSW) were measured. Depending on the ontogenesis stage, the sexual dimorphism of maxillary sinus characteristics varies. Males have larger maxillary sinuses at 2-3 years old according to all examined criteria (Agnieszka *et al.,*2020).

Patients with cystic fibrosis (CF) deal with a severe systemic condition that impacts many facets of their lives. The children with the disease and the control group's computed tomography (CT) scan findings were analyzed. 126 pictures of healthy children aged 0 to 18 and 114 CT images of the study group's children were included in the study. Analysis was done on the frontal, sphenoid, and maxillary sinus volumes. The outcomes were statistically evaluated

and compared with those of the control group. Statistically significant differences were seen between the study and control groups, despite the fact that both groups' paranasal sinus volumes and developments grew with age (Agata et al 2024). The purpose of this research is to measure the maxillary sinus volumes and areas in patients with clinically unilateral sinus disease. A total of 50 individuals (28 men and 22 women, ages 43.6 years (SD = 18.3), had their contralateral sinuses measured, 50 of which had pathological sinuses and the other 50 of which were healthy. The afflicted sinuses had a three-dimensional occupation volume of 97.1 mm3 (62.5%), while the healthy sinuses had a volume of 40.6 mm3 (22.8%) ($p<0.0001$). In the frontal plane, the group with cysts had a substantially wider medial-lateral sinus (32.4 mm, CI: 23-41.8 mm) (Mario *et al.,* 2020).

This study sought to determine if sex could be ascertained by using maxillary sinus measures from CBCT scans. One hundred patients (fifty males and fifty females) had their maxillary sinus width, length, and height measured using CBCT pictures. One hundred patients (fifty males and fifty females) had their maxillary sinus width, length, and height measured using CBCT pictures. Male and female differences in the measured parameters were compared using the student's t-test and discriminant function analysis. 78% of females and 74% of males correctly predicted their sex, for an overall accuracy of 76%. Maxillary sinus height was the most noticeable factor in the distinction of sex groups, according to discriminant analysis (Maryam 2017). The average age of 60 adults (31 females and 29 males) was found to be 29.90 ± 10.91 years. They were categorized into three groups based on skeletal vertical face growth patterns: high-angle, low-angle, and normal-angle participants. Using CBCT images, the maxillary sinuses' morphological and dimensional alterations were assessed. In terms of the right maxillary sinus length parameter, the low-angle vertical growth pattern group achieved noticeably superior outcomes than the high-angle group (Ridvan 2017).

The aim of the current investigation was to create an automated instrument that measures the combined air-free and total volume of the maxillary sinus by utilizing computed tomography images. The quantification tool aims to normalize measurements of maxillary sinus volume, so enabling improved analyses and comparisons of the variables affecting maxillary sinus size. The automated instrument made use of morphological operators, thresholds, and watersheds in image processing. In thirty patients, the maxillary sinus volume was measured. To assess the precision of the automated technology, and the outcomes were contrasted with segmentation carried out manually by a skilled radiology professional following a defined protocol. For the total and air-free maxillary sinus volume, the mean percent differences between the automated and manual approaches were 7.19% ± 5.83% and 6.93% ± 4.29%, respectively (Guilherme *et al.,* 2018).

The purpose of this study was to use computed tomographic (CT) scanning based on gender to measure the dimensions of the right and left maxillary sinus in Turkmen ethnic groups living in Gorgan, northern Iran. 100 individual's maxillary sinus were measured after scanning. Males had greater width, height, and volume of the left and right maxillary sinuses than females (Arash *et al.,* 2021). An analysis of the impact of concha bullosa variation on maxillary sinus volume and uncinate angle was conducted. The maxillary sinus volume, uncinate angle, and presence of concha bullosa were measured from the paranasal sinus computed tomography of these patients. maxillary sinus volume and the uncinate angle were same in patients with and without concha bullosa (Uygar *et al.,* 2014). Maxillary sinus evaluation requires radiographic inspection, particularly on CBCT pictures, there is a clear correlation between maxillary sinus septa occurrence and ostium height.It was discovered that the size of maxillary sinus drainage system was not significantly impacted by nasal septal deviation, concha bullosa, Haller cells, or other sinusopathies (Gulsun *et al.,* 2020).

CONCLUSION

The size of the maxillary sinuses has been shown to vary by sex in a large number of studies. The maxillary sinuses of males are larger than those of females in terms of volume, length, width, and height. Understanding how maxillary sinus size varies by gender has applications outside of forensics. It has applications in radiology, anatomy, dentistry,

illness screening, therapy monitoring, clinical diagnosis, and surgical planning. Better patient care, precise surgical planning, fewer surgical complications, and earlier disease detection are all possible because to an appreciation of these differences. In cases involving pathology or anatomical anomalies of the maxillary sinuses, it can increase the accuracy of the diagnosis.

Knowing that men and women have different sized maxillary sinuses is crucially important. Because of this information, doctors may give patients more individualised care. Being aware of these differences is vital for achieving positive results whether diagnosing sinusitis, planning orthodontic operations, performing maxillofacial surgeries, or implanting dental prostheses. The significance of this knowledge in disease screening and early management is further emphasised by the possible link between sinus dimensions and systemic disorders. The clinical implications of maxillary sinus dimensions can be explored further in future studies. The implications of these differences on related medical fields and subpopulations of patients can be investigated.

The gender differences in sinus dimensions can be used in future research to produce individualised medicinal and surgical procedures. Care for patients and the success of treatments can both benefit from this method. Radiological methods of measuring the size of the maxillary sinuses need to be improved as technology advances. This could further boost diagnostic skills and improve patient care. Future research may benefit from focusing on the possible connections between systemic disorders and the size of the maxillary sinuses. If these associations can be understood, perhaps diseases can be detected and treated sooner. The maxillary sinuses and their anatomical variations should be a mandatory element of any medical or dental curriculum. For more precise instruction and diagnosis, more study can aid in the creation of educational methods and resources that take into account differences between the sexes.

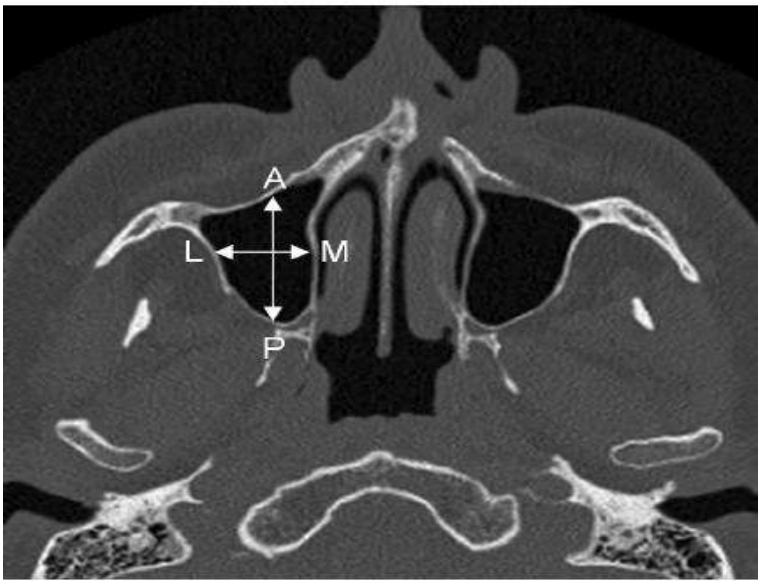
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Fig.1. Serial axial slice showing measurement of the maxillary sinus dimensions: anteroposterior (AP) and mediolateral (ML) measures were performed at 5, 10, 15 and 20 mm above the most apical level of the maxillary sinus floor.

RESEARCH ARTICLE

Class IV Laser Therapy on Ejection Fraction, Cardiac Biomarker and Functional Outcomes in Acute Coronary Syndrome: Randomized Sham Controlled Trial Protocol

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ABSTRACT

Acute Coronary Syndrome (ACS) is a major health issue that adversely affects survival as well as Disability Adjusted Life Years (DALYs). Early reperfusion is extremely important and a key component in the management of ACS. However, the process of reperfusion is also associated with myocardial reperfusion injury for which no preventive measure has been proven unequivocally effective. Aim of this trial is to explore the possible value of Class IV laser therapy in limiting myocardial reperfusion injury and thereby improving cardiovascular outcomes. This randomized sham-controlled trial is a prospective study which includes60 individuals with ACS who satisfy selection criteria will be randomly assigned

into two groups by block randomization. All the participants will receive guideline directed interventional and pharmacological therapy on discretion of treating cardiologist irrespective of randomization group. Experimental group will be given Class IV laser over 3 spots in 2nd, 3rd and 5thIntercostal Spaces for duration of 60 seconds at each spot, whereas in the control group laser probe will be placed over the same spots but the laser energy will not be delivered. Ejection fraction will be assessed at baseline and on third day, post intervention. Troponin I will be assessed at baseline, peak hours (at 10 hours after PCI) and 3rd post intervention. Functional outcomes will be assessed at baseline and after one month follow up. The trial will provide evidence for efficacy of class IV laser therapy to reducing myocardial reperfusion injury and improving cardiovascular outcomes among the individuals undergoing percutaneous coronary revascularization for ACS.

Keywords: ACS, Cardiac Biomarkers, Class IV Laser, Ejection Fraction.

INTRODUCTION

Acute Coronary Syndrome (ACS) is a major health issue that adversely affects survival as well as Disability Adjusted Life Years (DALYs) which accounts for approximately annually 7 million deaths and 129 million DALYs [1, 2]. In India, CVD accounts for one fourth of all mortality [3]. Early reperfusion of the ischemic area followed by coronary artery occlusion is accepted, extremely important and a key component in management of ACS to reduces size of infarction and improving cardiovascular outcomes [4, 5]. Reperfusion of an ischemic cardiac tissue (ischemia of more than 45 minutes) itself induced myocardial injury and death of cardio myocytes, phenomenon called as myocardial reperfusion injury [5, 6]. Some experimental studies suggest that reperfusion injury accounts for upto 50% of the final size of infarction [5]. However, currently there is no preventive measure has been proven unequivocally effective to prevent this myocardial reperfusion injury in post revascularization patients [7]. Photobiomodulation in the form of low level laser therapy (LLLT) is a novel cardiac intervention which reduces the infarct size, decreases inflammation and scarring, controls cardiac damage as evidenced by bio-marker levels and enhances tissue repair [8]. Effects of LLLT in cases of myocardial injury are well documented in in-vivo and in-vitro animal models, as well as in human clinical trials to prevent myocardial reperfusion injury. Class IV laser is a recent advancement in the field of laser therapy which overcomes the limitations of low level laser, as it has higher tissue penetration.

Study objectives

This is a pre- post test randomized sham controlled trial to assess the effectiveness of class IV laser to limit the myocardial reperfusion injury.

MATERIAL & METHODS

The study is a pre-post test randomized sham controlled trial; Figure 1 shows an overview of this trial plan. The Helsinki Declaration (updated, 2013) and National standards for biomedical and health research involving human subjects (Indian Council of Medical Research, 2017) shall serve as the guidelines for this study. The Maharishi Markandeshwar Institute of Medical Sciences & Research's Institutional Research Ethics Committee gave its approval for this study at Mullana-Ambala, Haryana, India vide project ID: MMDU/IEC/2157. The trial is registered at clinicaltrials.gov (NCT05160519) on 02/12/2021 and Universal Trial number is U1111-1270-8393. This trial will follow the spirit (standard protocol items for randomized trials) guidelines.

Study Population

This experiment will involve people who have been diagnosed with acute coronary syndrome, have had angioplasty with drug-eluting implantation, are older than 18, and are hemodynamically stable. People with growths or tumors

near the mediastinum; those with pacemakers, either implanted or temporary; having left ventricular ejection fraction (LVEF) ≤ 30%; who are receiving photosensitive drugs; pregnant and epileptic individuals will be excluded from this study. Study procedure will be informed to the selected participants and asked to sign an informed consent for their voluntary participation. Using the effect size of 0.8 and the study's power of 80%, the sample size was determined using the G power program, version 3.1.9.4 (Heinrich Heine University Dusseldorf, North Rhine-Westphalia, Germany). Minimum sample size required is 54 (27 in each group). We planned to recruit a total sample size of 60, 30 individuals in each group including 10% dropout rate.

Randomization and Blinding

Block randomization procedure will be conducted manually by drawing 60 blocks (15 rows with 4 blocks in each row). The primary investigator is a more than five year experienced cardio-respiratory therapist who provide laser irradiation and the cardiologist who perform echocardiography, the lab technician who assess cardio biomarker will be blinded. Laser protected eye wears will be used for participants blinding.

Study Procedure

After assessing the baseline outcome measures, the experimental group will be irradiated with Class IV laser for three days; immediately (within 30 minutes) after the angioplasty and subsequent two days. The irradiation will be given at three areas over the pericardium (left sternal border to mid clavicular line in the 2nd, 3rd intercostal space and over the apex) [10] for a duration of 60 seconds at each point as shown in figure 2. The dosage of laser irradiation will be $6J/cm^2$ over three areas for 60 seconds at each area with a laser power of 6W and wavelength of 980nm using LCT-1000C (LiteCure Medical). Total energy delivered over one area will be 360J. During the irradiation phase, the probe will be placed perpendicularly and in direct contact with the skin. ECG rhythm and other vitals will be keenly observed during the entire period of irradiation. To maintain laser standard practice, both the participant and the laser provider will wear laser-protected eyewear. The sham control group, on the other hand, will have the identical class IV laser probe over the same regions, but laser energy will not be given. All the participants will receive pharmacological therapy on discretion of treating cardiologist irrespective of randomization group.

Outcome measures

Basic demographic details and medical history will be taken prior to the outcome measures.

Cardiac Biomarker

Troponin is the best marker for definitive diagnosis of acute myocardial injury [11]. Troponin I is used as an early marker as it is more sensitive. Normal reference range of troponin I is 0.04ng/ml [12]. Cardiac Biomarker Troponin I will be assessed by lab investigations. Troponin I will be evaluated at three times: at baseline, at peak hours (after 10 hour of PCI) and on third day post intervention.

Ejection Fraction

One clear way to measure the left ventricle's systolic function is to look at its left ventricular ejection fraction (LVEF). Normal range of LVEF as per the European Association of Cardiovascular imaging and American society of Echocardiography is 52%-72% and 50%-70% as per the American college of Cardiology, and less than 30% is labeled as severe dysfunction [13]. LVEF will be assessed by Philips EPIQ 7 echocardiography and at two time periods: baseline and third day post intervention.

Functional outcomes

A self-administrated Seattle Angina Questionnaire (SAQ) will be used to assess functional status and Quality of life in patients with coronary artery disease. It measures all five major domains of health related quality of life- physical limitation, angina stability, angina frequency, treatment satisfaction and quality of life [14, 15]. SAQ will be assessed at baseline and after one month follow up. Figure 3 shows the enrollment, intervention and assessment schedule.

The chairman of the student project committee will lead the Data and Safety Monitoring Committee (DSMC), which will keep an eye on the data that is gathered and will routinely audit the trial. All this will not be informed to the primary researcher.

RESULTS/ STATISTICAL PLAN

The Statistical Package of Social Sciences (SPSS) version 20 will be used for analysis. Kolmogorov-Smirnov test will be used to assess normality of the data. For normally distributed data, the descriptive statistics will be expressed as mean ± SD and 95% confidence interval and Paired t test will be used for within group comparison and unpaired t test for between the group comparison. For not normally distributed data, the descriptive statistics will be expressed as median (interquartile range) with range and Mann-Whitney U test will be used for within group comparison and Wilcoxon signed rank test for between the group analysis. Statistical significance will be set at $p<0.05$ to minimize type1 error. Post hoc power analysis will be performed using G power to verify whether the study attained sufficient power or not.

DISCUSSION

In this study, we intend to determine the efficacy of Class IV Laser therapy in improving cardiovascular outcomes in individuals undergoing percutaneous coronary intervention for ACS. We hypothesized that class IV laser therapy can have beneficial effects on LVEF, cardiac biomarkers and SAQ amongst individuals with acute coronary syndrome after undergoing coronary angioplasty. Myocardial reperfusion injury results as a complex redox stress response. Any mechanism which may change this deleterious redox stress response in to a protective redox reaction is essential to avoid this injury [16]. Multiple molecular and cellular mechanisms including mitochondrial respiration, mitochondrial signaling, modulation of inflammatory cytokines, pro-angiogenic and antioxidant actions of laser therapy in the form of low level laser therapy has been observed in number of animal trials [8, 17]. Most of the studies conducted among the animal model and *in-vitro* with low level laser therapy, were found to be effective in improving myocardial infarction size, improving inflammatory profile, reducing oxygen free radical and scarring of tissue [18, 19, 20, 21, 22, 23, 24]. In a human trial, the low level laser therapy after CABG is found to be effective in reduction of cardiac cellular damage and enhancing the tissue repair [10]. Post STEMI, LLLT to bone marrow is also effective to improve Troponin level without any delay in door to balloon time [25]. Low level laser therapy has its limitations as it has less deep penetration [26] with the help of class IV laser therapy we can overcome this limitation. So we can anticipate better outcomes with its use. In this trial, we are limiting the type 1 error less than 5% and type 2 errors less than 10% and this maybe the first study in exploring the cardioprotective effects of class IV laser therapy. Limitation of this trial can be single centered study and short duration of the intervention. This trial can be extended to assess the efficacy of class IV laser with different wavelength and power output and on other cardiac biomarkers like Myoglobin, BNP also. Study can also be conducted among individuals with coronary artery disease other than ACS.

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CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

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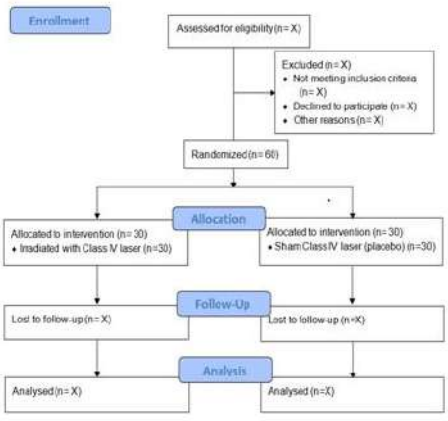


Figure 1: Flow Diagram of the study

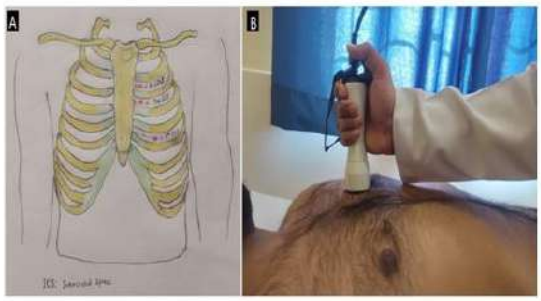


Figure 2: Placement of laser probe

Figure 3: Schedule of enrollment, intervention and assessment

	STUDY PERIOD							
	Enrolment	**Allocation**	**Post-allocation (treatment)**			**Follow-up (evaluations)**		
TIMEPOINT**	**Day 1**	**Day 1**	**Day 1 (Within 30 minutes after angioplasty)**	**Day 2**	**Day 3**	**10 hour post angioplasty**	**Day 3**	**Follow up at 1 month**
ENROLLMENT:								
Eligibility screen	X							
Informed consent	X							
Randomization		X						
Allocation		X						
INTERVENTIONS:								
Group A: Experimental			X	X	X			
Group B: Sham Control			X	X	X			
ASSESSMENTS:								
Troponin I		X				X	X	
Ejection Fraction		X					X	
Seattle angina Questionnaire		X						X

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RESEARCH ARTICLE

On Disconnected Spaces via Liberal Class of Sets

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ABSTRACT

The main objective of this paper is to establish a novel concept of disconnectedness in topological spaces. We aim to examine the new spaces namely j-disconnectedness and extremally j-disconnectedness us- ing j-open sets. We also attempted to explore its properties using the- orems and suitable examples.

Keywords and Phrases : j-open set, j-separated set, j-disconnected, ex- tremally j-disconnected.
2020 Mathematics Subject Classification: 54G05

INTRODUCTION AND PRELIMINARIES

Connectedness is the massive topological property. In the same time we discuss the other side of connectedness equally disconnectedness in topological spaces. Many researchers have focused on finding various types of disconnectedness such as ba- sically disconnected, extremally disconnected, perfectly disconnected and totally disconnected in topological spaces [6,11]. Of all these areas extremally discon- nectedness has peculiar applications in topological spaces. Majority of researchers have examined this area of disconnectedness [2, 10]. In 1967, Dona discusses the characterization of disconnected spaces among Hausdorff spaces [4]. In 2013, Ma- jid Mirmiran found the various equivalent statements of extremally disconnected spaces [5]. Sanjay Mishra introduced alpha τ -disconnectedness and investigates the relationship between alpha τ -disconnected and alpha τ -connected sets in 2015 [7]. Recently, Researchers examined various properties of disconnected spaces in differ- ent topological spaces [3,9]. Motivated with these researchers we aimed to examine a new spaces called j-disconnectedness and extremally j-disconnectedness in topo- logical spaces using j-open sets. We also made an attempt to explore the properties of these spaces using theorems and suitable examples.

Throughout this paper (X, τ_X) denotes the topological space τ on X.

Definition 1.1 [1] A subset R of a topological space (X, τ_X) is said to be j-open if $R_1 \subseteq int(pcl(R_1))$. The complement of j-open set is j-closed.

Definition 1.2. [1] Let (X, τ_X) be a topological space and R_1 be any subset of (X, τ_X), then
The interior of R_1 is the union of all j-open sets contained in R_1 and it is denoted by $int_j(R_1)$. i.e., $int_j(R_1) = \bigcup \{M : M$ is j-open set and $M \subset R_1\}$.
the closure of R_1 is the intersection of all j-closed sets containing R_1 and it is denoted by $cl_j(R_1)$. i.e., $cl_j(R_1) = \bigcup \{N : N$ is j-closed set and $R_1 \subset N\}$

Remark 1.3. [1] If R_1 is a subset of any topological space (X, τ_X). Then
R_1 is j-open if and only if $int_j(R_1) = R_1$
R_1 is j-closed if and only if $cl_j(R_1) = R_1$
The family of all j-open sets of a topological space is denoted by $JO(X)$ (or) τ_j.

Remark 1.4. [2] If R_1 and R_2 are any two subsets of $(, \tau_X)$. Then the following statements are hold.
$int(\phi) = \phi$
$cl(\phi) = \phi$
$int(X) = X$
$cl(X) = X$
$int(R_1 \cap R_2) \supseteq int(R_1) \cap int(R_2)$
$cl(R_1 \cup R_2) \subseteq cl(R_1) \cup cl(R_2)$
$int(R_1) \subseteq R_1$
$cl(R_1) \supseteq R_1$

Definition 1.5. [8] Let (X, τ_X) be a topological space if the two nonempty subsets R_1 and R_2 of (X, τ_X) is said to be j-separated if and only if $R_1 \cap cl_j(R_2) = \phi$ and $cl_j(R_1) \cap R_2 = \phi$.

Definition 1.6. [8] A topological space (X, τ_X) is said to be j-connected if $X \neq R_1 \cup R_2$ where R_1 and R_2 are j-separated sets in X .

Definition 1.7. [7] A topological space (X, τ_X) is said to be disconnected if X can be expressed as a union of two non-empty open sets in X . i.e., $X = R_1 \cup R_2$ where R_1 and R_2 are two sets with $R_1 \cap R_2 = \phi$.

Definition 1.8. [5] A topological space (X, τ_X) is called as extremally disconnected if $cl(R_1)$ is open for every open sets R_1 of (X, τ_X).

Definition 1.9. [3] A fuzzy topological space (X, τ_X) is said to be extremally fuzzy α-disconnected if $cl_\alpha(\lambda)$ is fuzzy α-open for every fuzzy α- open sets of (X, τ_X).

Definition 1.10. [7] Let (X, τ_X) and (X, τ_α) be two topological spaces. Then R_1 and R_2 of (X, τ_X) are said to be α-τ separated if and only if R_1 and R_2 are non-empty, $R_1 \cap cl_\alpha(R_2) = \phi$ and $cl_\alpha(R_1) \cap R_2 = \phi$ also $R_1 \cap R_2 = \phi$

j-disconnected spaces
Definition 2.1. A topological space (X, τ_X) is said to be j-disconnected if X can be expressed as a union of two non-empty j-separated sets in (X, τ_X).

Example 2.2. Consider $X = \{q, r, s, t\}$ and $\tau_X = \{\phi, \{q\}, \{r, s, t\}, X\}$. For this topology, we have ϕ, $\{q\}$, $\{r, s, t\}$ and X are j-open sets. Then $X = \{q\} \cup \{r, s, t\}$. Since $\{q\}$ and $\{r, s, t\}$ of (X, τ_X) are j-separated sets. i.e.,$\{q\} \cap cl_j\{r, s, t\} = cl_j\{q\} \cap \{r, s, t\} = \phi$. Thus (X, τ_X) is a j-disconnected space.

Theorem 2.3. A topological space (X, τ_X) is disconnected if and only if (X, τ_X) is j-disconnected.
Proof Let us take a topological space (X, τ_X) to be a disconnected space. Then

$X = R \cup S$, where ϕ R and ϕ S, such that R and S are separated sets. This implies, $cl(R) \cap S = \phi$ and $R \cap cl(S) = \phi$. Also $cl_j(R) \subseteq cl(R)$, which implies, $cl_j(R) \cap S \subseteq cl(R) \cap S = \phi$. Correspondingly, $R \cap cl_j(S) \subseteq R \cap cl(S) = \phi$. Thus R and S are j-separated sets such that $X = R \cup S$. Hence (X, τ_X) is j-disconnected.

Conversely, suppose (X, τ_X) is not j-disconnected. Then we have, $cl_j(R) \cap S$ ϕ or $R \cap cl_j(S) \vDash \phi$, for any two j-open subsets R and S of (X, τ_X). This implies $cl(R) \cap S \vDash \phi$ or $R \cap cl(S)$ ϕ. Thus (X, τ_X) is not disconnected.

Theorem 2.4. A topological space (X, τ_X) is j-disconnected if and only if there exists a proper subset $\phi = R$ of X is both j-closed and j-open.

Proof Suppose (X, τ_X) is j-disconnected space. Then $X = R \cup S$ where $\phi \vDash R$ and $\phi = S$ are j-separated sets. i.e., $cl_j(R) \cap S = R \cap cl_j(S) = \phi$. This implies $R \cap S = \phi$ and $X = R \cup S$. Then $S = R^c$ and $R = S^c$. We have $cl_j(R) \cap S = \phi$ and $R \cap cl_j(S) = \phi \Longrightarrow cl_j(R) \subseteq S^c = R$ and $cl_j(S) \subseteq R^c = S$. But we have, R $cl_j(R)$ and S $cl_j(S)$. Thus $R = cl_j(R)$ and $S = cl_j(S)$. Therefore, R and S are j-closed sets and also $R^c = S$, $S^c = R$ are j-open sets. Hence a non- empty proper subsets of X are both j-open and j-closed. Conversely, assume $\phi = R$ be a proper subset of X . Then there exist a subset S which is both j-open as well as j-closed and $R \cap S = \phi$. This implies $cl_j(R) = R$ and $cl_j(S) = S$. Now $cl_j(R) \cap S = R \cap cl_j(S) = \phi$. Thus R and S are j-separated such that $X = R \cup S$. Hence (X, τ_X) is j-disconnected space.

Remark 2.5. The following example shows that, every discrete space (X , τj) is

j-disconnected if the space contains atleast two elements.
Example 2.6. Let $X = \{q, r\}$. Then $\tau_X = \{ \phi, \{q\}, \{r\}, X \}$, $\tau_j = \{\phi, \{q\}, \{r\}, X \}$ and $\tau^c = \{ \phi, \{q\}, \{r\}, X \}$. Since $\phi = q$ is a proper subset of X which is both j-open and j-closed.Therefore (X, τ_j) is j-disconnected.

Theorem 2.7. If $\phi = R$ and $\phi = S$ are two j-separated subsets of a topological space (X, τ_j) then $R \cup S$ is also j-disconnected in (X, τ_j).

Proof Let R and S be the j-separated subsets of (X, τ_j). Then we have $\phi \vDash R$, $\phi \vDash S$, $R \cap cl_j(S) = \phi$, $cl_j(R) \cap S = \phi$ and $R \cap S = \phi$. Now, we consider $X - cl_j(R) = M_j$ and $X - cl_j(S) = N_j$. This implies $cl_j(R)$ ϕ and $cl_j(S) \vDash \phi$, also $cl_j(R)$ and $cl_j(S)$ are j-closed subsets of N (X, τ_X). Therefore M_j and N_j are non-null j-open subsets of (X, τ_X). But
$(R \cup S) \cap M_j = (R \cup S) \cap (X - cl_j(R))$
$= [R \cap (X - cl_j(R))] \cup [S \cap (X - cl_j(R))]$
$= [R \cap S] \cup [S \cap S]$
$= \phi \cup S$
$= S$

In the same way, we get $(R \cup S) \cap N_j = R$. It shows that, there exist a sub- sets M_j and N_j in τ_j such that $(R \cup S) \cap M_j$ and $(R \cup S) \cap N_j$ are non-empty. $[(R \cup S) \cap M_j] \cap [(R \cup S) \cap N_j] = \phi$ and $[(R \cup S) \cap M_j] \cap [(R \cup S) \cap N_j] = \phi = R \cup S = X$. Then $M_j \cup N_j$ is the j-disconnectedness of $R \cup S$. Hence $R \cup S$ is j-disconnected.

Theorem 2.8. Let (X, τ_X) and (X, τ_j) be two topological spaces, R be non-empty subset of X and $M_j \cup N_j$ be j-disconnection of R. Then $R \cap M_j$ and $R \cap N_j$ are j-separated subsets of (X, τ_j).

Proof Let $M_j \cup N_j$ be j-disconnection of R. Using our assumption and the definition of j-disconnected, there exist M_j, $N_j \in \tau_j$ such that $R \cap M_j = \phi$ and $R \cap N_j = \phi$ which implies $(R \cap M_j) \cap (R \cap N_j) = \phi$ and $(R \cap M_j) \cup (R \cap N_j) = R \cap [M_j \cup N_j] = R \cap R = R$. Now we prove, $cl_j(R \cap M_j) \cap (R \cap N_j) = \phi$ and $[R \cap M_j] \cap cl_j(R \cap N_j) = \phi$. Assume the contrary $cl_j(R \cap M_j) \cap (R \cap N_j) \vDash \phi$. This implies $x \in cl_j(R \cap M_j)$, $x \in R$
and $x \in N_j \Longrightarrow$ $(R \cap M_j) \cap N_j \phi. \Longrightarrow (R \cap M_j) \cap (R \cap N_j) \vDash \phi$ which
contradicts $(R \cap M_j) \cap (R \cap N_j) = \phi$. Thus $cl_j(R \cap M_j) \cap (R \cap N_j) = \phi$. Similarly
$(R \cap M_j) \cap cl_j(R \cap N_j) = \phi$. Hence $R \cap M_j$ and $R \cap N_j$ are j-separated sets in $[X, \tau_j]$.

Theorem 2.9. Let S be a subset of a topological space (X, τ_X) and (X, τ_X) be j-disconnected if and only if $S = R \cup S$ where R and S are j-separated sets.
Proof Assume $S = R \cup S$ where R and S are j-separated sets in (X, τ_X). Therefore, $R \cup S$ is j-disconnected. Hence S is also j-disconnected.

Conversely, let S be j-disconnected. To prove R and S are two j-separated subsets of X such that $S = R \cup S$. By the definition of j-disconnected there exists a subsets M_j and N_j in τ_j such that $S \cap M_j \neq \phi$ and $S \cap N_j \neq \phi$. $(S \cap M_j) \cap (S \cap N_j) = \phi$ and $(S \cap M_j) \cup (S \cap N_j) = S$. Put $S \cap M_j = R$ and $S \cap N_j = S$. Hence R and S are two j-separated subsets of $(, \tau_X)$ such that $S = R\ S$.

Extremally j-disconnected Spaces
Definition 3.1. A topological space (X, τ_X) is called extremally j-disconnected if $cl_j(R)$ is j-open for all $R \in JO(X)$.
Example 3.2. Let $X = \{q, r, s, t\}$ with $\tau_X = \{\phi, \{q\}, \{q, t\}, \{r, s\}, \{q, r, s\}, X\}$. Then $\tau^c = \{\phi, \{r, s, t\}, \{r, s\}, \{q, t\}, \{t\}, \phi\}$. For this topology, ϕ, X, $\{q\}, \{r\}, \{s\}, \{q, r\}, \{q, s\}, \{q, t\}, \{r, s\}, \{q, r, s\}, \{q, r, t\}, \{q, s, t\}$ are the collection of pre-open sets . Therefore we have ϕ, X, $\{q\}$, $\{q, t\}$, $\{r, s\}$, $\{r, st\}$ are the family of j-open sets. Here $cl_j\{q\} = \{q, t\}$, $cl_j\{q, t\} = \{q, t\}$, $cl_j\{r, s\} = \{r, s\}$ and $cl_j\ q, r, s$ =. Therefore j-closure of every j-open set is j-open. Hence $(\ , \tau_X)$ is extremally j- disconnected.

Theorem 3.3. In general, the following statements are equivalent for any topo- logical space (X, τ_X).
(X, τ_X) is extremally j-disconnected.
$int_j(R_a)$ is j-closed for all j-closed set R_a in X .
$cl_j(R_a) \cup cl_j[X - cl_j(R_a)] = X$ for all j-closed set R_a in X .
$cl_j(R_a) \cup cl_j(R_b) = X$ for every pair of j-open sets R_a and R_b in (X, τ_X) with
$cl_j(R_a) \cup R_b = X$.

Proof (i) $\Longrightarrow$ (ii)
Let R be a j-closed subset of (X, τ_X). To prove $int_j(R_a)$ is j-closed.
Put $X - int_j(R_a) = cl_j(X - R_a)$. Since R_a is j-closed and (X, τ_X) is extremally j-disconnected. Then $(X - R_a)$ is j-open and $cl_j(X - R_a)$ is j-open. This implies $(X - int_j(R_a))$ is j-open and $int_j(R_a)$ is j-closed.
(ii) $\Longrightarrow$ (iii)
Assume R_a is j-open subset of (X, τ_X). Put
$X - cl_j(R_a) = int_j(X - R_a)$.
Then $cl_j(R_a) \cup cl_j(X - cl_j(R_a)) = cl_j(R) \cup cl_j(int_j(X - R_a))$
$= cl_j(R_a) \cup int_j(X - R_a)$
$= cl_j(R) \cup (X - cl_j(R)) = X$

(iii) $\Longrightarrow$ (iv)
Let R_a and R_b be two j-open subsets of (X, τ_X) such that
$cl_j(R_a) \cup R_b = X$. (1)
Using (iii) $cl_j(R_a) \cup cl_j(X - cl_j(R_a)) = cl_j(R_a) \cup R_b$ (2)
$\Longrightarrow R_b = cl_j(X - cl_j(R_a))$. (3)

From (3) , $R_b = X - cl_j(R_a)$.
$X - cl_j(R_a) = cl_j(X - cl_j(R_a))$
$\Longrightarrow cl_j(R_b) = cl_j(X - cl_jR_a)$
$\Longrightarrow cl_j(R_a) = X - cl_j(R_a)$.
$cl_j(R_b) \cup cl_j(R_a) = X - cl_j(R_a) \cup cl_j(R_a)$
$= X$

(iv) ⟹ (i)
Let R_a be any j-open subset of (X, τ_X).
Take $R_b = X - cl_j(R_a) \Longrightarrow cl_j(R_a) \cup R_b = X$.
Using (iv) we have $cl_j(R_a) \cup cl_j(R_b) = X$ and $cl_j(R_a)$ is j-open in (X, τ_X). Hence (X, τ_X) is extremally j-disconnected.

Theorem 3.4. Let R_a and R_b be any two non-empty j-open subsets of (X, τ_X) and $R_a \cap R_b = \phi$. Then a topological space (X, τ_X) is extremally j-disconnected if and only if $cl_j(R_a) \cap cl_j(R_b) = \phi$ for every $R_a, R_b \in X$ such that $R_a \cap R_b = \phi$.

Proof Let $\phi = R_a$ and $\phi = R_b$ be two j-open subsets of extremally j-disconnected space (X, τ_X) with $R_a \cap R_b = \phi$. $cl_j(R_a) \cap int_j(R_b) = cl_j(R_a) \cap R_b = \phi$. $int_j(cl_j(R_a)) \cap int_j(cl_j(R_b)) = \phi \Longrightarrow cl_j(R_a) \cap cl_j(R_b) = \phi$.
Conversely, take G be an arbitrary j-open subset in (X, τ_X). Then $X - G$ is j-closed set. This implies $int_j(G)$ is j-open set such that $G\ int_j(G) = \phi$. By hypothesis,
$cl_j(G) \cap cl_j(int_j(X - G)) = \phi$
$\Longrightarrow cl_j(G) \cap cl_j(X - cl_j(G)) = \phi$
$\Longrightarrow cl_j(G) \subseteq int_j cl_j(G) \subseteq cl_j(G)$.
$\Longrightarrow cl_j(G) \cap [X - int_j[cl_j(G)] = \phi$.
$cl_j(G) \subseteq int_j[cl_j(G)]$ (4)
In general, $int_j(cl_j(G)) \subseteq cl_j(G)$ (5)

From (4) and (5), $cl_j(G) = int_j cl_j(G)$.Thus $cl_j(G)$ is j-open set in (X, τ_X). Also G is arbitrary j-open set. Hence (X, τ_X) is extremally j-disconnected.

Theorem 3.5. In a topological space (X, τ_X) the following relations are equivalent.
(X, τ_X) is extremally j-disconnected.
For every j-open subsets of R_a and R_b in X such that
$cl_j(R_a) \cap cl_j(R_b) = cl_j(R_a \cap R_b)$.
For every j-closed subsets S_a and S_b of X, $int_j(S_a) \cup int_j(S_b) = int_j(S_a \cup S_b)$.

Proof (i) ⟹ (ii)
Taking R_a and R_b as two non-empty j-open subsets of extremally j-disconnected space (X, τ_X). We have $cl_j(R_a) \cap cl_j(R_b) = cl_j(R_a \cap R_b)$.
(ii) ⟹ (iii)
Take S_a and S_b are two j-closed subsets of extremally j-disconnected space (X, τ_X).
Then $(X - S_a)$ and $(X - S_b)$ are j-open subsets. Therefore, we have
$cl_j(X - S_a) \cap cl_j(X - S_b) = cl_j[(X - S_a) \cap (X - S_b)]$.
$(X - int_j(S_a)) \cap (X - int_j(S_b)) = cl_j[X - (S_a \cup S_b)]$
$X - (int_j(S_a) \cup int_j(S_b)) = X - int_j(S_a \cup S_b)$.
Therefore, $int_j(S_a) \cup int_j(S_b) = int_j(S_a \cup S_b)$.
(iii) ⟹ (ii)
Proof is similar to (ii) ⟹ (iii).
(ii) ⟹ (i)
Let R_a be arbitrary j-open subset of (X, τ_X). Then $X - R_a$ is j-closed. $cl_j(R_a) = int_j(cl_j(R_a))$. Therefore, we have $cl_j(R_a)$ is arbitrary j-open set in (X, τ_X). Hence (X, τ_X) is extremally j-disconnected.

Theorem 3.6. If R_a and R_b are any two non-null j-open subsets of (X, τ_X). Then (X, τ_X) is extremally j-disconnected if and only if
$int_j(cl_j(R_a)) \cup int_j(cl_j(R_b)) = int_j(cl_j(R_a \cup R_b))$ for all R_a and R_b in X.

Proof Let (X, τ_X) be extremally j-disconnected space, R_a and R_b be arbitrary j-open subsets of (X, τ_X). Therefore $cl_j(R_a)$ and $cl_j(R_b)$ are j-closed subsets of (X, τ_X). Thus, $int_j(cl_j(R_a)) \cup int_j(cl_j(R_b)) = int_j(cl_j(R_a) \cup cl_j(R_b)) = int_j(cl_j(R_a \cup R_b))$.

Conversely, Let M_a and M_b are two j-closed subsets of (X , τ_X). Then $int_j(M_a)$ and $int_j(M_b)$ are j-open subsets of (X , τ_X). By our assumption, $int_j(cl_j(int_j(M_a))) \cup int_j(cl_j(int_j(M_b))) = int_j(cl_j[int_j(M_a) \cup int_j(M_b)])$, since M_a and M_b are j-closed

subsets of (X , τ_X). Therefore, we have
$int_j[cl_j[int_j[cl_j(M_a)] \cup int_j[cl_j(M_b)]]] = int_jcl_j[int_jcl_j[M_a \cup M_b]]$
$= int_jcl_j[M_a \cup M_b]$
Hence (X , τ_X) is extremally j-disconnected.

Theorem 3.7. If S_a and S_b are any two non null j-closed subsets of (X , τ_X). Then (X , τ_X) is extremally j-disconnected if and only if $cl_j(int_j(S_a)) \cap cl_j(int_j(S_b)) = cl_j(int_j(S_a \cap S_b))$ for all S_a and S_b in (X , τ_X).

Proof Assume (X , τ_X) is extremally j-disconnected and S_a, S_b are any two j- closed subsets of (X , τ_X). Then $int_j(S_a)$ and $int_j(S_b)$ are j-open subsets of (X , τ_X). Therefore, $cl_j(int_j(S_a)) \cap cl_j(int_j(S_b)) = cl_j(int_j(S_a) \cap int_j(S_b)) = cl_jint_j(S_a \cap S_b)$.
Conversely, let N_a and N_b be any two j-open subsets of (X , τ_X).
Then $cl_j(N_a)$, $cl_j(N_b)$ are j-closed subsets of (X , τ_X). Now $cl_j(int_j(cl_j(N_a))) \cap cl_j(int_j(cl_j(N_b)))$
$= cl_jint_j[cl_j(int_j(N_a))] \cap cl_jint_j[cl_j(int_j(N_b))]$
$= cl_jint_j(N_a) \cap cl_jint_j(N_b)$
$= cl_jint_j(N_a \cap N_b) = cl_j(N_a \cap N_b)$.
Hence (, τ_X) is extremally j-disconnected.

CONCLUSION

This paper deals with the findings and observations of j-disconnectedness and ex- tremally j-disconnectedness in topological spaces. We analyzed the characteristics of such spaces by suitable theorems and appropriate examples. Thus the study has proved that these concepts will be used in various areas of topological spaces.

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RESEARCH ARTICLE

Power Quality Enhancement in Radial Distribution System by Harmonic Filters using Ant Lion Optimizer

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ABSTRACT

This present study was performed to evaluate theenzymic and non-enzymicantioxidant activities of *Momordica charantia*and *Trigonella foenumgraecum* seed extracts in diabetes induced rats. Diabetes Mellitus was induced by a single intraperitoneal injection of STZ-NIC and rats with blood glucose concentration more than 250mg/dl were used for the study. The ethyl acetate seed extracts of the plant samples were administered at doses of 200, 400 mg/kg b.w.and glibenclamide for 21 days and the activities of enzymic antioxidants superoxide dismutase (SOD), catalase (CAT), glutathione peroxidise (GPx) and non-enzymic antioxidants namely vitamin C, vitamin E and reduced glutathione (GSH) and lipid peroxidation were evaluated. There was a significant improvement in the activities and the levels of enzymic and non-enzymic antioxidants catalase, glutathione peroxidase, superoxide dismutase, vitamins C, E and reduced

glutathione (GSH) and lipid peroxidationon treatment with 400mg/kg b.w of the plant extracts and glibenclamide. This study demonstrates the antioxidant effect of the *Momordica charantia*and *Trigonella foenumgraecum* seed extracts that might help in control and prevention of diabetes mellitus.

Keywords: Diabetes, Enzymic antioxidants, Non-enzymic antioxidants, *Momordica charantia,Trigonella foenumgraecum.*

INTRODUCTION

Diabetes mellitus (DM) is a complicated, and non-contagious endocrine ailment that has posed clinical challenges globally, often linked with threats related to complicated metabolic development in patients. It is marked by elevated blood glucose and lipids and oxidative stress, which results in chronic complications involving diverse organs, mainly the kidneys, eyes, nerves, and blood vessels, among others, in the body. World Health Organization (WHO) has reported that DM is an outbreak prone to high malaise and death [1].During hyperglycemia, production of reactive oxygen species and reactive nitrogen species increases. This results in decrease in the activity of antioxidant enzymes, induces oxidative stress in the body [2]. Reactive oxygen species (ROS) level elevation in Diabetes may be due to perturbations in antioxidant defense system. The variation in the levels of antioxidant enzymes makes the tissues susceptible to oxidative stress leading to the development of diabetic complications[3]. Antioxidants are biochemicals that can neutralize the potentially damaging action of free radicals such unstable molecules as peroxyl radical, hydroxyl radical and singlet oxygen and peroxynitrate radicals. Antioxidants either completely stop or significantly reduce the damaging effects of free radicals on cells. So, antioxidants and free radical studies are very important in today's research for understanding the relationships of diseases such as cancer, neurodegenerative diseases, Diabetes mellitus and cardiac arrest [4]. One of the great advantages of medicinal plants is that these are readily available and have fewer side effects for management of diabetes.

There are reports about 800 plants that may possess antidiabetic activities [5]. Antioxidants are present in all parts of plants like wood, bark, stems, pods, leaves, fruit, roots, flowers, pollen and seeds. The occurrence of such oxidative mechanisms in plants clarifies why a plenty of antioxidant compounds have been recognized in plant tissue. Plants mostly those with elevated levels of powerful antioxidant compounds have an essential role in the cure and treatment of illness concerning oxidative stress including Diabetes Mellitus [6] *Momordica charantia* commonly known as bitter melon grows in tropical and subtropic areas, and is used as a food and medicine. It yields prickly fruit and lovely flowers. While bitter melon seeds, leaves, and vines have all been utilized for medicinal purposes, the fruit of the plant is the most widely used and safest part [7]. *Momordica charantia*seed extracts showed potent free radical scavenging activity, alpha- amylase inhibition and the mechanism were found to be noncompetitive inhibition.[8] *Trigonella foenum graecum (*Fenugreek)is a leguminous bean and which belongs to the family Fabaceae. The seeds and green leaves of *Trigonella foenum graecum* used as food possess many medicinal applications. Total fenugreek production in India was 113 thousand metric tonnes in the year 2012- 2013.In India; it is extensively used as ayurvedic medicine and in China as traditional medicine. Fenugreek is consumed in various parts of the world in different forms and has been regarded as a treatment for many ailments known to man [9] Hence the present study was aimed to evaluate the *in vivo* antioxidant potential of *Momordica charantia*and *Trigonella foenumgraecum* seed extracts in Streptozotocin– Nicotinamide administered diabetes induced rats.

MATERIALS AND METHODS

Plant Collection, Identification and Preparation of Extract

*Momordica charantia*seeds (MCS) and *Trigonella foenum graecum* seeds (TGS) were dried, finely powdered, and stored in airtight containers at room temperature for further use.5 grams of *Momordica charantia*seeds (MCS) and *Trigonella*

foenum graecum seeds (TGS) powder were macerated with 50 ml ethyl acetate for 48 hours filtered and collected the solvent. The solvent was evaporated in water bath shaker to get dry extract and used for further analysis.

Experimental Animals

Adult male albino Wistar rats (6 weeks), weighing 150 to 200 g were used for the present antidiabetic study. The animals were housed in clean polypropylene cages and maintained in a well-ventilated temperature-controlled animal house with a constant 12-hour light/dark schedule. The animals were fed with standard rat pelleted diet and clean drinking water was made available *ad libitum*. All animal procedures were performed after approval from the Ethical Committee Clearance No: 53 IAE1012/c/17/CPCSEA-2013 and in accordance with the recommendations for the proper care and use of laboratory animals.

Acute toxicity studies

Acute oral toxicity study of *Momordica charantia*seeds (MCS) extract and *Trigonella foenum graecum* seeds (TGS) extract was studied in healthy rats (n= 3) according to guidelines set by Organisation for Economic Co-operation and Development (OECD). The plant extract was evaluated for the pharmacological potential in normal rats weighing 150 to 200 g. The animals were given 200 mg/kg of MCS and 2000 mg/kg of TGS initially, then 500, 1000, 1500, and 2000 mg/kg b.w., and their toxicity was assessed. For a full day, the animals were watched for signs of death. Further studies will be conducted using 1/5th and 1/10th of the highest dose (2000 mg/kg b.w.) as there was no mortality observed in the acute toxicity studies.

Induction of Diabetes Mellitus

The animals were kept overnight fasting and the initial fasting blood glucose was checked from tip of rat tail vein. Nicotinamide was dissolved in regular saline, and streptozotocin was dissolved in citrate buffer (pH 4.5). A single intraperitoneal injection of 60 mg/kg streptozotocin was given to overnight fasted rats 15 minutes after an i.p. injection of 120 mg/kg nicotinamide. This caused the rats to develop diabetes mellitus. Hyperglycemia was confirmed by the elevated levels of blood glucose determined after 72 hours. The animals with blood glucose concentration more than 250mg/dl were used for further study.The vehicle (saline), standard drug glibenclamide and plant extracts were administered to the respective group animals for 21 days. Throughout the study period glibenclamide and plant extracts were freshly dispersed in normal saline and distilled water before the administration.

Sample collection

At the end of the experimental period rats were fasted overnight and anaesthetized with diethyl ether (100ml/kg), blood samples were collected through retro-orbital sinus puncture with or without EDTA container for the estimation of selected biochemical and haematological parameters. The liver of the experimental rats was removed and a portion of each was stored at minus 40^0C for performing the assays involving enzymic and non-enzymic antioxidants.

Determination of Enzymic antioxidants

The activities of enzymic antioxidants namely superoxide dismutase, catalase and glutathione peroxidase were determined in the liver of the control and experimental rats to assess the protection rendered by MCS, TGS and glibenclamide [10,11,12]

Determination of Non enzymic antioxidants

The activities of non-enzymic antioxidants vitamin C, vitamin E and reduced glutathione were determined in the liver of the control and experimental rats to assess the protection rendered by MCS, TGS and glibenclamide [13,14,15].

Determination of lipid peroxidation

Hyperglycemia associated with hyperlipidemia could be the causative factor for the increased production of free radicals and lipid peroxides like malondialdehyde (MDA) [16]. Hencelipid peroxidation in experimental rats was estimated [17].

Statistical Analysis

The data were statistically analysed and statistical significance was determined by One-way Analysis of Variance (ANOVA) followed by Dunnett's multiple comparison test. A 'p' value of less than 0.05 was regarded as significant.

RESULTS AND DISCUSSION

An imbalance of oxidant and antioxidant defence systems result in alterations in the activity of antioxidant enzymes such as superoxide dismutase (SOD), catalase (CAT) and glutathione peroxidise (GPx). In the present study, the activity of superoxide dismutase, catalase and glutathione peroxidase in normal and Diabetes induced rats were evaluated. The results of antioxidant activity of enzymes on control and experimental rats are depicted in Figures 1 a, 1b and 1c.There was a significant decrease ($p<0.05$) in the activity of enzymic antioxidants namely superoxide dismutase, catalase and glutathione peroxidise in the liver of diabetic control rats. In diabetic rats treated with glibenclamide and plant extracts, there was a significant improvement ($p<0.05$) in the activity of these enzymes. The activity of these enzymes in rats treated with highest dose of 400mg/kg b.w of MCS was comparable to the activity of enzymes in glibenclamide treated rats. Oxidative stress is a condition of reduction in anti-oxidative enzyme activities of SOD, CAT and GPx. The antioxidant enzymes SOD and CAT play an important role in reducing cellular stress.While CAT reduces hydrogen peroxides and shields higher tissues from extremely reactive hydroxyl radicals, SOD scavenges the superoxide radical by converting it to hydrogen peroxide and molecular oxygen[18].

The decreased activities of CAT and SOD may be response for increased production of H_2O_2 and O_2 by the auto-oxidation of glucose.Because these enzymes accelerate the dismutation of oxygen radicals and remove organic peroxides and hydroperoxides produced by unintentional exposure to STZ, they are crucial for maintaining physiological levels of oxygen and hydrogen peroxide.[19]. Treatment with MCS and TGS seemed to increase the activity of these enzymes and might help to control free radicals when compared to Glutathione peroxidase enzyme is relatively stable, but it has been reported that is disabled in severe oxidative stress conditions. *Citrullus lanatus*(watermelon) treated diabetic rats showed an increase in the activity of Gpx status which was almost close to the control level and this is remarkable as this implies that the juice could have an ameliorating effect on the altered antioxidant status of diabetic rats [20].The activities of antioxidant enzymes SOD and CAT were significantly increased after the treatment of ethyl acetate fraction of ethanol extract of *Stereospermumsuaveolens* in STZ-induced diabetic rats indicating the free radical scavenging activity and their protective effect against diabetic kidney cellular damage [21].Treatment with root extracts of *Premnacorymbosa* (Rottl.) increased the activity of antioxidant enzymes SOD, CAT and GPx when compared to diabetic rats. The effect produced by plant extract was comparable with that of standard drug glibenclamide [22].

Non enzymic antioxidants

The changes in the levels of non-enzymic antioxidants namely vitamin C, vitamin E and reduced glutathione (GSH) are important in cellular system in curtailing reactive oxygen species. The levels of these non – enzymic antioxidants in control, diabetic and treated rats were assessed and the results are depicted in Figures 2 a, 2 b and 2 c. There was a significant reduction ($p<0.05$) in the nonenzymatic antioxidants namely vitamins C, E and reduced glutathione (GSH) in diabetic rats when compared to control rats. The levels of these antioxidants were significantly increased ($p<0.05$) in rats by treating with glibenclamide, MCS and TGS ethyl acetate extracts. The levels of vitamin C, E and reduced glutathione were found to be increased significantly ($p<0.05$) on treatment with 400mg /kg b.w.Vitamin C is an effective antioxidant in various biological systems [23]. Vitamin C plays a central role in the antioxidant protective system, protecting all lipids undergoing oxidation and diminishing the number of apoptotic cells [24]. Vitamin E acts

as a non-enzymatic antioxidant and reduces chain reactions of lipid peroxidation [25]. Vitamin E shields cell structures from damage by reducing lipid hydroperoxides produced during the peroxidation process.The decreased level of vitamin E found in the liver of diabetic rats as compared with control rats could be due to increased oxidative stress, which accompanies the decrease in the level of antioxidant and might be related to the cause of Diabetes Mellitus [26] Enhanced level of vitamin E or tocopherols in plant extract treated groups is based on their ability to donate phenolic hydrogens to lipid radicals. Vitamin E protects poly unsaturated fatty acids from being oxidized [27]. Decreased levels of nonenzymatic antioxidant vitamin C and E in diabetic rats, when compared to those of control rats. The levels of these antioxidants were significantly increased in different organs (liver, kidney, brain, heart and pancreas) of diabetic rats by treatment with root extracts of *Premnacorymbosa*(Rottl) [28]. GSH has a multifaceted role in anti-oxidant defence. It is a direct scavenger of free radicals as well as a co-substrate for peroxide detoxification by glutathione peroxidase [29]. Hyperglycemia is found to be an indirect cause of GSH depletion. As GSH is an important antioxidant molecule, its depletion leads to an increase of oxidative stress [30]. Oral administration of aqueous fruit extract of *Passiflora ligularis* for 30 days showed significant elevation in all the non-enzymatic antioxidants values and reached near normal values. This can reduce the oxidative stress leading to less degradation of GSH due to less production of ROS in diabetic stage [31]. In the present study, there was an increased level ($p<0.05$) of reduced glutathione in MCS and TGS treated groups which imply that the plant extracts might have an enhanced amount of GSH activity which plays a role in coordinating the body's antioxidant defense processes. Reduced glutathione, synthesized mainly in the liver is an important non- enzymic antioxidant in the antioxidant defense system.

Lipid peroxidation

The status of lipid peroxidation of control and experimental rats were studied and the results are depicted in Figure 3. Lipid peroxidation was increased significantly ($p<0.05$) in diabetic rats as compared to that of control rats. The rats treated with glibenclamide, MCS and TGS showed significant reduction ($p<0.05$) in lipid peroxidation. The diabetic rats treated with highest dose of 400mg/kg b.w showed significant improvement ($p<0.05$) in antioxidant activity and the reduction in malondialdehyde production was comparable to glibenclamide treated rats. Lipid peroxidation is an autocatalytic free radical process formed by oxidative damage of cells. ROS produced in tissues results in lipid peroxidation and subsequently enhances the levels of malondialdehyde which is the major end product and index of lipid peroxidation [32].Polyunsaturated lipids oxidatively deteriorate due to a process called lipid peroxidation, which is mediated by free radicals. The increase in oxygen free radicals in Diabetes could be primarily due to increase in blood glucose levels, which upon auto-oxidation generates free radicals [33] *Coleus vettiveroides* Jacob extractspossess potent antioxidant and lipid peroxidation activities and can be employed in protecting tissue from the oxidative stress, which might be responsible for its hypoglycemic property [34]. In the present study, increased lipid peroxidation in STZ-induced diabetic rats might be due to an increase in the generation of free radicals by STZ. The ability of MCS and TGS extracts to quench hydroxyl radicals seems to be directly related to inhibiting the process of lipid peroxidation. After oral administration of the plant extracts for 21 days the elevated values restored back to near normal level. Lipid peroxidation significantly decreased in the treated groups, indicating that it plays a protective role against lipid peroxidation.

CONCLUSION

In the present study *in vivo* antioxidant activities of *Momordica charantia*and *Trigonella foenumgraecum* seed extracts in streptozotocin– nicotinamide administered diabetes induced rats showed a significant improvement in the activities and the levels of enzymic and non-enzymic antioxidants catalase, glutathione peroxidase, superoxide dismutase, vitamins C, E and reduced glutathione (GSH) on treatment with plant extracts. The rats treated with MCS and TGS also showed significant reduction in lipid peroxidation. The various antioxidant activities exhibited by *Momordica charantia*and *Trigonella foenumgraecum* may be attributed to their effectiveness as good scavengers of free radicals. Hence, thesemight be useful in the control of hyperglycaemia and due to its potent antioxidant properties may help in prevention of complications in diabetes.

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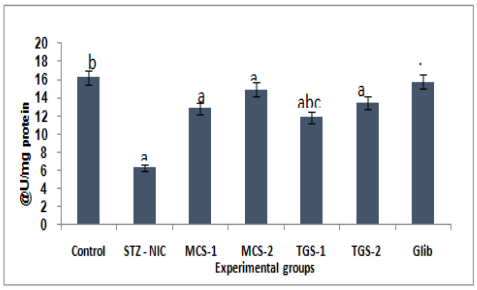
CONFLICTS OF INTEREST

The author declares that there are no conflicts of interest

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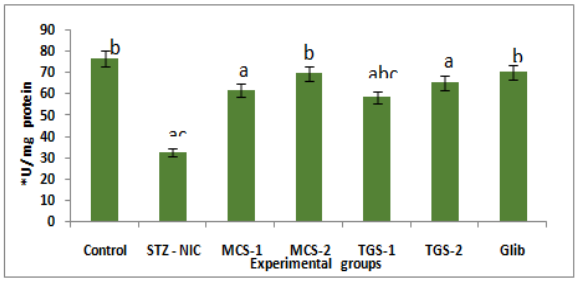
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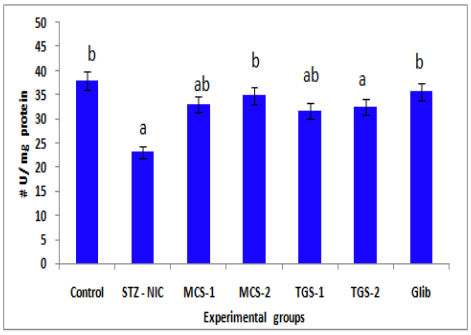
Values are mean± SEM (n= 6)
@ 1 Unit: Amount of enzyme that causes 50% reduction in NBT oxidation
a-p <0.05 compared with control group
b-p <0.05 compared with STZ –NIC group
c-p <0.05compared with Glib (200µg/kg b.w) treated group
(One way ANOVA followed by Dunnett's multiple Comparison test)
MCS -1: 200mg/kg b.w, MCS-2:400mg/kg b.w, TGS -1: 200mg/kg b.w, TGS 2:400mg/kg b.w.

Figure 1a: Activity of hepatic superoxide dismutase in the experimental rats



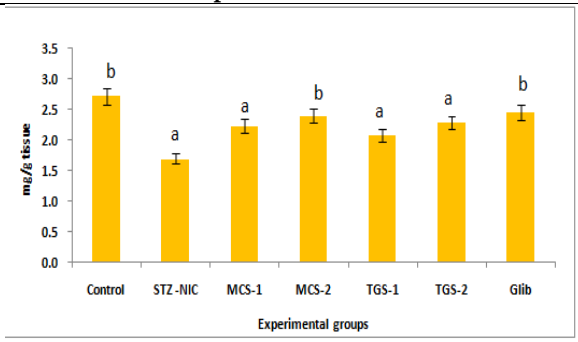
Values are mean± SEM (n= 6)
*1 Unit: Amount of enzyme required to decrease the absorbance at 240nm by 0.05 units
a-p <0.05 compared with control group
b-p <0.05 compared with STZ –NIC group
c-p <0.05compared with Glib (200µg/kg b.w) treated group
(One way ANOVA followed by Dunnett's multiple Comparison test)
MCS -1: 200mg/kg b.w, MCS-2:400mg/kg b.w, TGS -1: 200mg/kg b.w, TGS -2:400mg/kg b.w.

Figure 1b: Activity of hepatic catalase in the experimental rats



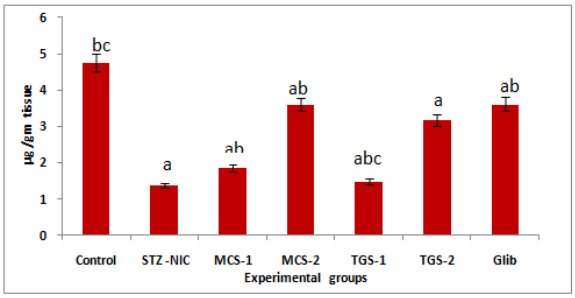
Values are mean± SEM (n= 6)
1 Unit: µ moles of GSH consumed/minute//mg liver protein.
a-p <0.05 compared with control group
b-p <0.05 compared with STZ –NIC group
c-p <0.05compared with Glib (200µg/kg b.w) treated group
(One way ANOVA followed by Dunnett's multiple Comparison test)
MCS -1: 200mg/kg b.w, MCS-2:400mg/kg b.w, TGS -1: 200mg/kg b.w, TGS -2:400mg/kgb.w

Fig 1c Activity of hepatic glutathione peroxidase in the experimental rats



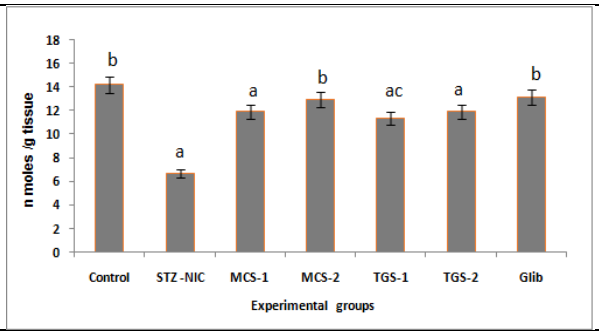
Values are mean± SEM (n= 6)
a-p <0.05 compared with control group
b-p <0.05 compared with STZ –NIC group
c-p <0.05compared with Glib (200µg/kg b.w) treated group
(One way ANOVA followed by Dunnett's multiple Comparison test)
MCS -1:200mg/kg b.w, MCS-2:400mg/kg b.w, TGS -1: 200mg/kg b.w, TGS -2:400mg/kg b.w.

Figure 2a Levels of hepatic vitamin C in the experimental rats



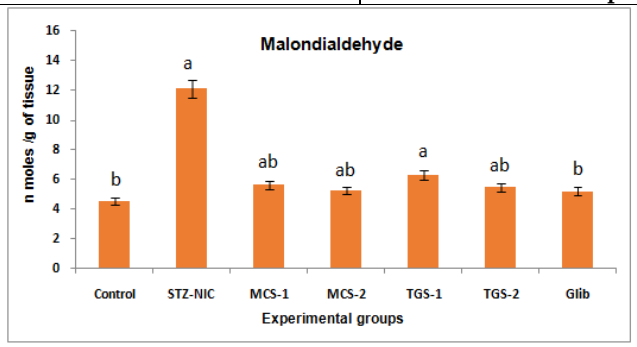
Values are mean± SEM (n= 6)
a-p <0.05 compared with control group
b-p <0.05 compared with STZ –NIC group
c-p <0.05compared with Glib (200µg/kg) treated group
(One way ANOVA followed by Dunnett's multiple Comparison test)
MCS -1: 200mg/kg b.w, MCS-2:400mg/kg b.w, TGS -1: 200mg/kg b.w, TGS -2:400mg/kg b.w.

Figure 2b Levels of hepatic vitamin E in the experimental rats



Values are mean± SEM (n= 6)
a-p <0.05 compared with control group
b-p <0.05 compared with STZ –NIC group
c-p <0.05compared with Glib (200µg/kg b.w) treated group
(One way ANOVA followed by Dunnett's multiple Comparison test)
MCS -1: 200mg/kg b.w, MCS-2:400mg/kg b.w, TGS -1: 200mg/kg b.w, TGS 2:400mg/kg b.w.

Figure 2 c Levels of hepatic reduced glutathione in the experimental rats



Values are mean± SEM (n= 6)
a-p <0.05 compared with control group
b-p <0.05 compared with STZ –NIC group
c-p <0.05compared with Glib (200µg/kg b.w) treated group
(One way ANOVA followed by Dunnett's multiple Comparison test)
MCS -1: 200mg/kg b.w, MCS-2:400mg/ kgb.w, TGS -1: 200mg/kg b.w, TGS -2:400mg/kg b.w.

Figure 3 Lipid peroxidation in the liver of experimental rats

RESEARCH ARTICLE

Effective Decolorization and Detoxification of Disperse Dyes using Newly Isolated Bacterial Strains

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ABSTRACT

A number of bacterial cultures were isolated from various sources and tested for their potential to detoxify and decolorize the disperse dyes present in the textile effluent. Out of twenty-two, three strains—*Fictibacillusgelatini, Bacillus subtilis subsp. inaquosorum, and Bacillus subtilis subsp. subtilis*—displayed exceptional capability for disperse dye decolorization. Enzyme profiling revealed effective production of laccase and azoreductase. A variety of synthetic dyes were selected for experimentation and all the strains showed 100% decolorization at optimum conditions including carbon sources (maltose, starch, mannitol and glucose), nitrogen supplies (yeast extract, ammonium nitrate, beef extract and peptone), pH (6.0- 9.0), temperature (30°C, 37°C and 40°C), inoculum size (3%, 5% and 7.5%), and dye concentrations upto 500 ppm. Microbial consortia of these three isolates resulted in complete decolorization of all the dyes at optimum conditions. These isolates significantly reduced the pH (28%), COD (49%), TDS (51%), and TSS (86%) levels in addition to removing the colors from these effluents.

Keywords: bacterial isolates, consortia, decolorization, disperse dyes, effluents

INTRODUCTION

The demand for synthetic dyes in the Indian textile industries has significantly expanded during the past decade. Due to scarcity and high cost of natural dyes, textile industry has to look for other more cost-effective, readily

accessible dyes. Out of an annual production of about 7×10^7tonnes, the textile sector uses about 10,000 tonnes of synthetic dyes per year [1]. Improper disposal of waste water by textile industries is one of the major challenges currently affecting the entire planet. These artificial dyes travel over long distances together with the wastewater [2] and persist in the soil and water for an extended period of time. It decreases the amount of dissolved oxygen in water bodies and prevents photosynthetic activity, which contributes to the rise in biological and chemical oxygen demand and eventually has an impact on health of aquatic life and habitats. Additionally, it alters microbial populations and raises soil salinity, causing soil contamination [3,4,5]. Many researchers have investigated the cytotoxic and genotoxic effects of synthetic dyes [6]. Synthetic textile dyes containing polycyclic, triphenylmethane and anthraquinone causes nuclear defects, liver cancer, urothelial carcinoma, spleen cancer and chromosomal abnormalities in human cells [7]. Disperse dyes are non-ionic dyes, toxic to store and difficult to degrade [8]. Synthetic textile dyes are stable and difficult to degrade due to their complex aromatic structure and often created to be resistant to fading from light, oxidising agents, and chemicals[9]. As a result, existing conventional physico-chemical processes for decolorizing dye effluent are costly and not very effective. These methods are economically unfeasible and generate toxic by- products as sludge [10, 11]. Textile effluents have been reported to be treated using ion exchange [12], adsorption [13], chemical coagulation [14], oxidative remediation [15], photo-degradation [16] and membrane treatment technologies including microfiltration, electrodialysis, nanofiltration, reverse osmosis, and ultrafiltration. However, these techniques are costly and could result in undesired byproducts [17], Therefore, in order to reduce the risk of water contamination, it is necessary to create environmentally safe and commercially feasible technologies for treating synthetic dyes in textile effluents. Researchers have investigated the ability of microbes, such as bacteria, yeast cells, fungal species, and algal species to decolorize and breakdown resistant textile dyes and mineralize to produce water and carbon dioxide. Biological approaches, however, have cheap operating costs and consistent results; are ecofriendly and do not generate a lot of sludge [18]. Numerous bacterial strains including *Bacillus subtilis, Paenochrobactrumglaciei, Brevibacilluspanacihumi, Bacillus cereus, Bacillus sphaericus, Paenibacilluspocheonensis* and *Escherichia coli* were found to be effective decolorizers of a wide range of disperse dyes [19]. Therefore, the present study is mainly focused on the isolation of potent bacterial cultures for the effective treatment of waste discharge of textile industries containing disperse dyes. The current study's objective was to identify and characterize effective bacterial strains having remarkable capacity to decolorize or degrade different types of disperse dyes. It was planned to use isolated bacteria, either by themselves or in a consortium, to create effective biological processes to facilitate the treatment of discharges containing various dyes.

MATERIALS AND METHODS

Dyes and Chemicals

Different Disperse dyes (Disperse red 1, Disperse orange 1, Disperse orange 30, Disperse blue 79, Disperse red 167, Disperse blue 183, Disperse yellow 198) were procured from Textile Mill, Bhiwani, Haryana, India. Analytical grade chemicals were acquired from Hi-Media Laboratories, India.

Isolation, screening and preservation of bacterial cultures

The following samples were taken from Nahar Textile Industry, Lalru, Punjab: soil, wet sludge, dry sludge, and effluent of disperse dyes. The samples were stored at room temperature in sterile vials, and experiments were performed within 24 hours after collection. 1% of the collected samples were aseptically inoculated in nutrient broth containing 500 mg/L each of the three dyes in a 250 mL Erlenmeyer flask. Dilution tubes were made from the enriched culture after 24 hours of incubation at 37°C under aerobic conditions. Using spread plate and streak plate methods, pure colonies of were isolated and their potency to decolorize the dye (500mg/L) was tested. The highest decolorizing colonies were chosen for additional studies. The pure single-colony cultures were kept at -20°C in 15% glycerol for storage. A number of bacterial cultures like *Brevibacilluslaterosporus*, *Enterobacter gergoviae* etc*[20]*.have been identified by other workers that have ability to degrade disperse dyes.

Biochemical and morphological identification of bacterial cultures

Morphological and biochemical tests were performed for identification of bacterial cultures. Gram's staining technique was used for morphological characterization. Further identification of bacterial cultures was done by MTCC, IMTECH, Chandigarh using 16 S r-DNA sequencing.

Effect of pH and temperature

To evaluate the impact of pH, 500 mg/L of each dye was mixed in modified ZZ media individually and kept at different pH values- pH 6.0, 7.0, 8.0, 9.0. The flasks were inoculated with 5 or 10% v/v of bacterial cultures and incubated at 37 ºC. The effect of temperature was investigated by inoculating overnight bacterial cultures in the modified ZZ medium and incubating them at 25ºC, 30ºC, 37ºC, 40ºC, and 50°C and pH of the medium was maintained at 7.0.

Effect of nitrogen and carbon source

Different sources were studied to evaluate the effect of nitrogen and carbon source. Glucose, galactose, fructose, mannitol, maltose, sucrose & starch were used as carbon sources. For nitrogen sources, ammonium nitrate, peptone, malt extract, yeast extract, beef extract and sodium nitrate were used at a concentration of 5g/L. These sources were added individually to modified ZZ media. The overnight growing bacterial culture was added to the flasks at concentration of 5 or 10% v/v, and incubated at a temperature of 37°C.

Enzyme screening assays: Quantitative assay

For interpretation, quantitative findings are presented numerically and compared with the related reference period. The activities of enzymes- laccase, azo-reductase, tyrosinase, and lignin peroxidase (LiP) were examined in cell free extracts and culture supernatants.

Laccase assay (EC. 1.10.3.2)

Laccase assay (EC. 1.10.3.2) was performed by a modified protocol of Zarvazinaet al. (2004) which used 2, 2′-azino-bis-(3-ethylthiazoline-6-sulfonate) (ABTS) as a substrate at pH 6.0. To start the reaction, 1 ml of the sample was added, which was then spectrophotometrically monitored at 436 nm. A unit of activity was defined as the total amount of enzyme necessary to convert 1 μM ABTS per minute per ml. Laccase assay was also done by using guaicol as a substrate at pH 6.5 and was measured spectrophotometrically at 465 nm [21]. The amount of enzyme needed to raise absorbance by 0.001 units at 37°C was defined as one unit.

Azoreductase assay (EC. 1.7.1.6)

Azoreductase assay was performed using the procedure, which included 4.45 M of dyes, 50 mM phosphate buffer (pH 7.4) containing 100 μM NADH and 1 ml of enzyme solution and change in color absorbance (430 nm) was observed at room temperature [22].

Tyrosinase

Tyrosinase assay was done by using a reaction mixture of 2 ml including 0.1M phosphate buffer (pH 7.4) with 0.01% catechol [23].

Lignin peroxidase (LiP)

To measure the activity of lignin peroxidase, a reaction was carried out using 2.5 ml of mixture containing 100 mM n-propanol, 50 mM tartaric acid and 10 mM H_2O_2 and the presence of propanaldehyde at 300 nm was monitored [24]. One unit of enzyme activity was described as the change in absorbance unit/min/mg of enzyme against blank test tube that included all the constituents other than the enzyme solution. All enzyme experiments were performed in triplicates, and the average results were determined. Protein content was estimated by Lowry's method [25].

Decolorization Assay

All decolorization tests were carried out in a 250 ml Erlenmeyer flask comprising 100 ml of pre-enriched bacterial culture in modified ZZ media. At regular interval of 12 hours, the samples (2ml) were taken out of the test and control media, and centrifuged at 10,000 rpm for 10 minutes to eliminate the cellular debris. Decolorization of dyes was assessed spectrophotometrically at the corresponding λ max of dye, and the results were compared with uninoculated medium containing 500mg/l of dye, taken as control. All the experiments were performed in triplicates. Decolorization efficacy of bacterial cultures was calculated by the given equation [26]:

Decolorization (%) = A^o-A/ A^o A× 100

A^o= absorbance before decolorization

A= absorbance after decolorization

Development of consortia

Three bacterial isolates identified as *Fictibacillusgelatini, Bacillus subtilis subsp. inaquosorum* and *Bacillus subtilis subtilis*, having greatest decolorization potential were utilizedfor consortium development.

Textile effluent and their physico- chemical analysis after treatment

The samples ofeffluents (L1, L2, and B1, B2)were collected from Nahar textile industry, Lalru, Punjab and Bhiwani textile mill, Haryana respectively. They were purple (L1), brown (L2), dark green (B1) and dark brown (B2) colored and smelled strongly.The effluents were treated with bacterial consortia and tested for their physiological characteristics like pH, color, total suspended solid (TSS), total dissolved solid (TDS), chemical oxygen demand (COD) before treatment and after treatment.

RESULTS

Screening and Isolation of bacterial cultures

Using an enrichment approach, twenty-two distinct types of bacterial strains were isolated. Out of which, three strains showed highest decolorization of dyes in minimum duration during screening protocol.

Biochemical, morphological characterization of bacterial strains and their molecular identification

Three most effective isolates which can decolorize the disperse dyes, were found to be rod shaped,present singly or in chains and gram positive. On the basis of their morphological, biochemical characterization and 16 S–rDNA analysis, they were recognized as *Fictibacillusgelatini*, *Bacillus subtilis* subsp. *inaquosorum* and *Bacillus subtilis* subsp. *subtilis*by MTCC IMTECH Chandigarh.

Analysis of dye spectrum

The percent dye decolorization by the strains was studied using an analytical approach. A spectrophotometric analysis was used to measure the absorbance of the supernatant withdrawn at appropriate time intervals for the dyes: DO 1 (483 nm), DY 198 (390 nm–520 nm), DR 167 (390 nm–520 nm), DO 30 (390 nm–520 nm), DB 183 (200 nm–800 nm), and DR 1 (502 nm) in the visible spectrum. Following that, the percentage of decolorization was computed using the difference between the initial and final absorbance values [29].

Enzyme profiling and activity calculation

In order to profile the enzymes secreted by bacterial cultures, various quantitative and qualitative assays were conducted for laccase, azoreductase, tyrosinase and lignin peroxidase. Enzymes- laccases and azo reductases have been found to be the most promising for bio-remediation of disperse dyes. Isolates *Fictibacillusgelatini* and *Bacillus subtilis inaquosorum* showed the highest enzymatic activity of laccase and azoreductase respectively, with low activities of LiP and tyrosinase. On the other hand, the isolate *Bacillus subtilis subtilis* showed highest enzyme activity of azoreductase and least of laccase, tyrosinase and LiP (Table 1).

Parametric optimization

By adjusting one parameter at a time, the optimization of various parameters was done in order to achieve an effective decolorization of disperse dyes. For desirable dye decolorization activity, each bacterial strain has its own unique set of requirements.

Effect of pH

Isolate *Fictibacillusgelatini* showed complete decolorization of DO 1 and DR 167 within 18 hours and all other dyes within 2 days at pH 7.0. At pH 8.0 and 9.0, complete decolorization of DO 1, DY 198, DO 30, DB 79 dyes was achieved between 1 to 8 days whereas decolorization was reduced by 20% for DR 167, 12% for DR 1 and 100% forDB 183 at pH 8.0. At pH 10, only three dyes, DO 1, DR 167 and DB 79 showed complete decolorization and 30% decolorization was observed for DY 198 while no decolorization of other dyes was found. At pH 6.0, there was no decolorization of dyes except for DO 30 which showed only 20% decolorization (Table 2). At pH 7.0, isolate *Bacillus subtilis inaquosorum*showed complete decolorization of all the dyes between 18 h to 8 days except DR 167 which showed 45% decolorization after 8 days and dye DB 183 that showed no decolorization. At pH 6.0, only two dyes, DO 1 and DB 79 were completely decolorized between 1 to 2 days and 50% decolorization was found in case of DO 30after 4 days (Table 3). At pH 7.0, isolate *Bacillus subtilis subtilis* showed complete decolorization of all the dyes between 18 h to 8 days except DB 183 that showed 53% decolorization after 8 days. At pH 6.0, DO1 and DB 79 showed complete decolorizationin 2 to 4 days and DR 167 showed 84% decolorization in 4 days (Table 4).

Effect of temperature

Isolate *Fictibacillusgelatini* showed complete decolorization of all the dyes at 37°C between 18 h to 8 days. At temperature 30°C, dye DR 1 was completely decolorized while DR 167 was 89% decolorized. At 40°C and 45°C, two dyes, DO 30 and DR 1 were100% decolorized whileDO 1 was decolorized up to86% and 75 % at these temperatures respectively, between 2 to 4 days (Table 2). *Bacillus subtilis inaquosorum* showed significant decolorization of disperse dyes at temperatures 37°C and 40°C. Total decolorization of all the dyes wasnoticed at 37 °Cbetween 18 h to 8 days except DR 167 which showed 45% decolorization after 8 days and DB 183 which showed no decolorization. At 40°C, 100% decolorization of dyes DR 167, DO 30 and DR 1 was obtained between 2 to 3 days whereasDO 1, DY 198 and DB 79 showed 89%, 85% and 96% decolorization respectively and no decolorization was noticed in case ofdye DB 183. At30 °C, DR 1 and DB 79 showed 100% and 89% decolorization respectively, after 3 days. At 45°C, DO 30 and DR 1 showed 100% decolorization while DO 1 and DY 198 showed 67% and 82% decolorization, respectively, after 3 days. At 50°C, dye DO 1 showed 62% decolorization after 3 days (Table 3). Isolate *Bacillus subtilis subtilis* showed complete decolorization of totaldyes at temperature 37°C and 40°Cbetween 18 h to 8 days except DB 183 which showed 56% decolorization at 37°C after 8 daysand no decolorization was observed at 40°C. At 30°C, DB 183, DB 79 and DR 1 showed 100% decolorization between 3 to 4 days and DY 198 showed 46% decolorization after 3 days. At 45°C, dyes DO 30, DB 79 and DR 1 showed 100% decolorization. At temperature 50°C, DR 167 and DB 79 showed 100% and 88% decolorization, respectively,after 3 days (Table 4).

Effect of Inoculum size

Different levels of decolorization were achieved using different inoculum sizes. Isolate *Fictibacillusgelatini* completely decolorized all the dyes with10% inoculum size betweentime period of 18 h to 2 days. At inoculum size 7.5 %, decolorization of all the dyes were obtained between 1 to 8 daysexcept DB 183 which showed no decolorization and DO 30 which showed 85% decolorization after 2 days. Inoculum size 3% resulted in complete decolorization of DO 1, DR167 and DB 79 between 3 to 7 days while 67% decolorization was observed in case of DO 30 after 7 days. In case of inoculum size 5%, complete decolorization of dyes DO 1, DR167, DO 30 and DB 79 were obtained after 3 to 4 days while 58% decolorization was observed in case of DR 1 after 6 days.Least decolorization was observed using1% inoculums which showed complete decolorization ofDO 1 and DB 79, between 3 to 4 days and 56% decolorization of DO 30 after 6 days (Table 2). With10% inoculum size, *Bacillus subtilis inaquosorum* showed complete decolorization of DO 1, DO 30, DB 79 and DR 1between 10 h to 2 days with86% and 98% decolorization of DY197 and DR167, respectively, between 6 to 8 days.Inoculum size 7.5 % resulted in complete decolorization of dyes DO 1, DR167 and DO 30 between 18 h to 2 days while 83% decolorization was noticed in case of DY 198, after 8 days. Least

decolorization was observed at inoculum size 1% and 3%, which resulted in complete decolorization of only a single dye-DO 1after 3 days. In case of inoculum size 5%, complete decolorization of DO 1 was observed after 3 days while 45% and 50% decolorization was noticed in case of dyes, DR167 and DO 30, respectively (Table 3). At inoculum size 5%, isolate *Bacillus subtilis subtilis* completely decolorized all the dyes between 18 h to 8 days except DB 183 which showed 56% decolorization after 8 days. At inoculum size 7.5%, dyes DO 1 and DY 198 were completely decolorized between 2 to 7 days while 60% decolorization was observed in case of DO 30 after 6 days. Inoculum size 10% resulted in complete decolorization of DO 1 after 4 days and 56% decolorization of DO 30 after 6 days. Least decolorization was observed in case of inoculum size 1% which resulted in 79% decolorization of DO 1 after 2 days. Inoculum size 3% resulted in complete decolorization of DY 198 and DR167 between 1 to 8 days (Table 4).

Effect of different concentration of dyes

Isolate *Fictibacillusgelatini* showed complete decolorization of all the dyes at 100ppm, 200ppm and 500ppm between 18 h to 8 days while DO 30 was decolorized upto78% after 5 days at 1000ppm (Table 2). Isolate *Bacillus subtilis inaquosorum*also showed complete decolorization of all the dyes at 100ppm and 200ppm between 12 h to 8 days. At 500ppm, complete decolorization of dyes DO 1, DO 30, DB 79 and DR 1 were observed between 18h to 2 days while DY 198 and DR167 showed 86% and 98% decolorization, respectively, between 6 to 8 days. At 1000ppm, 49% and 84% decolorization were observed in case of DO 30 and DB 79, respectively, between 3 to 4 days (Table 3).

Isolate *Bacillus subtilis subtilis* showed complete decolorization of all the dyes at 100ppm and 200ppm within 12 h to 4 days while at 500 ppm, all dyes were completely decolorized between 18 h to 8 days except dye DB 183 which resulted in 56% decolorization after 8 days. At 1000ppm, 62% and 40% decolorization were observed in case of DR 167 and DO 30, respectively, between 3 to 4 days (Table 4).

Effect of nitrogen source

The accessibility of nutrientsdetermines the growth of microorganisms which highly influence the decolorization of dyes. Different nitrogen sources resulted in different levels of decolorization. Isolate *Fictibacillusgelatini* showed complete decolorization of all the dyes in presence of yeast extract as nitrogen source between 18 h to 8 days and least decolorization was observed in presence of sodium nitrate which resulted in 100% and 42% decolorization of DO 1 and DY 198 respectively between 3 to 8 days. Using peptone as nitrogen source resulted in complete decolorization of DO 1 and DR 167 between 3 to 4 days while 35% and 87% decolorization were observed in case of DO 30 and DB 79, respectively, between 6 to 8 days. In case of malt extract, complete decolorization of dye DO 1 was observed after 2 days while 38%, 59%, 85% and 48% decolorization were obtained in case of DO 30, DB 183, DB 79 and DR 1, respectively, between 5 to 8 days. Beef extract as nitrogen source resulted in complete decolorization of DO 1 and DR 1 between 2 to 5 days while 17%, 20% and 80% decolorization were noticed in case of DO 30, DB 183 and DB 79, respectively, between 6 to 8 days. Utilizing ammonium nitrate as nitrogen source resulted in complete decolorization of DR 167 and DR 1 after 2 days while 82% and 98% decolorization were found in case of DO 1 and DO 30, respectively, between 3 to 4 days (Fig. 1). Isolate *Bacillus subtilis inaquosorum* showed complete decolorization of dyes in presence of yeast extract between 18 h to 8 days except DB 183which resulted in no decolorization and DR 167which showed 45% decolorizationafter 8 days. Complete (100%) decolorization of all the dyes were observed in presence of ammonium nitrate between3 to 5 days except DY 198 and DB 183which showed no decolorization. Least decolorization was observed in case of sodium nitrate which showed complete decolorization of only two dyes- DO 1 and DR 1 after 3 days. Using peptoneas nitrogen source resulted in complete decolorization of DO 1 and DR 1 after 3 days while 88% and 22% decolorization were observed in case of dyes DR 167 and DR 30, respectively, after 8 days. In case of malt extract, complete decolorization wasobserved for dye DO 1 while 27%, 42% and 20% decolorization were obtained for DO 30, DB 79 and DR 1, respectively, between 6 to 8 days. Beef extract resulted in complete decolorization of DO 1 and DR 1 between 2 to 5 days while 42%, 23% and 90% decolorization were noticed in case of DR 167, DB 183 and DB 79, respectively, between 6 to 8 days (Fig. 2). In presence of yeast extract, isolate *Bacillus subtilis subtilis* showed complete decolorization of all the dyes between 18 h to 8 days except DB 186 which resulted in 56% decolorization after 8 days. Using peptone delievered complete decolorization of dyes, DO 1 and DR 167, between 7 to 8 days, while 12%, 84% and 96% decolorization were noticed in case of DO 30, DB 79 and DR 1, respectively, between 6 to 8 days. Malt extract resulted in complete decolorization of DR 167 after 2 days while 46%,

20%, 39% and 32% decolorization were found in case of DO 30, DB 183, DB 79 and DR 1, respectively, between 6 to 8 days. Beef extract showed complete decolorization of DO 1, DR 167 and DO 30 after 2 days while 88% decolorization was obtained for DB 79 after 6 days. In case of ammonium nitrate, complete decolorization was observed for dyes, DO 1, DR 167 and DO 30 between 3 to 5 days. while 50% decolorization was obtained for DB 79 after 6 days. Sodium nitrate as nitrogen source resulted in complete decolorization of DO 1, DR 167 and DB 79 between 2 to 4 days while 28% and 80% decolorization was obtained in case of DY 198 and DB 79, respectively, after 8 days (Fig. 3).

Effect of carbon source

Different level of decolorization was observed utilizing different carbon sources. Isolate*Fictibacillusgelatini*showed complete decolorization of all the seven dyes in presence of maltose between 18h to 8 days. In presence of glucose, complete decolorization of dyes DO 1, DR 167 and DB 79 between 2 to 7 days was observed while 18% and 28% decolorization were obtained for dyes DO 30 and DR 1respectively, after 8 days. In presence of fructose, 100% and 80 % decolorization were noticed in case of DO 1 and DY 198 respectively, between 4 to 5 days. Galactose resulted in complete decolorization of dyes- DO 1 and DR 1 respectively, between 2 to 3 days while 38% decolorization was obtained for DO 30 after 8 days. No decolorization of dyes was obtained in presence of mannitol. In presence of sucrose, complete decolorization were obtained for DO 1, DR 167 and DR 1 between 1 to 5 days. Complete decolorization of all dyes was observed in case of starchexcept DY 198 and DR 1 which showed no decolorization(Fig. 4). In presence of maltose as carbon source, isolate *Bacillus subtilis inaquosorum*resulted in complete decolorization of all the dyes between 18h to 8 days except DB 183which showed no decolorization and 45% decolorization was observed in case of dye DR167 after 8 days. Using starch as carbon source also resulted in complete decolorization of all dyes between 2 to 8 days except DB 183 and DB 79 which showed no decolorization.

In case of Glucose, complete decolorization was observed only for DR 167 after 2 days and 25% and 15% decolorization were noticed for dyes DB 79 and DR 1 respectively, after 8 days. No decolorization was obtained in case of fructose and galactose. Mannitol resulted in complete decolorization of DO 1, DR 167 and DR 1 between 3 to 5 days while 50% decolorization was observed in case of DB 79 after 8 days. Sucroseresulted in complete decolorization of dyes DO 1, DO 30 and DB 79 between 3 to 4 days(Fig. 5). Utilizing maltose as carbon source, isolate *Bacillus subtilis subtilis* showed complete decolorization of all the dyes between 1 to 8 days except dye DB 183 which showed 56% decolorization after 8 days. In presence of glucose, complete decolorization was obtained for dyes DO 1, DR 167, DB 79 and DR 1 between 2 to 6 days while 63% and 80% decolorization were obtained for DY 198 and DO 30 respectively, between 2 to 8 days. No decolorization was obtained in case of fructose and galactose. Using mannitol resulted in complete decolorization of DO 1 and DR 1 between 4 to 5 days while 12%, 60% and 39% decolorization was obtained for DR 167, DB 183 and DB 79 respectively, after 8 days. in presence of sucrose, complete decolorization was noticed for DO 1and DR 1 between 3 to 4 days while 17% decolorization was obtained for DB 183 after 8 days. In presence of starch, complete decolorization was obtained for DR 167 and DR 1 between 3 to 4 days while 92% and 79% decolorization wasobtained for DO 1 and DB 79 between 4 to 6 days(Fig. 6).

Effect of bacterial consortia on decolorization of different dyes

Using a mixture of these three bacterial isolates (*Fictibacillusgelatini, Bacillus subtilis subsp. inaquosorum* and *Bacillus subtilis subtilis*) a consortium was prepared. Since almost all of the isolates gave useful results and the highest levels of decolorization were recorded above 60% to 100%, it was beneficial to create an effective consortium that could deliver significant results under all ideal conditions. Comparing the consortium to individual isolates, all the dyes were removed within 3 days under optimum conditions (Table 5).

Effect of bacterial consortia on different textile effluents

To determine the level of contamination for safeguarding the environment and natural resources, the classification of textile effluents is also necessary. Such an analysis report is crucial for textile industries to decide best prevention strategies forenvironmental pollution.

It was discovered that the pH of untreated effluents varies depending on the processes utilized in a certain company. Textile effluents L1, L2, B1 and B2 were treated with bacterial consortia. Typically, operations in textile companies

were conducted at alkaline pH; however, distinct untreated raw textile effluents were found to have different characteristics; pH variations of the four effluents were 14, 12, 10 and 9.8; COD: 558, 800, 500 and 520 mg/l; TDS: 3442, 3860, 2793 and 2421mg/l and TSS: 1344, 1380, 1440 and 1540 mg/l. All the effluents have been treated at pH 7-8 and their physico-chemical characteristics improved with decrease in COD, TDS, TSS; their new values after treatment beingCOD: 130, 365, 210 and 265 mg/l; TDS: 2101, 2293,1120 and 1181 mg/l and TSS: 140, 180, 100 and 202 mg/l respectively, their values got reduced to half or less than half after treatment (Table 6).Table 7 depicts the complete decolorization of effluents L1, B1 within 12 h and B2 within 4 days, whereas the effluent L2 was decolorized by 88%in 3 days.

DISCUSSION

Three isolates, identified as *Fictibacillusgelatini*, *Bacillus subtilis* subsp. *inaquosorum* and *Bacillus subtilis* subsp. *subtilis*were found to completely decolorize the dyes present in textile effluents. Enzymes-laccase, lignin peroxidase, azoreductase, and tyrosinase were found to be produced by these bacterial strains. The increased dye degradation of textile effluent by a bacterial coculture has been found to be very effective by other workers as well. Decolorization by oxidoreductase enzymes including laccase, NADH-DCIP reductase and azoreductase have been reported [27]. Abroad spectrum of textile dyes is mineralized by laccase enzyme [28]. The ideal temperature is a critical determinant of microbial growth, survival, and metabolic activities. The impact of temperature is a pivotal aspect in operations associated with microbial viability, including the bio-remediation of soil and water. The parametric optimization revealed that temperature of 37°C was optimum for dye biodegradation by bacterial isolates. At higher temperature, decolorization activity decreased due to degradation of reductase enzyme or loss of cell viability. A temperature between 30°C- 40°C was found to be optimum for decolorization of crystal violet by *Shewanella*sp. [29].
pH of the medium plays a critical role in dye decolorization processand pH 7.0 was found to be optimum for dye biodegradation in our studies. Enzyme metabolic activity is at its highest at this specific pH level, which makes it easier for the enzyme to attach to the active site of dye and boost the ability of dye to get decolorized. The rate of color removal is higher at the optimum pH level than at pH values that are too acidic or alkaline. The effectiveness of decolorization declines at lower pH values because dye cations cannot outcompete H+ ions. At high pH values, the strongest electrostatic interaction between the negatively charged surface of biomass and the positively charged dye cations is seen [27]. pH has a considerable impact on the efficacy of decolorization, with a typical pH range for color removal between 6.0 and 10.0 [30]. Optimal physiological performance of microbial cells and transport of various nutrient components across the cell membrane is crucially affected by pH of the medium.

Our results are in good agreement with [31], who reported that the decolorization of Methyl red by *Micrococcus strain R3* was found in the pH range of 6.0–8.0. The optimum pH for dyes decolorization ranged between 6.5 and 7.5, as the maximum decolorization occurred at pH 7.0 [32]. The parametric optimization studies indicated that inoculum size 10% was optimum for dye degradation by bacterial isolates. *A smaller inoculum volume decreases the biological reaction's overall rate, which lowers the rate of dye decolorization*. However, inoculum volume over the optimized level causes early nutritional depletion and microorganism mortality, which lowers the rate of dye decolorization. The increase in *B. cereus* inoculum size from 2.5 to 10% increased the rate of TerasilBlack effluent decolorization; however, increasei n inoculum up to 20% did not bring about any significant change in the color intensity [33]. Our parametric optimization results showed that complete dye decolorization by all the isolates under study was attained at dye concentrations- 100 ppm, 200 ppm and 500 ppm. The dye decolorization decreased by increasing its concentration beyond 500 ppm i.e., at 1000 ppm. When dyes are employed in high concentrations, dye decolorization is severely impeded, which may be due to the toxic impact of dyes on microorganisms. Bacterial isolate *Pseudomonas putida* MTCC 102 decolorizing the dyes by only up to 500mg/l [34]. Carbon and nitrogen sources also affect the decolorization process and the results showed that maltose and starch as carbon source and yeast extract as nitrogen source were optimum for complete decolorization of disperse dyes. Suitability of maltose can be due to the fact that *Bacillus* sp. lag phase was significantly shortened, resulting in an incubation time reduction from days to hours to achieve maximum dye elimination. Our results are in good agreement with [35], where *P.oestreatus* also showed

significant shortening of lag phase by one day to cause maximum removal of dye in presence of maltose and starch and these co- substrates also showed stimulatory effect on dye decolorization. Yeast extract has stimulatory effect on the growth of diverse microorganisms which is useful for the decolorization of dyes upto the maximum level. Yeast extract as nitrogen source in synthetic media showed highest decolorization of blue HER by *Trichosporonbeigelii* [36]. When the consortium of our microbial strains was applied to the textile effluent, almost 50% reduction in COD, TDS and TSS of the effluent was achieved. Decolorization can be accomplished using a single, particular strain or co-cultivated microbes. Although bacterial decolorization was discovered to be quicker and more effective, disperse dyes are typically too complex for a single bacterial strain to entirely break down. The intermediate compounds, which must be further broken down, are frequently cancer-causing aromatic amines. Due to the synergistic metabolic activities of the microbial community, treatment systems made up of mixed microbial populations have a higher degree of biodegradation than those made up of pure cultures providing significant degradation of synthetic colors [37]. Decolorization of Disperse red 1 up to 80% was noticed within 72 h by potential bacterial consortium (*Microbacterium sp*. *Leucobacteralbus*, *Klebsiella* sp. and *Staphylococcus arlettae*) at temperature 36ºC and pH 7.0 [38].
These isolates decolorized the effluents containing disperse dyes along with reducing down the cost of entire treatment course. The current investigation can be highly noteworthyas these isolates decolorized these textile effluents almost completely makingthe effluent transparent from opaque. Apart from the cost reduction, there was much decrease in their TSS, COD and TDS and which were brought down by these microbes.

Other workers have similar findings of reduction of COD and BODin the treated samples [39, 40].Considering these facts, the current research can be potentially applied in bioremediating the industrial textile effluent. Studies were conducted for decolorization by these isolates and optimization of different nutritional and fermentation parameters (incubation periods, pH, temperature and dye concentrations) was also carried out. Decolorization studies for assessment of theability of these strains on textile water effluents were also performed. It was seen that, higher decolorization was achieved at pH 7.0 and at a dye concentration up to 500 mg/l. Also, decolorization of a few dyes was also observed at a concentration of 1000mg/l in time lesser than anticipated. Similarly, four dye decolourizing isolates viz., *Bacillus sp. Salmonella sp. Klebsiella sp*. and *Pseudomonas species*were isolated from the textile effluent [41]. Out of which, *Bacillus sp*. was observed to be more efficient than other three strains in dye decolorization. Our studies indicated that using individual strains for dye decolorization of the textile effluent may not be as effective as using these microbes in the consortia. All these microbial strains when used singly led to complete dye decolorization in 18 hours up to 8 days. This time period was significantly reduced when they were used together leading to complete dye decolorization within 3 days. The nutritional and fermentation requirements of all these strains were similar which made the production and their application part both efficient as well as cost effective giving good results with supplementation of only minimum additives. This research can be efficiently used by the textile industries for decolorization and detoxification of their industrial effluents, thereby reducing the environmental pollution.

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Table 1: Enzyme Assay of Different Isolates

S.No.	Enzyme assay	Substrate	Enzyme Activity (IU/ml) *Fictibacillusgelatini*	Enzyme Activity (IU/ml) *Bacillus subtilis inaquosorum*	Enzyme Activity (IU/ml) *Bacillus subtilis subtilis*
1.	Laccase Assay	Guaicol& ABTSa	6.33±0.001 8.55±0.14	0.007±0.001 2.33±0.03	0.004 ± 0.001 0.001 ± 0.0002

2.	Azoreductase Assay of Dyes b	Dye+NADHc	3.73±0.03	1.39±0.12	1.23 ± 0.02
3.	Tyrosinase Assay	Catechol	0.004±0.0001	0.003±0.001	0.007± 0.001
4.	Lignin Peroxidase	n-Propanol	0.010±0.0007	0.006±0.001	0.018 ± 0.0013

a- 2, 2′-azino-bis-(3-ethylthiazoline-6-sulfonate), b-dye, c- nicotinamide adenine dinucleotide.

Table 2: Optimized Parameters for Decolorization of Various Dyes by Isolate *Fictibacillusgelatini*

S.No	Parameters	Bacteria						
		Fictibacillusgelatini						
		DO 1	**DY 198**	**DR 167**	**DO 30**	**DB 183**	**DB 79**	**DR 1**
1	pH	7.0/ 18h	8.0, 9.0/4 d	7.0/18h	7.0/12d	7.0/2d	7.0/2d	7.0/2d
2	Temperature (°C)	37°C/18h	37°C/8d	37°C/18h	37°C/1d	37°C/2d	37°C/2d	30°C, 37°C/2d
3	Inoculum size (%)	10%/18h	7.5%, 10%/8d	10%/18h	10%/1d	10%/2d	7.5%, 10%/2d	10%2d
4	Conc. of dye (ppm)	100, 500/18h	100/4d	100/12h	100/18h	100, 200, 500/2d	100, 200, 500/2d	500/2d
5	Nitrogen source	Yeast extract/18h	Yeast extract/8h	Yeast extract/18h	Yeast extract/1d	Yeast extract/2d	Yeast extract/2d	Yeast extract/2 d
6	Carbon source	Maltose/18h	Maltose/8 d	Maltose/18 h	Maltose/1 d	Maltose/2d 2	Maltose/2 d	Maltose, starch/2d

Table 3: Optimized Parameters for Decolorization of Various Dyes by Isolate*bacillus Subtilis Inaquosorum*

S.No.	Parameters	Bacteria						
		Bacillus subtilis inaquosorum						
		DO 1	**DY 198**	**DR 167**	**DO 30**	**DB 183**	**DB 79**	**DR 1**
1	pH	6.0/1d	7.0/6d	7.0/8d	7.0/1d	7.0	7.0/18h	7.0/2d
2	Temperature (°C)	37°C/2d	37°C/6d	40°C/2d	37°C/1d	-	37°C/18h	37°C/2d
3	Inoculum size (%)	7.5%, 10%/2d	10%/6d	7.5%/2d	7.5%/18h	-	10%/18h	10%/2d
4	Conc. of dye (ppm)	100/36h	100, 200/4d	100, 200/36h	100, 200, 500/1d	100, 200/2d	100/12h	100, 200, 500/2d
5	Nitrogen source	Peptone, Beef extract, Yeast extract/2d	Yeast extract/6d	Ammonium nitrate/4d	Yeast extract/1d	Beef extract/8d	Yeast extract/18h	Yeast extract/2d
6	Carbon source	Maltose, starch/2d	Maltose, starch/6d	Mannitol, starch/3d	Maltose/1d	-	Maltose/18h	Maltose/2d

Table 4: Optimized Parameters for Decolorization of Various Dyes by Isolate *Bacillus Subtilis Subtilis*

S.No.	Parameters	Bacteria						
		Bacillus subtilis subtilis						
		DO 1	**DY 198**	**DR 167**	**DO 30**	**DB 183**	**DB 79**	**DR 1**
1	pH	7.0/2d	7.0/8d	7.0/1d	7.0/2d	7.0/8d	7.0/18h	7.0/3d
2	Temperature (°C)	37°C/2d	40°C/4d	37°C/1d	37°C/2d	30°C/4d	37°C/18h	30°C, 37°C/3d
3	Inoculum size (%)	5%/2d	7.5%/7d	3%, 5%/1d	5%/2d	5%/8d	5%/18h	5%/3d
4	Conc. of dye (ppm)	100, 200/36h	100/2d	100, 200, 500/1d	200/36h	100, 200/1d	100/12h	100, 200/2d
5	Nitrogen source	Beef extract, Yeast extract/2d	Yeast extract/8d	Yeast extract/1d	Beef extract, Yeast extract/2d	Yeast extract/8d	Yeast extract/18h	Yeast extract/3d
6	Carbon source	Maltose/2 d	Maltose/8 d	Maltose/1 d	Maltose/2 d	Mannitol/8 d	Maltose/18 h	Glucose/3 d

Table 5: Screening of Bacterial Consortium on Different Dyes

S. No.	Dyes	Decolorization by bacterial consortia
1	DO 1	C± 0.03/ 18h
2	DY 198	C±0.02/ 3d
3	DR 167	C± 0.32/ 1d
4	DO 30	C± 0.55/ 12h
5	DB 183	C± 0.17/ 1d
6	DB 79	C± 1.02/ 1d
7	DR 1	C± 1.5/ 2d

C- Complete decolorization (100%),
Time taken; h- hours, d- days

Table 6: Physico- Chemical Analysis of the Textile Effluents Before and After Treatment

Parameters	Observation before treatment of textile effluents				Observation after treatment of textile effluents			
	L1	L2	B1	B2	L1	L2	B1	B2
pH	14	12	10	9.8	7-8	7-8	7-8	7-8
Color	Purple	Brown	Dark green	Dark brown	Color-less	Light brown	Color-less	Color-less
COD	558	800	500	520	130	365	201	265
TDS	3442	3860	2793	2421	2101	2293	1120	1181
TSS	1344	1380	1440	1540	140	180	100	202

Table 7:Decolorization(%)of industrial effluents by consortium

Textile effluents	Decolorization (%)
L-1	C± 0.04 in 12h
L-2	88± 0.18 in 3d
B-1	C± 0.03 in 12h
B-2	C± 0.01 in 4d

C-complete decolorization (100%)

Time taken; h- hours, d- days.

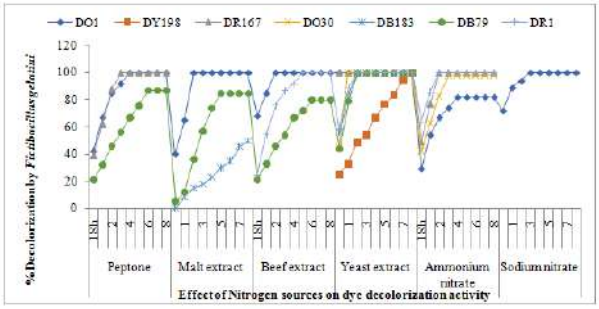


Fig 1:Effect of nitrogen source on % decolorization by *Fictibacillusgelatini*

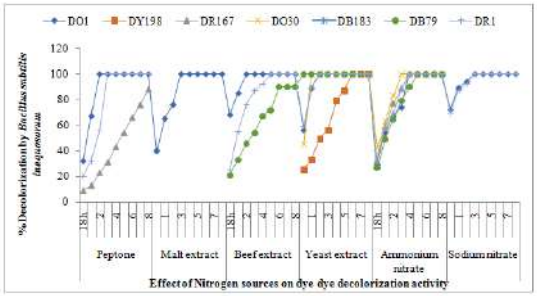


Fig 2. Effect of nitrogen source on % decolorization by *Bacillus subtilis inaquosorum*

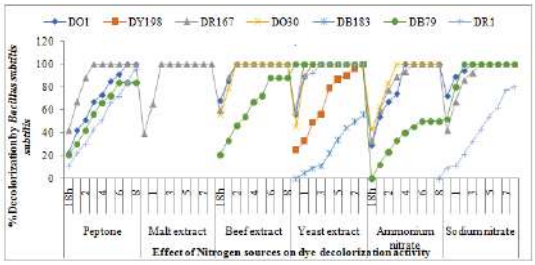


Fig 3. Effect of nitrogen source on % decolorization by *Bacillus subtilis subtilis*

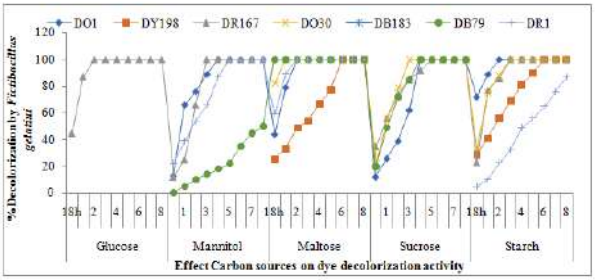


Fig 4. Effect of carbon source on % decolorization by *Fictibacillusgelatini*

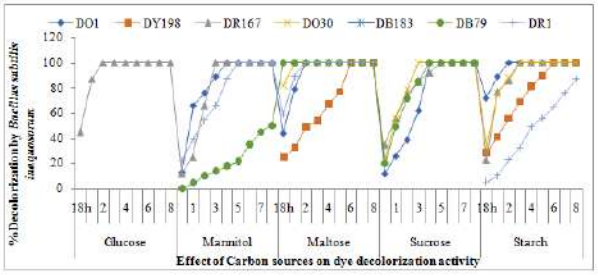


Fig 5. Effect of carbon source on % decolorization by *Bacillus subtilis inaquosorum*

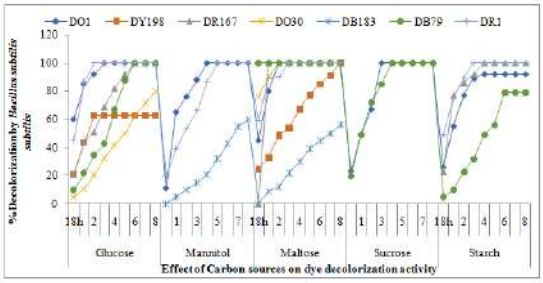


Fig 6. Effect of carbon source on % decolorization by *Bacillus subtilis subtilis*

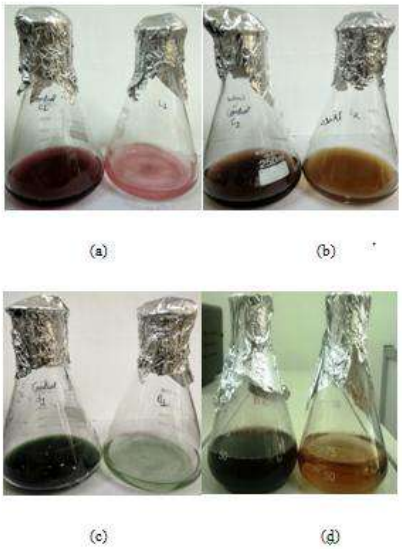


Fig 7: Comparison of untreated and treated textile effluent (a) Treated textile effluent L1, (b) Treated textile effluent L2, (c) Treated textile effluent B1, (d) Treated textile effluent B1

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RESEARCH ARTICLE

Strongly and Total Strongly Irregular Fuzzy Semigraphs

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ABSTRACT

This paper aims to pioneer and discuss the concept of strongly and strongly total irregular fuzzy semigraphs, conducting a comprehensive comparative examination of these two variants. We examine the unique features of strongly irregular fuzzy semigraphs and explore their relevance within the context of strongly totally irregular fuzzy semigraphs.

Keywords: Degrees,Fuzzy Semigraph, Irregular Fuzzy Semigraph, strongly irregular Fuzzy semigraphs ,strongly total irregular fuzzy semigraphs.

INTRODUCTION

The introduction of fuzzy semigraphs was subsequently expanded by K. Radha and Renganathan.P [1]. Archana.s and Preethi Kuttipulackal further elevated the field through significant contributions to regular fuzzy semigraphs[2]. N R Santhi Maheswari and K.Amutha contributed in the study of Neighbourly Edge Irregular Graphs [3]. J. Krishnaveni Jeganathan and N R Santhi Maheswari produced significant findings to support strongly irregular fuzzy graphs, developing their core principles in this area. [4]. S.Nithishraj, A. Nagoor Gani and P.Muruganantham have explored the domain On Irregular Fuzzy Semigraphs adding valuable perspectives and findings[5].This study aims to introduce the concepts of strongly irregular fuzzy semigraphs and strongly total irregular fuzzy semigraphs and

provides a comparative analysis of the two. In addition, the paper analyses the characteristics of neighbourly and highly irregular fuzzy semigraphs, showing significant findings in the area.

METHODOLOGY

By using nodes, edges, adjacent degrees, and consecutive adjacent degrees, we can determine the characteristics of strongly irregular and total strongly irregular. Then, we may proceed to examine neighbourly and highly irregular fuzzy semigraphs.

STRONGLY AND TOTAL STRONGLY IRREGULAR FUZZY SEMIGRAPH

Definition 2.1: Consider $\mathcal{G}: (\sigma, \mu, \eta)$ as a fuzzy semigraph in a semigraph $G: (\mathcal{V}, \mathcal{E}, \mathcal{X})$. The degree of a node$v$is $d(v) = \sum \eta(E)$ where the summation now encompasses all edges E having v as a terminal node. A fuzzy semigraph $\mathcal{G}$ is considered strongly irregular when eachpair of connected nodes in $\mathcal{G}$ have distinct degree. It is represented as $d_{\mathcal{G}}\ (v)$.

Definition 2.2: Consider $\mathcal{G}: (\sigma, \mu, \eta)$as a fuzzy semigraph in a semigraph$G: (\mathcal{V}, \mathcal{E}, \mathcal{X})$. When every pair of connected nodes in a fuzzy semigraph G has a distinct total degree, then G is said to be strongly total irregular.It is represented as $td_{\mathcal{G}}\ (v)$.

Definition 2.3: Consider $\mathcal{G}: (\sigma, \mu, \eta)$as a fuzzy semigraph in a semigraph $G: (\mathcal{V}, \mathcal{E}, \mathcal{X})$. If the edge degrees of adjacent nodes are distinct, we say that the fuzzy semigraph $\mathcal{G}$ is strongly v -edge irregular. It is represented as $d_e\ (v)$.

Definition 2.4: Consider $\mathcal{G}: (\sigma, \mu, \eta)$as a fuzzy semigraph in a semigraph $G: (\mathcal{V}, \mathcal{E}, \mathcal{X})$. If every pair of adjacent nodes has a distinct edge total degree, we say that the fuzzy semigraph $\mathcal{G}$ is strongly v -edge total irregular. It is represented as$td_e(v)$.

Definition 2.5: Consider $\mathcal{G}: (\sigma, \mu, \eta)$ as a fuzzy semigraph in a semigraph $G: (\mathcal{V}, \mathcal{E}, \mathcal{X})$. When each pair of connected nodes in $\mathcal{G}$ contains a distinct adjacent degree, we say that the fuzzy semigraph is strongly irregular in adjacent degree. It is represented as $d_{\mathcal{G}_a}\ (v)$

Definition 2.6: Consider $\mathcal{G}: (\sigma, \mu, \eta)$ as a fuzzy semigraph in a semigraph $G: (\mathcal{V}, \mathcal{E}, \mathcal{X})$. When each pair of connected nodes in $\mathcal{G}$ contains a distinct total adjacent degree, then the fuzzy semigraph is strongly irregular in total adjacent degree. It is represented as$td_{\mathcal{G}_a}\ (v)$.

Definition 2.7: Consider $\mathcal{G}: (\sigma, \mu, \eta)$ as a fuzzy semigraph in a semigraph$G: (\mathcal{V}, \mathcal{E}, \mathcal{X})$. When each pair of connected nodes in $\mathcal{G}$ contains a distinct consecutive adjacent degree, we say that the fuzzy semigraph is strongly irregular in consecutive adjacent degree. It is represented as$sd_{\mathcal{G}_{Ca}}\ (v)$.

Definition 2.8: Consider $\mathcal{G}: (\sigma, \mu, \eta)$ as a fuzzy semigraph in a semigraph$G: (\mathcal{V}, \mathcal{E}, \mathcal{X})$. When each pair of connected nodes in $\mathcal{G}$contains a distinct total consecutive adjacent degree,we say that the fuzzy semigraph is strongly irregular in total consecutive adjacent degree. It is represented as$td_{\mathcal{G}_{Ca}}\ (v)$.

EXAMPLE 2.9: Let $\mathcal{G}: (\sigma, \mu, \eta)$ represent a fuzzy semigraphin a given fig.1
All the nodes have distinct degrees, including the degree, edge degree, adjacent degree, consecutively adjacent degree, and its total degrees. Hence, the semigraph generated is both irregular and a totally irregular fuzzy semigraph as seen in the table above. It is easy to see that $d_{\mathcal{G}}\ (v) \leq d_e(v) \leq d_{\mathcal{G}_{Ca}}\ (v) \leq d_{\mathcal{G}_a}\ (v)$ and $td_{\mathcal{G}}\ (v) \leq td_e(v) \leq td_{\mathcal{G}_{Ca}}\ (v) \leq td_{\mathcal{G}_a}\ (v)$.

RESULTS AND DISCUSSION

Theorem 2.10 For a fuzzy semigraph $\mathcal{G}: (\sigma, \mu, \eta)$ is referred to$G: (\mathcal{V}, \mathcal{E}, \mathcal{X})$, where σ remains a constant function, the conditions i) and ii) are identical, indicating that $\mathcal{G}$ is both a strongly and strongly total irregular fuzzy semigraph.

Proof: Assume σ remains a constant function.
(i.e.) $\sigma(p) = c$, for all $p \in v$.
Let us assume a strongly irregular fuzzy semigraph $\mathcal{G}$, in which each node has a distinct degree.
Consider a pair of nodes P1 & P2, where P1 and P2 have distinct degrees T_1 and T_2 respectively.
(i.e.) $d_{\mathcal{G}}(P_1) = T_1$ and $d_{\mathcal{G}}(P_2) = T_2$ where $T_1 \neq T_2$
Suppose that all of the nodes in $\mathcal{G}$ have the same total degree if $\mathcal{G}$ is not a strongly total irregular fuzzy semigraph.
$\Rightarrow d_{\mathcal{G}}(p_1) = td_{\mathcal{G}}(p_2)$
$\Rightarrow d_{\mathcal{G}}(p_1) + \sigma(p_1) = d_{\mathcal{G}}(p_2) + \sigma(p_2)$
$\Rightarrow T_1 + c = T_2 + c$
$\Rightarrow T_1 - T_2 = c - c = 0$
$\Rightarrow T_1 = T_2$,
which is a $\Rightarrow\Leftarrow$to $T_1 \neq T_2$.
Consequently, the implication (i) to (ii) is established by knowing that $\mathcal{G}$ is a strongly total irregularfuzzy semigraph.
Assume that $\mathcal{G}$ is a strongly total irregular fuzzy semigraph. Subsequently, the nodes total degree is all are distinct. .
Let p_1& p_2 be the pair of nodes have distinct total degrees T_1 and T_2 respectively.
Now, $d_{\mathcal{G}}(p_1) \neq td_{\mathcal{G}}(p_2)$
$\Rightarrow d_{\mathcal{G}}(p_1) + \sigma(p_1) \neq d_{\mathcal{G}}(p_2) + \sigma(p_2)$
$\Rightarrow T_1 + c \neq T_2 + c$
$\Rightarrow T_1 - T_2 \neq c - c = 0$
$\Rightarrow T_1 \neq T_2$
Therefore, $\mathcal{G}$ is a strongly irregular fuzzy semigraph, which establishes the implication (ii) to (i).
As a result, we can deduce that (i) and (ii) are identical.

Theorem 2.11: For a fuzzy semigraph $\mathcal{G}: (\sigma, \mu, \eta)$is referred to$G: (\mathcal{V}, \mathcal{E}, \mathcal{X})$, where σ remains a constant function, the conditions i) and ii) are identical, indicating that $\mathcal{G}$ is both a v-edge degree in strongly irregular fuzzy semigraph and a v-edge degree in strongly total irregular fuzzy semigraph.

Proof: Let σ remains a constant function.
(i.e.) $\sigma(p) = c$, for all $p \in v$.
Suppose we have a v-edge degree in strongly irregular fuzzy semigraph $\mathcal{G}$ where the edge degree of its nodes all are distinct.
Consider a pair of nodes P1 & P2, where P1 and P2 have distinct degrees T_1 and T_2 respectively.
(i.e.) $d_e(P_1) = T_1$ and $d_e(P_2) = T_2$ where $T_1 \neq T_2$
The proof follows a similar structure as the proof of theorem 2.10.

REMARK 2.12: Anedgestrongly irregular fuzzy semigraph and the total degree is highly irregular. Fig.2.

Now,$d_e(p)$=0.6, $d_e(Q)$=0.5, $d_e(R)$=0.7, $d_e(S)$=0.8, $d_e(T)$=0.4 and $td_e(p)$=1.3, $td_e(Q)$=0.9, $td_e(R)$=1.3, $td_e(S)$=1.3, $td_e(T)$=1. In this case, the nodes of the semigraph have distinct edge degrees and are considered strongly irregular, and the total edge degree of the nodes is also distinct. Therefore, the fuzzy semigraph is highly irregular in total edge degrees.

Theorem 2.13: For a fuzzy semigraph $\mathcal{G}: (\sigma, \mu, \eta)$is referred to$G: (\mathcal{V}, \mathcal{E}, \mathcal{X})$, where σ represents a constant value, the conditions i) and ii) are identical, indicating that $\mathcal{G}$ is both an adjacent degree in strongly irregular fuzzy semigraph and an adjacent degree in strongly total irregular fuzzy semigraph.

Proof : Let σ remains a constant function.
(i.e.) $\sigma(p) = c$, for all $p \in v$.
Suppose we have an adjacent degree irregular fuzzy semigraph $\mathcal{G}$ where the adjacent degree of its nodes all are distinct.
Consider a pair of nodes P1 & P2, where P1 and P2 have distinct degrees T_1 and T_2 respectively.
(i.e.) $d_{\mathcal{G}_a}(P_1) = T_1$ and $d_{\mathcal{G}_a}(P_2) = T_2$ where $T_1 \neq T_2$
The proof follows a similar structure as the proof of theorem 2.10.

REMARK 2.14: An adjacent degree is neighbourly irregular fuzzy semigraph and its total degree is strongly irregular. Fig.3.
Now,$d_{\mathcal{G}_a}(p)$=0.7, $d_{\mathcal{G}_a}(Q)$=0.6, $d_{\mathcal{G}_a}(R)$=0.9, $d_{\mathcal{G}_a}(S)$=0.8, $d_{\mathcal{G}_a}(T)$=0.6 and $td_{\mathcal{G}_a}(p)$=0.9, $td_{\mathcal{G}_a}(Q)$=1.1, $td_{\mathcal{G}_a}(R)$=1.2, $td_{\mathcal{G}_a}(S)$=1, $td_{\mathcal{G}_a}(T)$=1.3.. In this case, the nodes of the semigraph have distinct adjacent degrees and are considered neighborly irregular, and the total adjacent degree of the nodes is also distinct. Therefore, the fuzzy semigraph is strongly irregular in adjacent total degrees.

Theorem 2.15: For a fuzzy semigraph $\mathcal{G}: (\sigma, \mu, \eta)$is referred to$G: (\mathcal{V}, \mathcal{E}, \mathcal{X})$,where$\sigma$ remains a constant function, the conditions i) and ii) are identical, indicating that $\mathcal{G}$ is both a consecutive adjacent degree in strongly irregular fuzzy semigraph and a consecutive adjacent degree in strongly total irregular fuzzy semigraph.

Proof: Let σ remains a constant function.
(i.e.) $\sigma(p) = c$, for all $p \in v$.
Suppose we have a consecutive adjacent degree irregular fuzzy semigraph $\mathcal{G}$ where the consecutive adjacent degree of its nodes all are distinct.
Consider a pair of nodes P1 & P2, where P1 and P2 have distinct degrees T_1 and T_2 respectively.
(i.e.) $d_{\mathcal{G}_{ca}}(P_1) = T_1$ and $d_{\mathcal{G}_{ca}}(P_2) = T_2$ where $T_1 \neq T_2$
The proof follows a similar structure as the proof of theorem 2.10.

REMARK 2.16: A consecutive adjacent degree is strongly irregular fuzzy semigraph and its total degree is neighbourly irregular. Fig.4. Now,$d_{\mathcal{G}_{ca}}(p)$=0.5, $d_{\mathcal{G}_{ca}}(Q)$=0.7, $d_{\mathcal{G}_{ca}}(R)$=1, $d_{\mathcal{G}_{ca}}(S)$=1.1, $d_{\mathcal{G}_{ca}}(T)$=0.9,$d_G(U)$=0.6 and $td_{\mathcal{G}_{ca}}(p)$=1.2, $td_{\mathcal{G}_{ca}}(Q)$=1.1, $td_{\mathcal{G}_{ca}}(R)$=1.9, $td_{\mathcal{G}_{ca}}(S)$=1.2, $td_{\mathcal{G}_{ca}}(T)$=1.6,$d_{\mathcal{G}_{ca}}(U)$=1. In this case, the nodes of the semigraph have distinct consecutive adjacent degrees and are considered strongly irregular, and the consecutive adjacent total degree of the nodes is also distinct. Therefore, the fuzzy semigraph is neighborly irregular in consecutive adjacent total degrees.

Theorem 2.17: For a fuzzy semigraph $\mathcal{G}: (\sigma, \mu, \eta)$is strongly irregular fuzzy semigraph then it is both highly irregular and neighbourly irregular fuzzy semigraph.

Proof: Let $\mathcal{G}$ be a strongly irregular fuzzy semigraph. It follows that every pair of nodes in $\mathcal{G}$ has distinct degrees. Clearly, it is obvious that every consecutive pair of nodes in $\mathcal{G}$ has distinct degrees, and each node in $\mathcal{G}$ is connected to nodes with distinct degrees. Consequently, $\mathcal{G}$ can be defined as a neighbourly irregular and highly irregular fuzzy semigraph.

Theorem 2.18: Fora fuzzy semigraph$\mathcal{G}: (\sigma, \mu, \eta)$is highly irregular and neighbourly irregular fuzzy semigraph is not required to be a strongly irregular fuzzy semigraph.

Proof: The nodes P&Q of $\mathcal{G}$,which are neither adjacent nor incident on the same node can have the same degree, contradicting the definition of a strongly irregular fuzzy semigraph.

CONCLUSION

This study, conducted a comprehensive analysis of strongly irregular and totally strongly irregular fuzzy semigraphs, delving into their edge, adjacency, and consecutive adjacency degrees. A thorough comparative investigation between strongly irregular and strongly total irregular fuzzy semigraphs was carried out, along with a detailed examination of neighbourly and highly irregular fuzzy semigraphs.

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Table:1

END NODES	**P**	**R**	**T**
$\mathbf{d}_{\mathcal{G}}(v)$	0.6	0.9	0.4
$\mathbf{d}_{\mathbf{e}}(v)$	0.6	0.9	0.4
$\mathbf{d}_{\mathcal{G}_{\mathbf{a}}}(v)$	1.2	1.5	0.4
$\mathbf{d}_{\mathcal{G}_{\mathbf{Ca}}}(v)$	0.6	1	0.4
MIDDLE NODES	**Q**		
$\mathbf{d}_{\mathcal{G}}(v)$	0		
$\mathbf{d}_{\mathbf{e}}(v)$	0.5		
$\mathbf{d}_{\mathcal{G}_{\mathbf{a}}}(v)$	1.1		
$\mathbf{d}_{\mathcal{G}_{\mathbf{Ca}}}(v)$	1.1		
MID- END NODES	**S**		
$\mathbf{d}_{\mathcal{G}}(v)$	0.7		
$\mathbf{d}_{\mathbf{e}}(v)$	0.7		
$\mathbf{d}_{\mathcal{G}_{\mathbf{a}}}(v)$	0.7		

$\mathbf{d}_{\mathcal{G}_{Ca}}(v)$	0.7		

Table:2

END NODES	P	R	T
$\mathbf{td}_{\mathcal{G}}(v)$	1.4	1.6	1.3
$\mathbf{td}_{\mathbf{e}}(v)$	1.4	1.6	1.3
$\mathbf{td}_{\mathcal{G}_a}(v)$	2	2.2	1.3
$\mathbf{td}_{\mathcal{G}_{Ca}}(v)$	1.4	1.7	1.3
MIDDLE NODES	**Q**		
$\mathbf{td}_{\mathcal{G}}(v)$	0		
$\mathbf{td}_{\mathbf{e}}(v)$	1		
$\mathbf{td}_{\mathcal{G}_a}(v)$	1.6		
$\mathbf{td}_{\mathcal{G}_{Ca}}(v)$	1.6		
MID- END NODES	**S**		
$\mathbf{td}_{\mathcal{G}}(v)$	1.2		
$\mathbf{td}_{\mathbf{e}}(v)$	1.2		
$\mathbf{td}_{\mathcal{G}_a}(v)$	1.2		
$\mathbf{td}_{\mathcal{G}_{Ca}}(v)$	1.2		

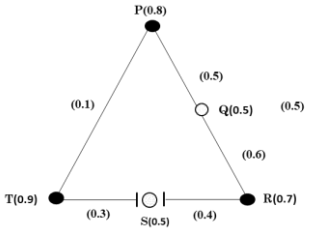


Fig-1

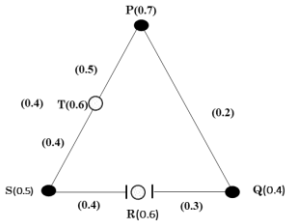


Fig-2

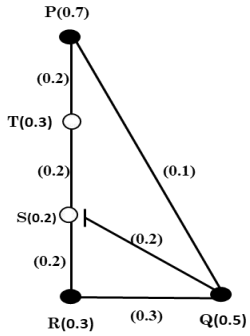


Fig-3

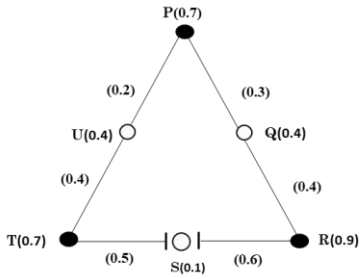


Fig-4

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RESEARCH ARTICLE

Bandicoot - One Stop Robotic Solution to Manual Scavenging in India

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ABSTRACT

The study develops substantial insights about the current situation regarding the still-pervasive, life-threatening practice of manual scavenging in India. It tries to understand the significance of Bandicoot, a robotic solution for the eradication of years-old manual scavenging practices and bringing commendable transformation to the lives of sanitation workers. Overall, it focuses on development of analytical skills towards designing robotic solutions for addressing pressing social issues by seamlessly combining robotics and artificial intelligence. Despite the enactment of The Prohibition of Employment as Manual Scavengers and Their Rehabilitation Act in 2013, employment as a manual scavenger is still allowed in India. With the vision of eradicating manual scavenging from the world, Bandicoot 2.0 was introduced in 2017 for cleaning any type of sewer manhole. With the interactive and user-friendly interface of Bandicoot, the poor manual scavenger's position has been elevated to that of a robot operator, preserving their dignity for leading a respectful life in society. The study is primarily based on secondary data, which was gathered through consulting business newspaper articles about the practice of manual scavenging in India and media stories explaining Genrobotics' development of Bandicoot. Additional data is gathered from the company's website, https://www.genrobotics.org/. For extracting relevant current information in the context of Bandicoot and manual scavenging, many other websites are referred to, like keralainsider.com, outlookindia.com, dailypioneer.com, and republicworld.com. Information about manual scavenging has been taken from reports by the Tata Trust Policy and the Public Information Bureau.

Keywords: Manual Scavenging, Robotic, Manhole, Cleaning, Sanitation

Arnaz Kaizad Wadia

INTRODUCTION TO HEARTBREAKING TRUTH OF SANITATION WORKERS IN INDIA

It is often said that anyone who is dissatisfied with their employment should only contrast it with the work of a manual scavenger in order to experience a miracle. One will undoubtedly feel fortunate to have a job that doesn't demand draining down dignity at the risk of life in a pitiful condition in a manhole. Fatalities with manhole cleaners are very common. Still, the contractors are least bothered to ensure safety precautions like a mask, safety belts, poisonous gas detectors, and checking oxygen levels for their sanitation workers just to cut down on the cost of cleaning. This dire situation raised the question of how to improve the miserable state of manhole cleaners. It's really difficult to come up with an effective remedy in the form of real safety protection for manual scavengers other than their very own prayers for all turning up well while entering the manhole. As manhole cleaners cover their noses and mouths with a small piece of cloth and work barehanded, the question is raised about how someone's life can be so cheap. Simultaneously, the need to get an answer to the question of who is responsible for this situation was strongly felt. Moreover, the major concern was the eradication of the centuries-old practice of manual scavenging, but how? With the birth of Bandicoot by Genrobotics, the much-needed hope of an effective solution for abandoning manual scavenging was enlightened. However, there was a big challenge in how to design the robotic scavenger capable of replacing manholes with robot holes. As an alternative, the dilemma of how successful a robotic scavenger would be compared to a manual scavenger was brought up. Additionally, Bandicoot's success led to the dilemma of how to secure alternate sources of livelihood for all those people who have relied solely on manual scavenging as their only source of income for years.Because of this, a dilemma about whether Bandicoot would be able to bring about the much-needed transformation in sanitation workers' lives and enablethem to carry on with their centuries-old practice of cleaning manholes without putting their safety or dignity in danger persisted along with its invention.

While these hazy clouds of confusion were wandering around, Considering the report of the Census of India (2011), it is observed that there are 7,94,390 dry latrines, with almost 73% in rural areas and the remaining in urban areas where men need to clean excreta. Although the employment of manual scavengers was outlawed in India many years ago, they are still employed to clean dry latrines, blocked gutters, and sewers all over the country. This emphasized the urgent need for an amicable solution to the issue that would allow the decades-old manual scavenging practice to continue while also taking all necessary precautions to ensure the cleaners' safety and security.In light of the foregoing debate, a number of questions were raised, such as what constitutes a workable solution to the issue of manual scavenging. How could asolution be derived? Can Bandicoot be a proven solution sufficient enough to fully address the pressing issue of manual scavenging? Moreover, it is worth noting that there has been a sudden spurt in the number of fatalities resulting in the deaths of sanitation workers. In one of the articles published in The Hindu on July 20, 2022, it is claimed that in the last five years, almost 347 people have died in India while cleaning sewers and septic tanks. Approximately 40% of these fatalities took place in Uttar Pradesh, Tamil Nadu, and Delhi. However, as per the Press Information Bureau scavengers in the country report posted on March 30, 2022, in total, state-wise, 325 sewer deaths were reported. Its details are highlighted in Table 1 below: Despite the enactment of The Prohibition of Employment as Manual Scavengers and Their Rehabilitation Act in 2013, employment as a manual scavenger is still continued. Sewers enter manholes in the daytime only, and it is considered government or corporation work, and not claimed as illegal. That's the tragedy. Therefore, a National Action Plan for Rs. 1.25 lakh crore was created with government intervention on March 6, 2020, to phase out manual scavenging with high-tech machines in 500 cities and gram panchayats (Daily Pioneer, 2020). However, as per the survey conducted in 2013 and 2018 in the context of Ministry of Social Justice and Empowerment Directive, manual scavengers were identified state-wise as follows in Table 2: These facts and figures presented a clear picture ofthe pathetic state of manual scavenging today.Also these discussions presented the biggest dilemma, namely whether Bandicoot will be a blessing for sanitation workers, protecting them as they clean septic tanks or gutters, or a curse, stealing their means of subsistence through their decades-old practice of manual scavenging.

Birth of Genrobotics

Genrobotics, the leading robotics company headquartered in Trivandrum, Kerala, India, was born out of the novel idea of providing service to the Indian army by developing a tailor-made product for soldiers to lift heavy military weapons at remote locations. It was in 2015 when Vimal Govind MK, Arun George, and Nikhil NP, all at 25 years of age, and Rashid Bin Abdulla Khan, at 24 years of age, came together to incubate this idea into reality in the form of Genrobotics, with a common interest in powered exoskeleton technology since their college days at MES College of Engineering in Kuttippuram, Kerala. Together, they developed the first-generation GI-powered exoskeleton, a wearable mobile machine that helps soldiers carry heavy military equipment in off-the-grid settings. This development was entitled Iron Man Suit. The G2 medical exoskeleton, which the team developed, has proven to be a blessing for physically challenged people, like amputees. It ensured their standing up and forging ahead in every step of their lives. As a result of this advancement, they won the best concept prize at the 2016 International Conference on Mechatronics and Manufacturing in Singapore (Forbes India, 2022). The group presented these developments while working with the Kerala Startup Mission (KSUM). Once their engineering studies were completed, they could not immediately continue with their experiments due to a lack of funds. This compelled them to take up IT-related jobs. However, their desire for innovation led them to attend any event where people were discussing the most recent advancements in robotics. Luckily, in 2016, they happened to meet IT Secretary Mr. Sivasankar at an event organized by KSUM, wherein they were enlightened about the burning issue of manual scavenging and the necessity to develop a workable solution. They quickly understood that working in this direction required full-time employment and was a very time-consuming chore. Therefore, they abandoned theirwell-paying careers despite the wishes of their families and friends because of the commitment needed to the new endeavor.

Left with just their savings, they once again brought Genrobotics to life. Additionally, as co-founder Mr. Rashid mentioned, the idea to start with Genrobotics came to them upon reading a newspaper article describing the asphyxiation deaths of two sewage cleaners and an auto driver who attempted to rescue cleaners in a manhole at Kozhikode. The company finally got registered in 2017 thanks to a grant of 10 lacs from KSUM. This led to the establishment of Genrobotics on June 21, 2017. In addition, five more students joined a core group to transform manholes into robot holes. Because of the team's dedication to their objective, they worked nonstop for days and nights without being disturbed by anything else. Since they were all sharing a single room, they could work together. It was important to figure out exactly what was needed. What was the size of the manhole, what were the problems with sewers, which were the major difficulties faced on entering the manhole, etc.? In the search for answers to these questions, they met and discussed them personally with engineers and sewer workers. These discussions turned out to be very fruitful for them, leading to the development of Bandicoot with the unique feature of adjustable expansion and contraction of robot legs to fit different sizes of manholes. Genrobotics won the first Startup Innovator Award by the Kerala Water Authority (KWA) and an innovation grant of 14 lacs based on the development of Bandicoot. This led to the production of its beta version in only a month. Then after, there was no looking back, with the Kerala Water Authority becoming the first public organization to deploy Bandicoot in Thiruvananthapuram. This way, the success story continued with receiving orders outside the state from other states like Tamil Nadu, Karnataka, Andhra Pradesh, and even international orders from Sharjah. Thus, the team tried hard to develop technology-driven solutions for the nation’s problems, but due to financial constraints and the high price of imported parts, they halted their efforts. However, the Kerala Startup Mission (KSUM), the state government's nodal agency for the development of startups and entrepreneurship support to replace the job of manual scavenging with technology, led to the birth of Bandicoot, a robotic solution from Genrobotics for replacing men with a machine for cleaning manholes. This turned out to be the biggest blessing for sanitation workers, saving them from manhole-related deaths.

Genrobotics - Product Portfolio

Three robotic solutions, Bandicoot, Wilboar, and G-Beetle, are offered under the product portfolio of Genrobotics. The names of the Bandicoot and Wilboar robots are derived from the names of animals fond of doing similar work, such as searching underground, just like the robots do while cleaning manholes and other confined spaces.Manholes of any kind are cleaned with the robotic solution of Bandicoot. The robot is composed of two units: a stand unit and a robotic drone unit. A drone unit enters a manhole. Its dive depth is adjusted according to the situation. Any corrosive

sewage situation is handled with a nanocoating in addition to a powder coating. A number of tasks are performed by the drone unit's extending robotic arm, such as grabbing, shovelling, and unclogging manholes. For high-definition displays, the drone units are outfitted with IP68 waterproof cameras. Moreover, the drone unit is tracked continuously with the sensor-based feedback system. This has raised the standard of cleaning without human involvement. Confined spaces like petroleum tanks, sewers, and water treatment plants are cleaned with the technically advanced solution of Wilboar 2.0. The hard sludge in confined spaces is uncloged by the Wilboar high-pressure water jetting system. The waste gets accumulated in the waste collection chamber with the in-built sucking module. Also, tanks are examined from outside with the help of Wilboar ATEX-certified high-resolution machine vision technology for the identification of any kind of sludge.G-Beetle is used for cleaning the skyscraper facade. It has brought a much-awaited revolution to the safety and security of skyscraper facade cleaners. G-Beetle made cleaning and beautification possible without being concerned about the frightening heights of skyscrapers. Its productivity standards are augmented by the robotic drone system and artificial intelligence. During the cleaning process, the required facade contact is maintained by the dynamic balancing of propellers and thrusters. Thus, G-Beetle offered a solution for performing the world's most dangerous jobs at ease without threatening the lives of cleaners working at great heights.

Working of the Robotic Scavenger-Bandicoot

For easier portability, Bandicoot has four robotic legs. Solid waste is removed by its 360-degree rotating robotic arms from every nook and cranny of the manhole. Water jets are fitted to them in order to eliminate sewage obstructions. Through the night vision cameras that are attached to them, a clear image of the interior of the manhole is obtained. The robot may be operated by itself. It comes with features including dirt-proofing, waterproofing, and corrosion protection. Most crucially, it possesses the competency to complete the task of three manual scavengers' three-to-four-hour work in only 45 minutes. The robot can effortlessly raise the bulky manhole covers, which formerly required at least two to three workers. The sensors that are attached to them can also be used to detect poisonous gases. Bandicoot robots use artificial intelligence to mimic any human movement. It is capable of carrying out a variety of activities, including excavating, holding, picking up, and positioning the water-jet for specific cleaning. Any human hand movements are replicated by robotic arms. Considering these numerous benefits of Bandicoot, 17 states have started to avail of its services, including Madhya Pradesh, Maharashtra, Haryana, Gujarat, Uttar Pradesh, Punjab, Andhra Pradesh, Kerala, Tamil Nadu, Assam, Rajasthan, etc. And this way, it has resulted in the successful eradication of years-old barbaric practices of caste-wise discrimination by forcing Dalits to perform all degraded jobs like manual scavenging. Bandicoot 2.0 is proven to be the best technology for enabling zero human intervention in the cleaning process of hazardous gutters, manholes, and septic tanks. Moreover, Bandicoot has successfully contributed to the "Swachh Bharat Abhiyan and Make in India" initiatives of the Government of India. It is evident of our nation's prospering progression. Being designed and manufactured completely in India, it has set an exemplary role model for promoting the Aatma Nirbhar Bharat Abhiyan. Bandicoot has worked wonders in people's lives. As per the article dated December 6, 2021 in The Hindu Business Line Sachin Yadav, a 42-year-old sanitation worker working for Brihanmumbai Municipal Corporation (BMC) for the last 14 years, finds a radical change in his life. As of now, there is a robot working as a ginny in his place, performing all his life-threatening jobs. Bandicoot proved to be a blessing that completely changed his life. Now, he is not supposed to enter the manhole, and his work is done much quicker. This assured his family of his safety. As the robot cleans and removes clotting from any type of manhole and septic tank. From the very beginning of the cleaning process, which starts with the lifting of the gutter covers, to finally collecting the solid waste in a bucket, the robot is well equipped to perform the complete cleaning process without human intervention. Infrared cameras mounted on Bandicoot help project the interiors of the manhole on the monitor screen beforehand only. This assures easy cleaning with a clear picture of a blocked manhole.

Mitigating Covid-19 and Occupational Hazards Risk with Bandicoot

The best part about Bandicoot was realized at the time of COVID-19. The robot worked out as a real miracle at that time, providing Indian sanitation workers with the advantage of operating a manhole from a distance without compromising on any kind of safety measure. During the pandemic, sanitation workers were the front-line workers,

and they were exposed to hazardous waste on a daily basis. Moreover, due to the COVID-19 situation, a tremendous surge in waste in the form of used masks, gloves, and other bio-hazardous materials was observed. This was an alarming situation at the places where manual scavenging was practiced, threatening the lives of sanitation workers. In this hard situation, Bandicoot provided a much-needed protection shield. Getting involved with manual scavenging can be as risky as ending a life. Because breathing in harmful chemicals within sewers can be fatal. According to data from Safai Karmachari Andolan (SKA), manual scavengers—who are primarily women—are paid between 180 and 200 rupees per month per household and have an average life expectancy of 40 to 45 years, along with the threat of hepatitis, cholera, meningitis, typhoid, and cardio-vascular problems (The Hindu Businessline 2021, December 06). The article also mentioned records from the National Commission for Safai Karamcharis, which stated 376 deaths between 2015 and 2019 while clearing septic tanks and sewers, as well as the presence of 62,904 manual scavengers between December 2013 and January 2020. This data illustrates the challenging environment in which manual scavenging is practiced in India.

Manual Scavengers Social Obligation in India

Manual scavengers hesitate to reveal their identities. They work most of the time without any kind of protective measure except a rope tied around their waist. It is observed that in India people take up the work of manual scavenging because there are no other job options. And once they take up this task of making the world a better place to live, they end up making their lives hell. Once a manual scavenger tag is applied, no other job is entrusted to him. Even in Indian societies, manual scavenging is always looked down upon as a dignity-less job. To stand on par with society's social obligations, manual scavenger identity is hidden just to get the much-needed acceptance and equally fair treatment that are the rights of every citizen in India, the world's largest democracy. Tata Trusts and the Municipal Corporation of Greater Mumbai jointly initiated Mission Garima in March 2014 to restore the dignity of sewers. The mission emphasized greater usage of technology to minimize manual handling of waste. However, effective results showcasing upliftment in the dignity of manual scavengers were not observed.

Indian Government Measures and Policies for Abolishing Manual Scavenging

No one may be required to perform manual scavenging in accordance with the Civil Rights Act of 1955. Aiming to end the practice of manual scavenging, the Employment of Manual Scavengers and Construction of Dry Latrines (Prohibition) Act of 1993 and the Prohibition of Employment as Manual Scavengers and Their Rehabilitation Act of 2013 were both passed. In addition, the Supreme Court declared on March 27, 2014, that the government must step in to end the practice of manual scavenging and to rehabilitate those who got engaged with it. This guarantees the constitutional obligation to help sewers find better alternative work in order to regain their diminished dignity. The Building and Maintenance of Insanitary Latrines Act of 2013 also forbids the development of such facilities (Outlook India, 2022). It assures the demolition of insanitary toilets or their conversion into sanitary toilets. Therefore, despite all of the legal restrictions that are currently in place to stop manual scavenging, a large number of people from lower social classes have started engaging in it. This reflects administrative inefficiency in the successful implementation of an established law prohibiting one of the most disrespectful manual scavenging practices. Moreover, the worst part of manual scavenging is believed to be untouchability and disrespect for those engaged in this work. As in India, manual scavenging has historically been institutionalized based on caste differentials. Since there are no better employment options, the majority of the people who got engaged in manual scavenging are members of the downtrodden and disadvantaged class.

Bandicoot collaboration with IOCL & other Institutions

In June 2022, IOCL teamed up with Genrobotics to develop a robotic cleaning solution for refineries in light of the widespread success of Bandicoot, the first robotic scavenger in history. At the moment, Bandicoot is used in refineries to clean storm-water and oily sewers. Bandicoot is used by numerous different public and private sector organizations in order to minimize human intervention while cleaning manholes. Indore and Surat Municipal Corporations (SMC), which received the accolade for being the cleanest cities, also make use of Bandicoot services. Additionally, an announcement regarding expanding the use of Bandicoot 2.0R robots for cleaning refineries was made on the 63rd Foundation Day of IOCL. The fire-resistant feature of Bandicoot 2.0R has made it the ideal choice

for cleaning the OWS and SWS of refineries. Both the Municipal Committee of Leh and the Municipal Corporation of Pune use bandicoot services. Now that Leh has a robotic scavenger, even bad weather doesn't hinder the manhole cleaning process there. With Bandicoot's development, the Municipal Committee of Leh is better able to support the Ministry of Housing and Urban Affairs' Safai Mitra Suraksha Challenge and Mission Zero Manual Scavenging. Bandicoot is being used by the municipal corporations of Ullhasnagar and Dhule to repair the manholes in the cities. The 16th state to adopt Bandicoot is Rajasthan. Kanpur Smart City Limited has shifted to robotic cleaning with Bandicoot as part of the Smart City Programme.

Bandicoot Turnaround Story

The Ministry of Housing and Urban Affairs (MOHUA) recognized Bandicoot: The Robotic Scavenger as the best innovation for eradicating the practice of manual scavenging. It won the Swachhta Start-Up Challenge in September 2022. Due to its highly advanced technology, this robotic scavenger offered not only societal and environmental benefits but also financial ones as well. As it cleaned 10 manholes in contrast to a manual scavenger's capacity of cleaning just one or two manholes every day. As a result, there are significant labour savings compared to what would have been necessary for manual scavenging. In places where other technology, like grabbing machines, fails to extract solid waste, the bandicoot offers much more advanced technology for cleaning by reaching every corner of the confined manhole. Its services are utilized on a daily basis by 17 states in addition to numerous other urban local bodies, smart cities, and refineries. Thus, it is evident that Mission Robohole, geared by Genrobotics is advancing every day. According to an article in the Times of India from June 8, 2022, Mr. Govind claims that more than 1 lakh robots will be needed to put an end to manual scavenging in India. The main cause driving the demand for Bandicoot deployment is rapid urbanization. In this context, the comment made by Mr. Rashid in the CNBC TV18 Upadhyay, A. (2022, July 19) report is worth noting that "Version 2.0 of Bandicoot is currently available for Rs 39.5 lakh (including the goods and services tax) makes clear that its demand is flourishing. From a small office in 2017, we now have a 12,000 square foot production area in Thiruvananthapuram and one in Palakkad". Additionally, Genrobotics and Google have partnered to offer a better user interface. Furthermore, Bandicoot provides built-in training assistance. This assures efficient learning for sanitation workers in less time. All these developments cleared the dilemma about success of Bandicoot for bring much-needed transformation in lives of sanitation workers.

Future Prospect of the Robotic Scavenger

The illegal practice of manual scavenging can be stopped by Bandicoot. It has been recognized by Ministry of Housing and Urban Affairs and Smart City Mission India. The chairman of the Mahindra Group, Anand Mahindra, also made an investment in Genrobotics as stated in one of S. Chowdhary's articles from Financial Express (2020, October 19). Anand Mahindra also tweeted that there are many worries about how AI and robots will affect society in the future in light of this fantastic invention and its capabilities. Nevertheless, he would still continue to offer prayers at the temple of technology and robotics if robots could free people from this most abhorrent job in the universe. Considering this innovative advancement, Bandicoot could be considered one of the most innovative robotic solutions, reflecting the progression of progressive Swatch Bharat. Additionally, the Genrobotic Innovations founders have been chosen for a fellowship by the influential Adani Group. According to the article in The Hindu (2022, December 26), the fellowship will assist Genrobotics in growing its business into new industries and creating solutions for a range of social issues. Also, it stated that with the company's foray into overseas markets like the UK, Malaysia, UAE, and South Korea, the organization's brighter prospects are very apparent.

The capability of Bandicoot to be technically advanced yet user-friendly has highlighted it in the eyes of global-level marquee investors. Stepping one step ahead, global-level expansion of the organization is possible with its unique and novel robot manufacturing capacity. It is also worth noting that the rehabilitation of sewer workers who lost their jobs due to automation is carried out throughout the year at Genrobotics. They are rehabilitated by training them to operate Bandicoot.Additionally, Bandicoot has been designed to provide a simple user interface that ensures seamless navigation of controls. This measure taken by Genrobotics acts as a protection shield for the daily earnings of sewer workers and doesn't let technology snatch away means of livelihood from the hands of the workers. The most rewarding moment, though, for Mr. Arun, one of the Genrobotics co-founders, is witnessing a sewage worker

transformed into a machine operator. Diligently handling the machine without being tortured by getting into the sewage lines full of toxic and hazardous gases. Genrobotics' success disproves the notion that hardware start-up companies frequently fail and have lengthy gestation periods. It exemplifies how Bandicoot's solution to the critical social issue of manual scavenging provided a lifeline for low-paid sanitation workers and ultimately turned out to be an incredible blessing for humanity. Hence, Bandicoot has not only revamped sanitation but also empowered the lives of more than 3,000 sanitation workers in 17 states and several union territories across India, ensuring their sustainable existence. Bandicoot has succeeded in achieving nine of the 17 Sustainable Development Goals (SDGs) of the United Nations. It comprises good health and well-being; quality education; clean water and sanitation; decent work and economic growth; industry, innovation, and infrastructure; reduced inequality; sustainable cities and communities; responsible consumption and production; and peace, justice, and strong institutions. Wilboar and G Beetle, two more Genrobotics products, also offer breakthrough technological advancement. Therefore,the main takeaway from all of these facts is that reliance on cutting-edge technology supported by robotics and artificial intelligence needs to be significantly utilized in order to ensure the advancement of a progressive nation like India, as it also aids in the attainment of sustainable development goals.

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Table 1. Information about deaths of people in septic tanks and sewers over the previous five years (2017 - 2021)

Sr. No.	Name of State/UT	Total Number of sewer death
1	Andhra Pradesh	13
2	Bihar	2
3	Chhattisgarh	1
4	Chandigarh	3
5	Delhi	42
6	Gujarat	28
7	Haryana	33
8	Karnataka	26

9	Kerala	1
10	Maharashtra	30
11	Madhya Pradesh	1
12	Odisha	2
13	Punjab	16
14	Rajasthan	13
15	Tamil Nadu	43
16	Telangana	6
17	Uttar Pradesh	52
18	West Bengal	13
	Total	325

Source: PIB (2022, March 30). Scavengers in the country. Retrieved from https:// pib.gov.in /PressReleaseIframePage.aspx?PRID=1811403

Table 2. State-wise number of manual scavengers

Sr. No.	Name of State/UT	No. of Manual Scavengers
1	Andhra Pradesh	1793
2	Assam	3921
3	Bihar	131
4	Chhattisgarh	3
5	Gujarat	105
6	Jharkahand	192
7	Karnataka	2927
8	Kerala	518
9	Madhya Pradesh	510
10	Maharashtra	6325
11	Odisha	230
12	Punjab	231
13	Rajasthan	2673
14	Tamilnadu	398
15	Uttar Pradesh	32473
16	Uttarakhand	4988
17	West Bengal	680
	Total	58098

Source: PIB (2022, March 30). Scavengers in the country. Retrieved from https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1811403



Figure 1. Manual Scavenger
Source: The Indian Express, New Delhi Edition retrieved from https://indianexpress.com/article/india/athawale-in-parliament-73-31-of-manual-scavengers-from-scheduled-castes-7653092/



Figure 2. Genrobotics Founder Members
Source: https://images.cnbctv18.com/wp-content/uploads/2022/07/Genrobotic_1.jpg



Figure 3. The Birth of Generobotics
Source:https://images.cnbctv18.com/wp-content/uploads/2022/07/Genrobotic_4.jpg



Figure 4. Bandicoot
Source: https://www.genrobotics.org



Figure 5. Manufacturing of Bandicoot
Source: https://www.genrobotics.org



Figure 6. Bandicoot Key Features
Source: https://images.cnbctv18.com/wp-content/uploads/2022/07/Genrobotic_3.jpg



Figure 7. Bandicoot State-wise Adoption Chart
Source:https://images.cnbctv18.com/wp-content/uploads/2022/07/Genrobotic_2-1019x573.jpg

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RESEARCH ARTICLE

Solubility and Dissolution Rate Enhancement of Ticagrelor and Development of Fast Dissolving Tablets

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ABSTRACT

The aim of the present work is to enhance the solubility and dissolution rate of poorly soluble drug, Ticagrelor by formulating as solid dispersions. The solid dispersions were formulated with Gelucire 50/13, poloxamer-P188 and Kollidon VA64 as carriers. The kinetics and mechanisms of drug release from in-vitro dissolution parameters were calculated. The solid dispersions TPFM2 and TGFM2 in the drug: polymer ratio of 1:2 prepared by fusion method showed rapid drug release when compared to the pure drug. Further the optimized dispersions are used for preparation of fast dissolving tablets using different super disintegrants like Croscarmellose sodium and Sodium Starch Glycolate by direct compression technique. The prepared formulations were evaluated for physical parameters such as weight uniformity, hardness, friability, disintegration time and drug content & in vitro drug release. It was found that the formulation F7 and F13 with SSG at 15% showed the rapid drug release when compared to marketed and other tablet formulations. A drug release of tablet formulations in the presence of various super disintegrants were in the order of SSG>CCS.

Keywords: Solid Dispersion, Ticagrelor, Superdisintegrants, Poloxamer –188, Gelucire 50/13.

INTRODUCTION

Although various novel and advanced drug delivery systems have been introduced for therapeutic use, the popularity of oral dosage forms particularly tablets have not been eclipsed, because of its numerous advantages. [1] However in case of the oral route there are several challenges such as limited drug absorption resulting in poor bioavailability and poor pharmacological response resulting into inadequate and erratic oral absorption. Drug absorption from the gastrointestinal (GI) tract can be limited by a variety of factors with the most significant contributors being poor aqueous solubility and/or poor membrane permeability of the drug molecule. When delivering an active agent orally, it must first dissolve in gastric and/or intestinal fluids before it can then permeate the membranes of the GI tract to reach systemic circulation. Therefore, a drug with poor aqueous solubility will typically exhibit dissolution rate limited absorption and a drug with poor membrane permeability will typically exhibit permeation rate limited absorption. Hence, two areas of pharmaceutical research that focus on improving the oral bioavailability of active agents include enhancing solubility and dissolution rate of poorly water-soluble drugs and enhancing permeability of poorly permeable drugs. This article focuses on the former, in particular, the use of solid dispersion [2] and fast dissolving/disintegrating tablets (FDDTs) technologies to improve the dissolution characteristics of poorly water-soluble drugs and in turn their oral bioavailability. Hence, fast dissolving/disintegrating tablets (FDDTs) are a perfect fit for them. FDDTs dissolves or more commonly disintegrate rapidly in the saliva without the aid of water.[3]Ticagrelor is used for the prevention of thrombotic events in people with acute coronary syndrome or myocardial infarction with ST elevation.[4]The aim of the work is to enhance the solubility, dissolution rate and oral bioavailability of poorly soluble drug, Ticagrelor by formulating as solid dispersions using fusion method with Gelucire 50/13, Poloxamer-P188 and Kollidon VA64 and subsequent preparation of fast dissolving tablets from solid dispersions using different superdisintegrants and comparing them with that of the marketed product.

MATERIALS AND METHODS

Ticagrelor was obtained as Gift sample from NATCO, Hyderabad. KollidonVA64 Poloxamer P188 and Gelucire 50/13 were obtained as Gift sample from NATCO, Hyderabad. Sodium Starch Glycolate and Croscarmellose sodium was commercially obtained from S.D Fine Chem, Ltd., Mumbai.

Saturated Solubility Studies

Saturated solubility studies of Ticagrelor were performed in different dissolution media. 200mg of Ticagrelor was weighed and transferred into different conical flask. 25ml of different dissolution media i.e., 6.8 pH phosphate buffer, 7.4 pH phosphate buffer, 0.1N HCl, 0.2% Tween 80 and Distilled water were transferred into individual conical flask and were closed appropriately.[5]All the conical flasks were placed in the REMI incubator shaker. The shaker was allowed to operate at 50 rpm at 37º C ± 1º C for 48 hrs. Then the conical flasks were removed from the incubator shaker and the samples were filtered by using Whattmann filter paper. The clear solution obtained by filtration was suitably diluted with appropriate dissolution media and the absorbance values were noted at 296 nm by using corresponding dissolution media as blank solutions. The saturated solubility studies indicated that ticagrelor showed maximum solubility in 0.2% Tween 80 in distilled water.

PREPARATION OF TICAGRELOR SOLID DISPERSIONS

Solid dispersions were prepared by using Poloxamer P188, Gelucire 50/13 and Kollidon VA 64 as carriers by employing fusion method for the preparation of solid dispersions. Specified quantity of carrier was taken in a china dish and subjected to melting by keeping china dish on hot plate. After melting of carrier, specified quantity of drug was added to this melted carrier. Soon after incorporation of drug in to the carrier, the china dish was kept a side for 24 hrs. Then after collect solid dispersion and stored hermetically in desiccator. The composition of various solid dispersions was given in table 1.

Evaluation of Solid Dispersions: The prepared solid dispersions were evaluated for various pre formulation parameters such as angle of repose, Carr's index and Hausner's ratio.[6]The results were given the table 2.

***In-Vitro* Dissolution Studies of Ticagleor Solid Dispersions**

The dissolution studies for the solid dispersions was carried out in USP Apparatus Type II (paddle)with 900 ml of 0.2% tween 80 as the dissolution medium. The samples were drawn at 5, 10, 15, 30 and 45 minutes. Fresh volume of the medium was replaced with the withdrawn volume to maintain the sink conditions and constant volume throughout the experiment. Samples withdrawn were suitably diluted with same dissolution medium and the amount of drug dissolved was estimated by ELICO SL-210 double beam spectrophotometer at 296nm and subsequently analyzed for the cumulative percentage of drug released. The dissolution profiles of ticagrelor solid dispersions were shown in the figures 1&2. Based on the dissolution studies performed on all the formulations, some of the optimized solid dispersions were selected and further characterized by FT-IR and XRD studies[7]. FT-IR and XRD patterns were shown in the figures 3,4.

Development of Ticagrelor Fast Dissolving Tablets From Solid Dispersions

Preparation of Ticagrelor Fast Dissolving Tablets

Among the solid dispersion prepared and based up on dissolution studies performed, Solid dispersions prepared by Fusion method containing Drug:Poloxamer and Drug: Gelucire 50/13 in the ratio of 1:2 were optimized for further preparation of fast dissolving tablets. The tablet was prepared by direct compression process. The tablet formulation consists of Solid dispersion, superdisintegrant, diluent and anti frictional agents. The ratio of drug: carrier was maintained constant while the superdisintegrant concentration was varied.[8]The composition of various tablet formulations were given in table 3. Physical parameters such as weight variation, friability, hardness, disintegration and drug content were evaluated for the prepared tablets.The results were shown in table 4.

***In-Vitro* Dissolution Studies of Ticagrelor Fast Dissolving Tablets.**

The formulated tablets were also further evaluated for drug content, for *in vitro* drug release studies. [9]The dissolution test was carried out in USP Apparatus Type II (paddle) with 900ml of 0.2% tween 80 as the dissolution medium. The samples were drawn at 5, 10, 15, 30 and 45 minutes.The amount of drug dissolved was estimated by ELICO double beam spectrophotometer at 296 nm and subsequently analyzed for the cumulative percentage of drug released[10,11]The drug release profiles for all the formulations were shown in figures 5,6.The comparitive drug release profiles of optimised ticagrelor tablet formulations with marketed formulation were given in the figure 7.

Similarity and Difference Factor of Tablet Formulations

The dissolution profiles of F7 and F13 tablet formulations were compared with marketed Ticagrelor tablets.[12]The difference factor (f1) and similarity factor (f2) of formulations results were given in the table 6.

Accelerated Stability Data of Tablet Formulations

Accelerated stability studies were performed for the optimized formulations (F7 and F13). The product was subjected to accelerated stability studies at 40°C±2°C/75% ±5% RH for 60days.There were no significant changes observed in drug release from the tablets after storage at different conditions[13] remained unaltered and found to be quite stable and the results were shown in the figure 8 and 9.

DISCUSSION OF RESULTS

The spectrophotometric method used for estimation of Ticagrelor in 0.2% tween 80 in distilled water was found to be linear and reproducible. The saturated solubility studies for pure drug was carried out in different media. The studies indicated that Ticagrelor showed maximum solubility in 0.2% tween 80 in distilled water. Solid dispersions of Ticagrelor drug were prepared by Fusion method by using Poloxamer P188, Gelucire 50/13 and Kollidon VA 64 as polymers. The dispersions were evaluated for angle of repose and Carr's index and for drug content. The angle of

repose values obtained for various solid dispersions were in the range of 13^0 -23^0. Carr's index values obtained for various solid dispersions were in the range of 9 – 17%. Particle sizes of prepared solid dispersions were found to be in the range of 172 – 179 μm. The drug content of prepared solid dispersions was found to be in the range of 88.58–89.8 mg. The *in vitro* dissolution studies were performed for various solid dispersions in 0.2% tween 80 in distilled water. It was found that the solid dispersions TPFM2 and TGFM2 in the drug:polymer ratio of 1:2 by employing polaxomer P188 and gelucire 50/13 prepared by fusion method shows rapid drug release when compared to the pure drug. The optimized solid dispersions were selected and further investigated for FTIR, DSC and PXRD.IR studies of Ticagrelor and optimized formulations were carried out to study the interaction between the drug and excipients used. N-H stretching, R-COOH stretching, C=N stretching and fluoride of pure Ticagrelor and the optimized formulations were almost in the same. It showed that IR spectrum of Ticagrelor and optimized formulations were having similar fundamental peaks and pattern. Powder X-ray diffraction (PXRD) patterns were traced employing X-ray diffractometer Bruker AXS, DH Advance, Germany for all the samples.

The solid dispersions that shows rapid dissolution when compared to pure ticagrelor was further selected for the preparation of fast dissolving tablets. The fast dissolving tablets were prepared by using superdisintegrants like CCS and SSG at various concentrations. The compressed tablets were further evaluated for physical parameters such as weight uniformity, hardness, friability, drug content and disintegrating time. All the physical parameters evaluated were with the specified limits. The direct compression process was found to be suitable for compressing optimized solid dispersions as fast dissolving tablets dissolution studies were prepared on all the tablet formulations by using USP type II apparatus(paddle). Among the formulations prepared the formulations F7 and F13 prepared by using solid dispersions Poloxamer P188 and Gelucire 50/13 and with 15% SSG as superdisintegrant were found to release the drug rapidly than other formulations. The dissolution profiles of F7 and F13 tablet formulations were compared with marketed Ticagrelor tablets. The difference factor and similarity factor were calculated for these tablet formulations. The difference factor f_1 values are 9 and 12 and similarity factor f_2 values are 54 and 60. The formulations F7 and F13 showed the similarity factor values above 50 indicated that the release profiles for these formulations were similar to that of marketed formulation. The optimized fast dissolving tablet formulations were subjected to accelerated stability studies. These formulations were stored at $40^oC \pm 2^oC$, 75%±5% RH for 6 months. Then after storage these formulations were evaluated for the physical parameters like weight uniformity, hardness, friability and drug content. There were no significant changes observed in drug release from the tablets after storage at different conditions remained unaltered and found to be quite stable.

CONCLUSION

In the present study an attempt was made to improve solubility and dissolution rate of Ticagrelor by solid dispersions technique with carriers like Poloxamer P188, Gelucire 50/13 and Kollidon VA 64. It was found that the solid dispersions prepared by Poloxamer P188 and Gelucire 50/13 employing fusion method in the ratio of 1:2 showed rapid drug release when compared to the pure drug. The direct compression process was found to be suitable for compressing optimized solid dispersions as tablets. The formulation F7 & F13 with Sodium Starch Glycolate at 15% showed the rapid drug release when compared to other tablet formulations. It may be concluded that Ticagrelor tablets prepared by using solid dispersions with 15% SSG was found to be ideal formulation.

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Conflict of Interest : None

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Table 1: Composition of various solid dispersions of Ticagrelor by fusion method.

S. No	Composition	Ratio
Drug: Poloxamer P188		
1	TPFM1	1:1
2	TPFM2	1:2
Drug: Gelucire 50/13		
3	TGFM1	1:1
4	TGFM2	1:2
Drug: Kollidon VA 64		
5	TKFM1	1:1
6	TKFM2	1:2

Table 2: Evaluation of Ticagrelor Solid Dispersions

S.No	Solid Dispersion	Angle of repose (º)	Carr's Index(%)	*Particle size (microns)*	Drug Content (%)
01	TPFM1	23.21	17.23	176±2	99.95±0.3

02	TPFM2	21.45	14.56	175±4	97.35±0.9
03	TGFM1	19.85	13.77	173±3	98.20±1.1
04	TGFM2	19.22	13.25	177±2	99.15±0.5
05	TKFM1	18.65	11.14	178±2	97.35±2.1
06	TKFM2	16.52	13.64	176±5	97.10±1.5

Table 3: Compositions of Ticagrelor Fast Dissolving Tablet Formulations

Ingredients									
Formulations	**TPD(mg)**	**TPFM2 (mg)**	**TGFM2 (mg)**	**CCS (mg)**	**SSG (mg)**	**MCC Avicel pH 102**	**Mg. Stearate (mg)**	**Talc (mg)**	**Total weight (mg)**
F1	90	-	-	-	-	355	2.5	2.5	450
F2	-	270	-	45	-	130	2.5	2.5	450
F3	-	270	-	67.5	-	107.5	2.5	2.5	450
F4	-	270	-	90	-	85	2.5	2.5	450
F5	-	270	-	-	45	130	2.5	2.5	450
F6	-	270	-	-	67.5	107.5	2.5	2.5	450
F7	-	270	-	-	90	85	2.5	2.5	450
F8	-	-	270	45	-	130	2.5	2.5	450
F9	-	-	270	67.5	-	107.5	2.5	2.5	450
F10	-	-	270	90	-	85	2.5	2.5	450
F11	-	-	270	-	45	130	2.5	2.5	450
F12	-	-	270	-	67.5	107.5	2.5	2.5	450
F13	-	-	270	-	90	85	2.5	2.5	450

Table 4: Evaluation of Ticagrelor Fast Dissolving Tablet Formulations

S. No	Formulation	Weight uniformity (mg)	Hardness (kg/cm)	Friability (%)loss	Drug Content (mg/tablet)	Disintegration time (Sec)
1	F1	449 ± 3	3.5 ± 0.3	0.16	89.10 ± 0.2	120
2	F2	448 ± 3	3.5 ± 0.4	0.17	89.10 ± 0.2	70
3	F3	450 ± 4	3.5 ± 0.3	0.16	89.64 ± 0.2	110
4	F4	449 ± 3	3.5 ± 0.2	0.16	89.90 ± 0.3	110
5	F5	451 ± 2	3.5 ± 0.3	0.18	89.74 ± 0.3	80
6	F6	449 ± 3	3.5 ± 0.3	0.17	89.82 ± 0.4	97
7	F7	449 ± 3	3.5 ± 0.3	0.16	89.10 ± 0.2	112
8	F8	448 ± 3	3.5 ± 0.4	0.17	89.10 ± 0.2	106

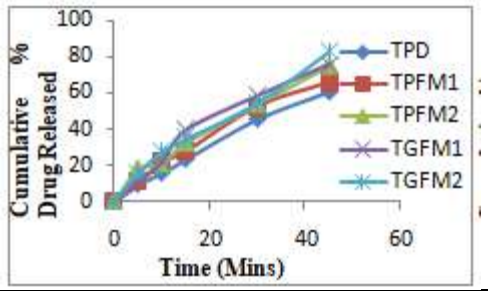
9	F9	450 ± 4	3.5 ± 0.3	0.16	89.64 ± 0.2	83
10	F10	449 ± 3	3.5 ± 0.2	0.16	89.90 ± 0.3	80
11	F11	450 ± 2	3.5 ± 0.3	0.18	89.74 ± 0.3	92
12	F12	449 ± 3	3.5 ± 0.3	0.17	89.82 ± 0.4	97
13	F13	449 ± 3	3.5 ± 0.3	0.18	89.74 ± 0.3	85

Table 5: Evaluation of Drug Release Parameters of Ticagrelor Tablets

FORMUALTION	% Drug released at 30 mins	T_{50} (min)	DE 30%	Zero order		First order		Hixon Crowell	
				R^2	K(mg)	R^2	K(min^1)	R^2	K ($mg^{1/3}$)
TMF	85.03	14	45.00	0.897	1.884	0.983	0.044	0.959	0.046
F1	53.16	32	25.83	0.900	1.186	0.966	0.017	0.022	0.959
F2	80.12	18	36.66	0.901	1.787	0.990	0.037	0.042	0.987
F3	90.06	16.5	40.00	0.900	1.965	0.992	0.051	0.053	0.997
F4	91.54	16	45.00	0.901	1.991	0.993	0.055	0.056	0.995
F5	90.28	14	43.33	0.900	2.028	0.991	0.052	0.054	0.983
F6	96.25	13	45.00	0.902	2.109	0.967	0.071	0.065	0.989
F7	97.50	12.5	50.83	0.901	2.120	0.953	0.079	0.069	0.987
F8	87.08	17.5	37.50	0.899	1.943	0.989	0.046	0.053	0.995
F9	89.19	17	38.33	0.898	1.970	0.988	0.049	0.052	0.998
F10	89.97	15.5	41.66	0.899	1.937	0.992	0.050	0.052	0.998
F11	93.21	14.5	43.33	0.900	2.097	0.979	0.059	0.059	0.985
F12	95.20	14	45.00	0.901	2.112	0.977	0.066	0.063	0.988
F13	95.30	13.5	46.66	0.899	2.088	0.977	0.066	0.063	0.990

Table 6: Similarity and Difference Factor Results of Optimized Ticagrelor Tablet Formulations (F6, F7 and F13).

Formulations	f1 Difference Factor	f2 Similarity Factor
F7	12	54
F13	9	60



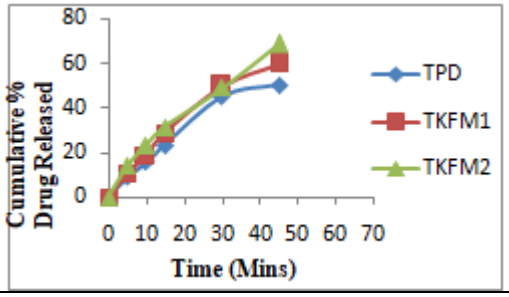


Figure 1 & 2 : Drug Release Profiles of Ticagrelor Solid Dispersions TPFM1, TPFM2; TGFM1 and TGFM2 ; TKFM1 and TKFM2 Prepared by Fusion method

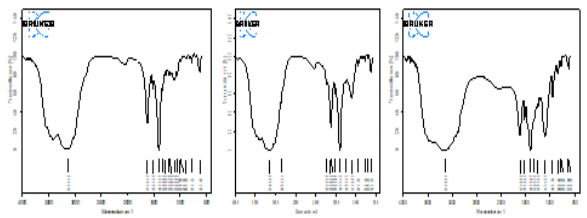


Figure 3: IR Interpretations of (a) TPD (b) TPFM2 (c) TGFM2

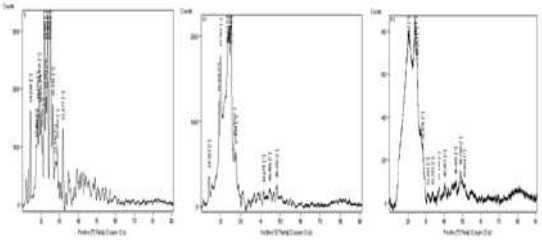
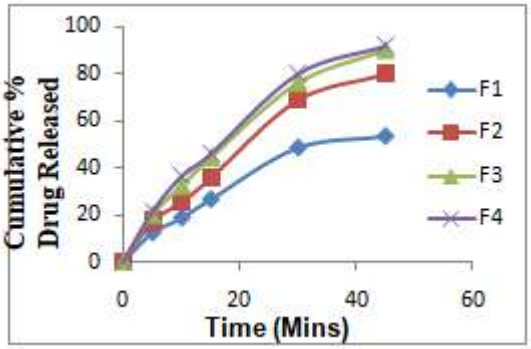


Figure 4: Powder X-ray Diffraction (PXRD) patterns for (a) TPD (b) TPFM2 (c) TGFM2



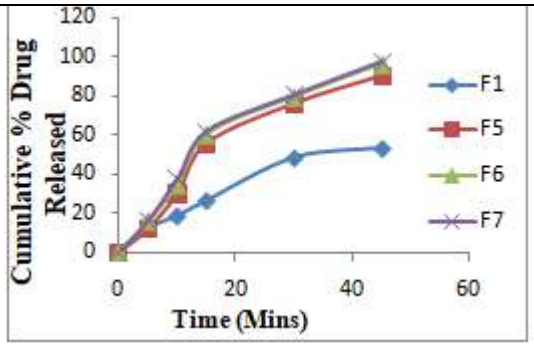
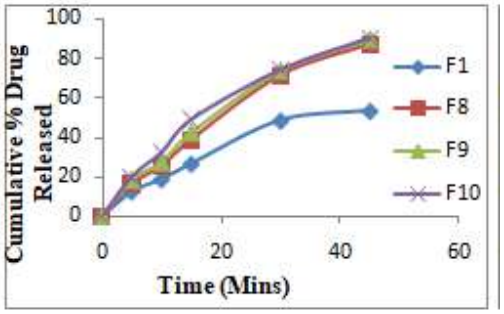


Figure 5: Drug Release Profiles of Ticagrelor Tablet Formulations using TPFM2 Solid dispersions with Croscarmellose Sodium and Sodium Starch Glycolate.



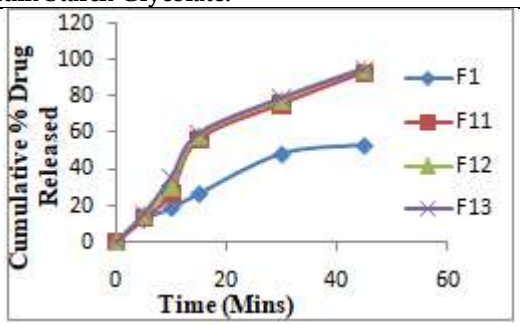


Figure 6: Drug Release Profiles of Ticagrelor Tablet Formulations using TGFM2 Solid Dispersions with Croscarmellose Sodiumand Sodium Starch Glycolate

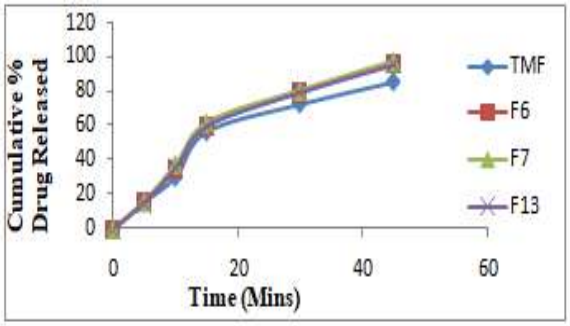


Figure 7: Comparitive Drug Release Profiles of Optimised Ticagrelor Tablet Formulations with Marketed Formulation.

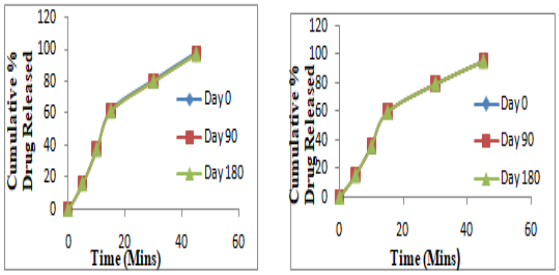


Figure 8: Drug Release Profile Curves of F7 & F13 Ticagrelor Tablet Formulation at Accelerated Conditions.

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RESEARCH ARTICLE

Traffic Control and Shortest Path

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ABSTRACT

Urban areas worldwide face a mounting challenge in the form of traffic congestion, necessitating innovative solutions to augment transportation efficiency. This study presents an approach through the integration of an advanced traffic control system and shortest path optimization, incorporating real-time traffic density estimation. Leveraging Reinforcement Learning (RL), specifically the Improved Deep Q-Network (IDQN) algorithm, the research adaptively manages traffic flow by synthesizing insights from an Improved Single Shot Detector (ISSD) algorithm. The developed system dynamically adjusts traffic signal timings and recommends optimal routes by learning from real-time density metrics. Through continuous interaction with the urban environment, RL agents evolve optimal control policies that strike a delicate balance between minimizing travel time and maximizing traffic flow efficiency. Rigorous experiments conducted in realistic scenarios showcase significant reductions in congestion and substantial improvements in route optimization. This research presents a unified framework, unifying RL and real-time traffic density estimation, contributing substantially to intelligent transportation systems.

Keywords: Traffic Density Estimation, Shortest Path, RL, SSD, DQN

INTRODUCTION

The enormous rise in the number of automobiles on roadways is a major challenge to urban transportation systems across the globe [1]. This is a direct result of urbanization and population expansion. Continued urbanization has a negative impact on residents' quality of life in addition to causing significant economic losses [2]. In order to overcome this obstacle, we need creative strategies to increase transportation effectiveness and decrease traffic [3]. When it comes to dynamically adjusting to the ever-changing traffic patterns of metropolitan areas, traditional approaches of traffic management, although useful to a certain degree, typically fall short [4-5]. This study is groundbreaking because it combines cutting-edge traffic management systems with shortest route optimization methods [6-7] to reduce traffic congestion in metropolitan areas. The employment of real-time traffic density estimate is crucial to this cutting-edge technology since it gives vital insights into the present status of traffic on road networks [8-9]. The study's ultimate goal is to revolutionize traffic management and route optimization techniques by using this real-time data to make them more flexible, efficient, and sensitive to the ever-changing nature of urban traffic [10, 11]. The central tenet of this investigation is the use of Reinforcement Learning (RL), a potent paradigm in AI, for efficient traffic management [12, 13]. The system is able to learn optimal control policies through persistent interaction with the urban environment thanks to RL algorithms, in particular the Deep Q-Network (DQN) [14].

These algorithms can dynamically adjust traffic signal timings and recommend optimal routes by analyzing real-time density metrics [15]. The proposed system seeks to significantly reduce congestion and improve route optimization in urban areas [16] by striking a balance between minimizing travel time and maximizing the efficiency of traffic flow. Through rigorous experimentation in realistic scenarios, this research aims to demonstrate the effectiveness of the integrated system in significantly reducing congestion and optimizing travel routes. We anticipate that this study's findings will provide a cohesive foundation for intelligent transportation system development by integrating RL approaches with real-time traffic density estimates [17-18]. With this structure in place, urban transportation might be improved, making it more efficient, adaptable, and long-term viable in the midst of rising traffic and fast urbanization. In order to build smarter and more efficient urban settings, novel approaches are essential, such as the one offered in this study, which is especially important since cities undergo continuous change [19-20]. DQN, a type of deep reinforcement learning, is able to reliably predict traffic density in dynamic urban settings as it constantly adjusts its parameters through trial and error [21]. This system provides real-time estimates of traffic density, allowing traffic management systems and authorities to make data-driven decisions, optimize traffic signal timings, and improve overall traffic flow, ultimately leading to more efficient and responsive urban transportation networks [22-23]. The remaining sections of this work are organized as follows. In Section 2, a background study of various researches on estimating traffic density using CNN, DQN, and SSD has been discussed. Section 3 presents the suggested model and the findings are given in Section 4 and conclusion is presented in Section 5.

Motivation of the paper

This study offers a groundbreaking solution to urban traffic congestion by integrating advanced traffic control and real-time traffic density estimation using Reinforcement Learning (RL). Through innovative algorithms and adaptive traffic management, the research significantly reduces congestion, improves route optimization, and contributes substantially to intelligent transportation systems. The system's adaptability to diverse traffic conditions positions it as a robust and efficient solution, concrete the way for smarter, sustainable urban mobility and responsive urban environments.

Background study

In order to forecast highway traffic density, A. Agarwal et al. [1] proposed a modern CNN paradigm. The author used a max pooling layer and a batch normalized layer to enhance the model's accuracy. Images taken from three different traffic films have been used to evaluate the concept. 30 epochs of data were collected for examination of accuracy and loss. With these factors in mind, the author evaluates the suggested technique against an alternative

CNN model. Additional datasets with restrictions such as lighting and occlusion can be taken into account in the future. To find the traffic conjunction on the signal G. T. Prabavathi and M. Kavitha [5] presented ISSD-YOLOV4 hybrid neural network architecture. The objective of this study is to generate a high-quality vehicle density using the network-based combination of extracted features from low-resolution feature maps. We evaluated the experimental research accuracy with the following models: TV networks include CNN, SPPNET, YOLOV3, YOLOV4, and SSD . The final result of the research showed that YOLOV4 and ISSD gave a better accuracy than the above mentioned models. M. Kavitha and G. T. Prabavathi [12] attempted to review the Intelligent Transportation Systems Safetyand Challenges in cyber security of ITS. M. Kavitha and G. T. Prabavathi [13] reviewed the various algorithm in RL DL for traffic signal control and intelligent transportation.

Problem definition

Congestion in metropolitan areas is a prevalent problem that this research aims to alleviate. Rapid urbanization and increased vehicle usage have led to significant challenges in transportation efficiency. Traditional traffic management methods are often insufficient to handle the complexity of modern urban environments. This research aims to tackle this problem by devising solution that integrates advanced traffic control, real-time traffic density estimation, and RL techniques. By optimizing traffic signal timings and recommending optimal routes based on real-time data, the study addresses the intricate challenges posed by congested urban transportation networks, ultimately aiming for more efficient and sustainable urban mobility.

MATERIALS AND METHODS

This section provides a detailed overview of the experimental setup, methods, and algorithms used (Improved DQN & Improved SSD) and the systematic process followed to conduct experiments in realistic scenarios. The traffic control and shortest path optimization through real-time traffic density estimation model flowchart is shown in Figure 1.

System & Energy model

Using the RL paradigm, and more specifically the DQN algorithm, the proposed system integrates an advanced traffic control system with shortest path optimization and real-time traffic density estimation. The real-time traffic density data which is the output from the Improved SSD algorithm is fed into RL agents. RL agents constantly interact with their surroundings and learn optimal control policies allowing for dynamic route recommendations and adaptive traffic flow management. Through shortest path optimization, the proposed system can show significant reduction in congestion in real-world scenarios by adjusting traffic signal timings and suggesting optimal routes based on real-time density metrics. The flexibility of this unified framework under varying traffic conditions makes it an effective answer to the complex problems facing urban transportation networks and paves the way for more responsive and sustainable city planning. The system optimizes traffic light timings and suggests alternate routes with an eye toward reducing fuel consumption in addition to improving travel time and traffic flow. The DQN algorithm used by RL agents constantly learn and interact with the urban environment to optimize traffic signals and routes in order to cut down on energy waste caused by sudden starts, stops, and idling. The system not only reduces congestion but also significantly lessens the carbon footprint associated with urban transportation by promoting smoother traffic flow and reducing energy-intensive traffic patterns.

Traffic Flow management using Improved SSD

The goal of the improved SSD is to detect real-time objects belonging to different classes in a single frame. The feature pyramid networks allow the Improved SSD to detect objects of varying sizes and scales within an image. One of the algorithm's most notable feature is its ability to detect small and large objects simultaneously. Aspect ratio clustering and anchor box refinement are two methods that have been incorporated in this research work. Algorithms can gain a deeper understanding of the shapes of objects they are detecting with the help of aspect ratio clustering, which groups objects with similar aspect ratios together. The aim of anchor box refinement is to adjust the

predefined anchor boxes, which are utilized to predict object bounding boxes, in order to better align with the actual shapes of objects in the image, thereby enhancing the accuracy of object localization. During the training phase, SSD uses the Adam Optimizer to reduce the sum of the classification loss and the localization loss, which is the loss function being minimized. SSD performs classification using a multi-class softmax loss. Where Z is the number of default-boxes-to-background matches from equation 1.

$$L_{clss}(Z,Z) = -\sum_{c=1}^{l}\sum_{i\in pros} z_{i,c}.\log(Z_{i,c}) - \sum_{j\in neg}\log(Z_{j,\sigma}) \quad \text{----- (1)}$$

$$smooth_{\frac{l}{1}}(X) = \begin{cases} 0.5 \times x^2 \; if|X| < 1 \\ |x| - 0.5 \;\; otherwise \end{cases} \quad \text{------ (2)}$$

$$\sigma = [Z\ B + D] \quad \text{------ (3)}$$

As the object's exact bounding box, the probabilities in the L class read from the rows of the confusion matrix. Second, in each class, SSD performs ultimate detection with non-maximal suppression. Each recognized item is a tuple (class label, confidence score, bounding box coordinates).

Algorithm 1: Improved Single Shot Detector

Input: An image or a frame from a video feed that contains multiple objects belonging to different classes.

Steps:

1. **Feature Pyramid Network:**
   To enable the identification of objects of different sizes and scales, use a feature pyramid network to extract multi-scale features from the input picture.
2. **Aspect Ratio Clustering:**
   $$smooth_{\frac{l}{1}}(X) = \begin{cases} 0.5 \times x^2 \; if|X| < 1 \\ |x| - 0.5 \;\; otherwise \end{cases}$$
3. **Anchor Box Refinement:**
   $$L_{clss}(Z,Z) = -\sum_{c=1}^{l}\sum_{i\in pros} z_{i,c}.\log(Z_{i,c}) - \sum_{j\in neg}\log(Z_{j,\sigma})$$
4. **Classification and Localization:**
   - Perform classification using a multi-class softmax loss function to predict class probabilities for each default box.
   - Compute the localization loss to minimize the discrepancy between predicted bounding boxes and ground truth boxes.

Output: List of detected objects along with their corresponding bounding boxes and class labels.

Traffic Density Estimation Using Improved DQN

Improved DQN combines real-time data collection with state-of-the-art machine learning techniques. Relevant features, such as vehicle count, speed, and spacing, are extracted and fed into a neural network by combining data from traffic cameras, sensors, and other sources. The DQN algorithm uses this neural network's ability to learn traffic density estimation patterns. The neural network that makes up a DQN is part of DQ Learning, which sidesteps the Q-table. The neural network's input states are action and Q-value pairs, so there is no need to map states to Q-values. In this case, DQN consists of Q-Network and Target-Q-neural networks. Since the Q-learning method relies on discrete states to generate the Q-table, it is affected by the Curse-of-Dimensionality problem. This problem is solved by DQ learning methods by approximating the Q-value function Q(s, a) with an ANN.

$$L_i(\theta_i) = E(s,a)[Q*(s,a) - Q(s,a;\theta_i)]2 \quad \text{-------- (4)}$$

For every iteration, the goal Q value Q∏ (s, a) is provided by

$$Q*(s,a) = E_s\ 0 \in S[R(s,a) + r\ max\ a0\ Q(s0,a0;\theta_{i-1}|s,a] \quad \text{-------- (5)}$$

Where $Q(s\ 0, a0, i\ 1)$is the next state's Q-value computed using the previous iteration's Q-network weights, and R(s, a) is the reward for the current state's action pair (s, a) gleaned from the environment.

$$Q(s,a) = E_{s'\sim p}[r + r\max_a Q\,(s', a')|s, a]$$

------- (6)

In this setting, deep neural networks can explain the car's behaviour based on the following parameters: r, the instantaneous reward received by state s after action an in states, p is the probability of a state transition, while γ is the discount factor. Therefore, the Q function is represented as a neural network, namely q(s,a;θ), where θ denotes the parameters of the network. Additionally, DQN defines the Q function Q(s,a;), where s is a 1:1 duplicate of the argument. Depicted in Equation 6 is the DQN's loss function. Equation 7 shows the DQN's loss function.

$$L(\theta) = E_{(s,a,r,s)\sim U}[(r + r\max_a Q\,(s', a'; \theta-)$$

-------- (7)

The distribution in the experience replay buffer is denoted by U, and the experience tuple is derived by sampling in the buffer. Afterwards, the network parameters are updated using stochastic gradient descent to constantly minimize the loss function, as illustrated in the equation below.

$$\theta \leftarrow \theta - \alpha\nabla_\theta L(\theta)$$

--------- (8)

In the context of vehicle obstacle avoidance training, the learning rate is used, but instead of updating the target network during training, the parameters are recopied after multistep training. Algorithm 2 shows the density estimation algorithm.

Algorithm 2: Density Estimation algorithm

Input: Real time continuous data from traffic image.

Steps: Deep Q-Network (DQN)

Q-Value Computation

$$Q(s,a) = E_{s'\sim p}[r + r\max_a Q\,(s', a')|s, a]$$

Loss Function Calculation

$$L(\theta) = E_{(s,a,r,s)\sim U}[(r + r\max_a Q\,(s', a'; \theta-)$$

Optimization:

Apply stochastic gradient descent to update the neural network parameters iteratively.

$$L(\theta) = E_{(s,a,r,s)\sim U}[(r + r\max_a Q\,(s', a'; \theta)$$

Output:

Traffic Density: The output is a real-time estimation of traffic density in specific urban areas

RESULTS AND DISCUSSION

This section presents the outcomes of the experiments, providing insights into the effectiveness of the proposed methodology in addressing urban traffic congestion. Additionally, it discusses the implications of these results, highlighting the practical applications and significance of the research in the context of intelligent transportation systems. Figure 2 shows density estimation, flow estimation error, density estimation error, and parameters estimation error of CNN, DNN, RCNN and Improved DQN algorithms. The superiority of the proposed methodology becomes evident. The existing methods CNN, DNN and RCNN exhibit relatively higher errors across all parameters, indicating limitations in accuracy. In contrast, the proposed methodology significantly enhances performance. The traffic density estimation error reduces to 0.05, flow estimation error to 0.1, density estimation error to 0.15 and parameters estimation error to 0.2. These substantially lower error values demonstrate the effectiveness of the Improved Deep Q-Network in achieving more precise and reliable traffic density estimation, highlighting its potential for enhancing the accuracy and efficiency of urban traffic management systems.

CONCLUSION

In the face of escalating urbanization and the resultant surge in vehicular traffic, this research has provided a transformative solution to one of the most pressing challenges of time and urban traffic congestion. By integrating RL through the DQN algorithm and real-time traffic density estimation, an efficient traffic management system has been designed. The outcomes of this experiments in real-world scenarios unequivocally demonstrate the efficacy of the proposed approach. The rigorous experiments conducted in realistic scenarios validate the efficacy of this unified framework, showcasing its potential to significantly enhance intelligent transportation systems in urban areas worldwide. Moving forward, continued research and implementation of such innovative solutions will be crucial in addressing the evolving complexities of urban mobility, paving the way for more sustainable and efficient transportation networks.

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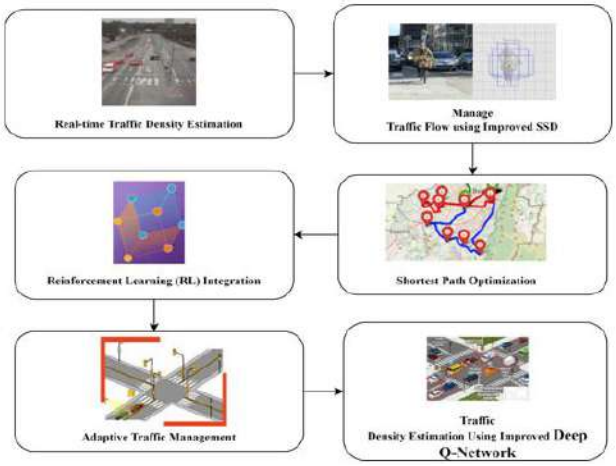


Figure 1: Overall architecture

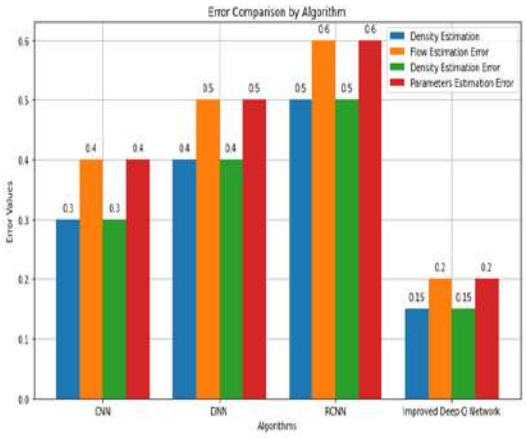


Figure 2: CNN, DNN, RCNN, Improved DQN comparison chart

RESEARCH ARTICLE

Comparative Evaluation of Chemical Hair Dyes and Natural Hair Dyes and Their Effect on Normal Hair Flora

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ABSTRACT

Herbal hair dyes are commonly used as traditional way of coloring the hair. Traditional System may indicate safety, but not up to its efficacy, especially in herbal leaves where tradition is almost completely based on remedies containing active principles at very low and ultra-low concentrations, or relying on magical-energetic principles. The present study is on antimicrobial activity of 4 different herbal natural sources and chemical commercial dye on normal flora of hair. The maximum and minimum zone of inhibition 3nm & 2nm was observed against chemical dyes. The maximum and minimum zone of inhibition 1.7 nm & 1 nm was observed against was observed against herbal natural sources. Traditional herbal natural sources are very much good for maintaining the health of hair where it won't damage the normal flora of hair. Where the chemical dyes will damage the hair and also disturb the normal flora of hair. By these effects there will be allergic reaction on the scalp Governments, international agencies and corporations are increasingly investing in traditional herbal medicine research. Yet little literature

addresses ethical challenges in this research. In this paper, we apply concepts in a comprehensive ethical framework for clinical research to international traditional herbal medicine research.

Keywords: Herbal, chemical, Hair- Dye, Normal Flora and Antimicrobial Activity.

INTRODUCTION

Herbs are natural products and their chemical composition varies depending on several factors and therefore varying from people to people, from energetic decoctions to the use of herbal extracts following Western methodologies of mainstream medicine. Traditional medicines has a very long history: it is the sum total of the practices based on the theories, beliefs and experiences of different cultures and times, often inexplicable, used in the maintenance of health, as like in the prevention, diagnosis, improvement and treatment of illnesses. In every country traditional medicine find foundation in magical or religious beliefs, or popular experience and the World Health Organization is engaged to establish definitive guidelines for methodology of clinical research and the appraisal of effectiveness of traditional medicine. To evaluate the efficacy, effectiveness and safety of a traditional herbal remedy. Traditional herbal medicines are naturally occurring, plant-derived substances with minimal or no industrial processing that have been used to treat illness within local or regional healing practices. Traditional herbal medicines are getting significant attention in global health debates. Cases like these present challenging questions related to the role of traditional herbal medicines in public health. People have been using natural dyes since ancient times for the purpose of dyeing carpets, rugs and clothing's by the use of roots, stems, barks, leaves, berries and flowers of various dye yielding plants [1]. In India, henna has been used traditionally for colouring palms and hairs. There are so many herbs like Kikar, Bihi, Bhringraj, Patnag, Akhrot, Narra, Jaborandi, Jatamansi, Amla, Kuth, Giloe, Behera which are used as a major constituent in hair care preparations mainly meant for dyeing hair [2 – 5]. In general, international research on traditional herbal medicines should be subject to the same ethical requirements as all research related to human subjects. An ethical framework previously outlined by Emanuel et al. Greying of hair is a natural phenomenon attributable to ageing and frequent use of synthetic shampoos which has encouraged application of synthetic dyes with the increase in the usage of hazardous chemicals in the process of manufacturing and revised for international research offers a useful starting point for thinking about the ethics of international traditional herbal medicine research. [6] This framework includes eight ethical requirements for clinical research These ethical requirements are universal and comprehensive but must be adapted to the particular social context in which the research is implemented. Of these, fair subject selection, independent review, informed consent, and respect for enrolled subjects have been discussed previously in the literature on the ethics of global health research and raise few issues unique to international traditional herbal medicine research. India is a country of vast bio-geographic diversity. Because of the country's diversified climatic and physiographic factors, India is blessed with all types of vegetation: tropical, subtropical, temperate, and alpine. Due to its wide-ranging environmental regimes and diverse biological communities, the country is one of the world's top 12 "mega diversity" nations. [7] However, social value, scientific validity, and favorable risk–benefit ratio raise specific challenges in international herbal medicine research that have not been adequately discussed.

MATERIALS AND METHODS

Collection of the sample

Firstly the samples of normal hair flora was collected from the human scarp and inoculated on to the nutrient agar media and sub-cultured it for further studies (Fig 1). Gram's staining was done to differentiate Gram positive and Gram-negative cell (Fig 2)

Preparation of dye extracts

Herbal: 3 different fresh herbal leaves of *Lawsonia inermis*(Henna), *Aloe barbadensis miller* (Aloe-vera), *Eclipta prostrata* (Bhrinraj) *and Hibiscus rosa-sinensis*(Mandara-aku) were collected from the garden of St. Ann's Degree college for Women and brought to microbiology lab under sterile condition. Immediately the leaves were wash under running tap water separately. These leaves homogenised by using motor and pestle to make it into fine paste

Chemicals dye: Commercially Available godrej dye packet was purchased from a local market and made into paste form for further studies

Antimicrobial activity

Both nutrient and PDA media were prepared, inoculated with the normal flora culture samples which was collected previously by spread plate method under sterile conditions. Both herbal and chemical dye were loaded into the wells on the lawn culture plates (Fig 3) The antimicrobial activity was studies by using well diffusion plate method. The zone of inhibition was measured by using Vernier caliper (Fig 4).

Open Patch Test

Sensitizing the potential of formulation is to be tested. Hence a small quantity has been applied on the fore arm to check for any local reaction

RESULT AND DISCUSSION

Herbal dyes give maintain the health of hair with any damage to the hair as well as normal flora of scalp. They antimicrobial activity was mainly because of compound that are naturally synthesized by the plant. There was a lot of difference in the effect of herbal and chemical dyes on normal flora. In the present study four different colonies were observed after incubation. Two Gram positive and Gram-negative cells were identified by Gram staining (Table 1, Fig 5). The range of antibacterial activity ranges from 1.0nm to 1.7nm by the herbal dye and 2.0 nm to 3.0nm by chemical dyes (Table 2). Now-a-days gray hair was a big problem for the people. so, people are preferring chemical dyes to color their hair. But the chemicals like phenylenediamine and P-phenylenediamine showing chemical reactions on the normal flora of scalp and also leading to skin allergies. The herbal leaves are in their bioactive compound which are naturally synthesized will not disturb the normal flora of scalp. Herbal dye maintains the health of hair and color will remain for long period of time. By open patch test there was a local reaction by the chemical dye like irritation and erythrema within three hours of application where there is no such type of reactions

CONCLUSION

The present study evaluates the formulation of organic hair dye comprising a mixture of powdered plant materials having natural products useful for dying the hair. It is evident from the results that this formulation is highly effective at slightly alkaline pH without causing hair damage and skin irritation. A fixative Iron filing with these powders gives darker and stable shade preferred in hair dying. Efficacy data shows that all these active constituents have prolonged dying effect on hair. The surfactant used cause dry scalp and loss of fat under the skin, which enhances the drying and damage of the hair follicle, thus hair fall starts. Advantage of this formulation is that the plant pigments penetrate into the cortex region without rupturing the hair follicles.

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Table 1: The result of Gram staining of four different colonies & microscopic images

Color of the colony	Gram Staining
1 White Rough Colony	Gram positive
2.Yellow colony	Gram negative
3. *Orange colony*	Gram negative
4. *White Smooth Colony*	Gram positive

Table 2 Anti-bacterial activity (nm) of herbal leaves

Name of the herbal leaves	White Rough Colony	Yellow Colony	Orange Colony	White Smooth colony
1. *Aloe barbadensis miller (Aloe-vera)*	1.2nm	1.4nm	1.7nm	1.3nm
2. *Lawsonia inermis (Henna)*	1.1nm	1.6nm	1.2nm	1.7nm
3. *Hibiscus rosa-sinensis* (Mandara-aku)	1.0nm	1.2nm	1.0nm	1.3nm
4. *Eclipta prostrata (Bhrinraj)*	1.4nm	1.3nm	1.3nm	1.6nm
5. Chemical dye (Godrej powder)	3nm	2.8nm	2.5nm	2.0nm

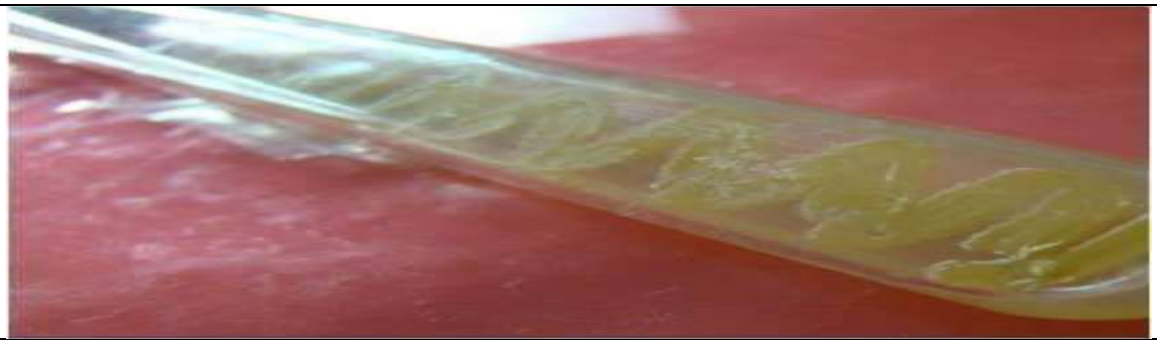


Fig: 1 Sub-cultured tubes of normal flora

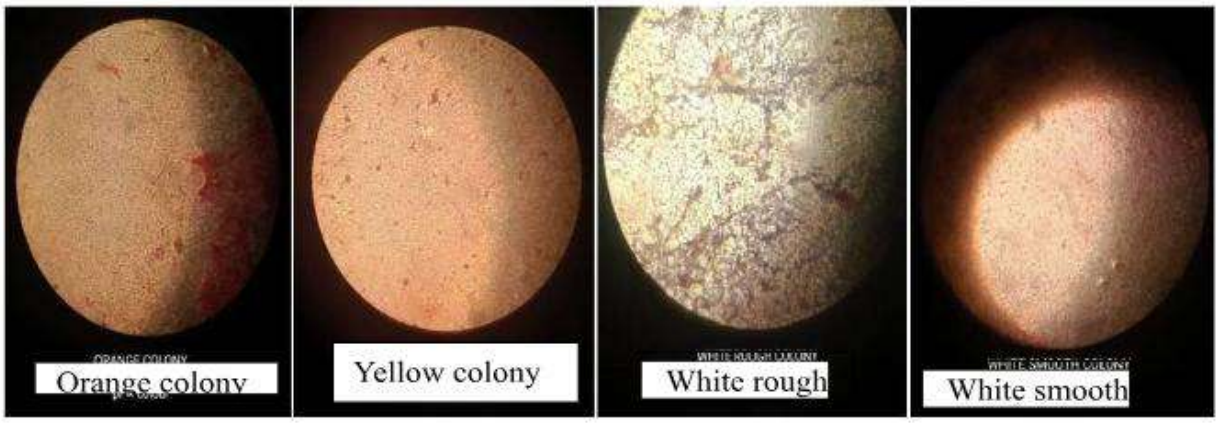


Fig 2: Gram staining of different colonies of normal flora



Fig 3: Inoculating the normal flora culture on to the media by spread plate method



Fig 4: Aseptic loading of herbal paste in the well of cultured plates

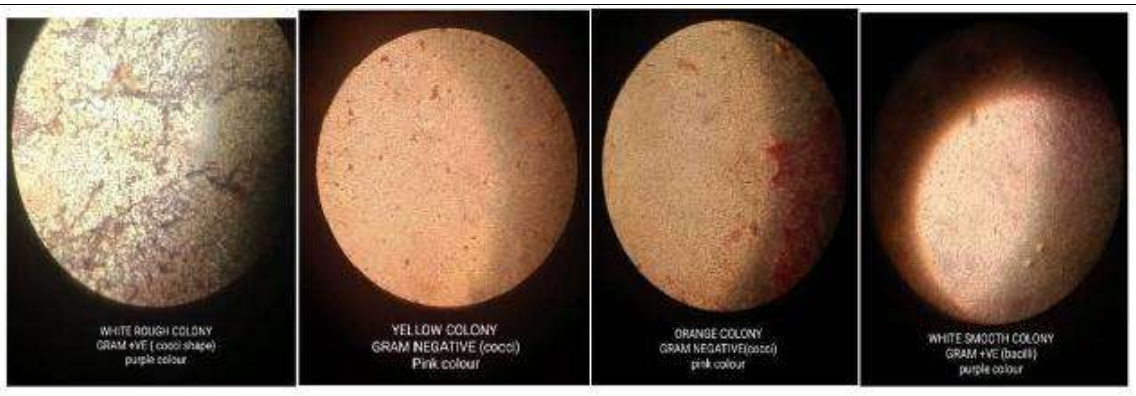


Fig.5. four different colonies



Fig 5. Measuring the zone of inhibition by using Vernier caliper

RESEARCH ARTICLE

Immediate Effect of Intercostal Stretch and Pursed Lip Breathing Exercise on Thoracic Expansion and Pulmonary Function on Mild to Moderate COPD Subjects – A Comparative Study

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ABSTRACT

In the emerging countries, COPD is the most common pulmonary diseases, as a persistent reduction of lung airflow that interferes with normal breathing and is not entirely reversible. COPD is the third most common cause of death worldwide. It is multifactorial and Inhalational exposures to substances such as tobacco consumption, cigarette smoke, genetic risk factors, and work-related dusts and chemicals are frequently cited as risk factors. **Aim:** To compare the immediate effect of intercostal stretch along with thoracic expansion exercise and pursed lip breathing along with thoracic expansion exercise on pulmonary function and thoracic expansion on mild to moderate COPD subjects**.** 60 subjects were included in the study according to inclusion and exclusion criteria. subjects with mild to moderate COPD were randomly divided into 2 groups on the basis of the cheat method. 30 subjects were included in Group A received Intercostal Stretch Along with Thoracic Expansion Exercise. 30 subjects were included in Group B received Pursed Lip Breathing Along with Thoracic Expansion Exercise. outcome measures were PFT and CHEST EXPANSION measured pre-post intervention. Pre measures of mean values for Group A for FVC, FEV1, FEV1/FVC were 1.95,1.23,62.89 and the post measures were 2.14,1.60,77.38 respectively. The p-value for FVC, FEV1, FEV1/FVC was 0.000. The pre measures of mean values for Group B for Group B for FVC, FEV1, FEV1/FVC were 1.77,1.03,57.99 and the post measures were 1.83,1.22,66.39 respectively. The p-value for FVC was 0.05 and for FEV1, FEV1/FVC was 0.000. The pre measures of mean values for Group A for Axillary level, nipple level, xiphisternal level were 1.21,1.68,2.06 and post measures were 2.23,2.78,3.26 respectively. The p- value for Axillary level, nipple level, xiphisternal level was 0.000. The pre measures of mean values for Group B for Axillary level, nipple

level, xiphisternal level were 1.23,1.48,1.85 and post measures for Axillary level, nipple level, xiphisternal level were 2.11, 2.55, 3.02 respectively. The p- value in both the groups for pre and post measures was found out to be <0.05. The mean scores for Group A for FVC, FEV1, FEV1/FVC were 0.18,0.37,14.48 and for Group B were 0.06,0.18,8.40 respectively. The p- value for FEV1 was 0.000 and for FEV1/FVC were 0.002. The mean scores for Group A for Axillary level, nipple level, xiphisternal level were 1.01, 1.10, 1.20 and for Group B were 0.88,1.06, 1.17 respectively. The p-value for Axillary level was 0.042. The present study concluded that there is statistically improvement on pulmonary function and chest expansion after immediate application of intercostal stretch and pursed lip breathing along with thoracic expansion exercise. But after immediate application of intercostal stretch along with thoracic expansion exercise there is more improvement on pulmonary function and chest expansion.

Keywords: Mild to moderate COPD, Pursed lip Breathing, Intercostal stretch, Chest Expansion, PFT.

INTRODUCTION

Chronic obstructive pulmonary disease is a widespread, preventable, and treatable condition defined by recurrent respiratory symptoms and persistent air-flow limitation caused by abnormalities in the airways and alveoli, which are usually induced by extensive exposure to noxious particles and gases." [1] "According to World Health Organization report, tobacco smoking contributed to more than 5 million fatalities.[2] The Global Initiative for Chronic Obstructive Lung Disease standards were created to provide healthcare workers with the best suggestions for diagnosing and managing COPD patients.[3] In COPD patients who have barrel-shaped chest, physical changes such as chest tightness occur.[4] Healthcare practitioners frequently utilize the cloth tape measurement approach to evaluate chest expansion.[5] It was used to assess the excursion of the chest wall at upper, middle, and lower lobes.[5] Breathing exercises have been an important part of a comprehensive pulmonary rehab program for individuals with COPD.[6] The purse-lip breathing technique allows users to control their oxygenation and ventilation.[7] The forces that occur during exhalation cause the cartilage-free airways to draw inward and toward the lumen, blocking airflow by raising airway resistance, which may result in carbon dioxide entrapment.[7] In (PNF), the muscle is passively stretched and alternately contracted.[1] This method expands the length of a muscle's nerve receptors.[1] So, the aim of the study is to compare the immediate effect of intercostal stretch along with thoracic expansion exercise and pursed lip breathing along with thoracic expansion exercise on pulmonary function and thoracic expansion on mild-moderate COPD subjects.

MATERIALS AND METHODS

A comparative study was conducted on mild to moderate COPD subjects at Parul Sevashram Hospital, Vadodara, Gujrat. Following an initial screening subjects were selected Both males and females of age is between 40 to 60. [1] Patient with mild, moderate airway obstruction based on gold criteria: gold 1-(mild: fev1 /fvc< 0.70, FEV1> 80% of predicted) gold 2 -(moderate: FEV1 /FVC < 0.70, 50% < FEV1< 80% of predicted). [1] Medically diagnosed COPD patient. [8] Willing to participate. [8] smokers or ex-smokers of more than 10 pack-years, and symptoms suggestive of COPD. [9] Exclusion criteria were Hemodynamically unstable subjects. [10] Patients with severe orthopedic problems related to spine, fracture of rib, sternum fracture, neurological deficits, affecting the respiratory muscles, unstable cardiac condition, recent myocardial infarction, intercostal muscles strain. [1] Previous lung – volume reduction surgery, lung transplantation or pneumonectomy.[1] Patient is having history of core pulmonale.[1] Ethical approval was taken by Parul University institutional ethics committee for Human Research (PUIECHR/PIMSR/00/081734/4502). The trial was registered prospectively at the clinical trials registry of India (CTRI/2023/04/051427).

Outcome measures

1. **Pulmonary function (FEV1, FVC, FEV1/FVC)**: "The patient was comfortably seated in front of a PFT machine. The mouthpiece was placed comfortably between the two lips, preventing excess air escaping from the mouth. The patient was then instructed to take a deep breath and exhale as much as possible for several seconds through a mouthpiece. It is not permitted to breathe through the nose. 2 to 3 repetitions were taken. The study included the following parameters: FEV1, FVC, and FEV1/FVC."
2. **Chest expansion (tape method)**: "Subjects were seated on stool, arms crossed behind their backs, heads turned to one side. A cloth tape was used to measure chest expansion at three different rib cage levels. The anatomical marks for thoracic expansion are the axillary level, nipple level, and xiphisternum level. The advantage of selecting these locations is that they represent the elasticity of different lobes. The subjects were instructed to exhale through their mouth, inhale slowly through their nose, and press their chest against the tape to measure the expansion of their lungs. The participants were instructed to exhale through their mouths. The cross-hand technique was used to take measurements at three different levels. Measurements were taken into centimeters (CM)."

Procedure

- Based on inclusion and exclusion criteria, subjects were recruited from the Parul Sevashram hospital in Vadodara. The study was carried out by informing the subjects about the study and obtaining their informed and written consent. The subjects' privacy and confidentiality were respected.
- The study sample included subjects with mild to moderate COPD. The subjects were interviewed, and the clinical histories of the participants were known.
- Prior to starting the intervention, outcome measures in the form of a pulmonary function test and chest expansion were evaluated. The treatment time was 45 minutes.
- After the intervention, i.e., at the end of 45 minutes, outcome measures were Re-evaluated, and a comparison of pre- and post-data were obtained.
- Statistical analysis was done and results were calculated.

Intervention

Subjects will be divided in 2 groups by randomization (chit method).

Group A: inter costal stretch

"patients were in a supine lying position.[1] The Therapist stand behind the patient.[1] First therapist should palpate the suprasternal notch then go downward about 5 cm to palpate the angle of louis.[1] Then trace the finger laterally to palate the 2nd rib and intercostal stretch was given bilaterally at 2nd and 3rd rib with the help of index finger and middle finger.[1] The direction of stretch was downward towards the next rib in midaxillary line.[1] The stretch was maintained as he/she continues to breathe.[1] The stretch was applied at the end of the exhalation for 10 breaths with 1 minute rest and for 10 repetitions. Total treatment duration was 45 minutes." [1]

Group A: inter costal stretch along with thoracic expansion exercise

Intercostal stretch (10 Breaths With 1 Min Rest For 10 Repetition) [1] Thoracic expansion exercise (breathing with mainly expiration: - 15 minutes of breathing exercise after 2 minute of respiration subjects rested for 1 minute) [11]

Group B: "Pursed lip breathing exercise

Patients were assigned a comfortable seating position.[12] Patients were instructed to inhale slowly through the nose and hold it for 3 to 4 seconds before exhaling gradually and slowly through the mouth by pursing the lips together so that if a flame is held in front of them, the flame bends but does not blow off.[12]Expiration should last approximately twice as long as inspiration.[13] Total 10 Repetition With 5 Min Rest For 3 Set were done."[12]

Group B: pursed lip breathing along with thoracic expansion exercise

Pursed lip breathing (10 Repetition With 5 Min Rest For 3 Set) [12] Thoracic expansion exercise (breathing with mainly expiration: - 15 minutes of breathing exercise after 2 minute of respiration subjects rested for 1 minute) [11]

Thoracic expansion exercise

"The patient was sitting comfortably in a chair.[11] The therapist stands in front of the patient and instructs him or her to inhale slowly and deeply through the mouth, followed by a prolonged expiration through the mouth.[11] Expiration is the primary mode of breathing (15 minutes of breathing exercise after 2 minute of respiration subjects rested for 1 minute)." [11]

STATISTICAL ANALYSIS

Non-parametric tests were used to analyse the results. IBM SPSS version 27 software was used for analysis. Normality was checked by using Shapiro Wilk Test. Mann-Whitney U test was used for between group analysis and for within group pre and post analysis Wilcoxon Signed Rank test was used. The alpha level of 0.05 was kept for analysis of data. Micro soft word and excel version 2010 were used to create group and tables.

RESULTS AND DISCUSSION

Result

WITHIN GROUP ANALYSIS OF GROUP A

Table 1.1 shows pre and post intervention mean±SD variance of PFT for Group A. Wilcoxon Signed Ranks Test was used for analysis of data. The pre- intervention mean±SD value for FVC was 1.956±0.746, post intervention mean±SD value for FVC was 2.140±0.899, pre- intervention mean±SD value for FEV1 was 1.233±0.473, post intervention mean±SD value for FEV1 was Table 1.2 shows pre and post intervention mean±SD variance of chest expansion for Group A. Wilcoxon Signed Ranks Test was used for analysis of data. The pre- intervention mean±SD value for axillary level was 1.216±0.363, post intervention mean±SD value for axillary level was 2.233±0.409, pre- intervention mean±SD value for nipple level was 1.683±0.444, post intervention mean±SD value for nipple level was 2.783±0.386, pre- intervention mean±SD value for xiphi-sternal level was 2.066±0.468, post intervention mean±SD value for xiphi-sternal level was 3.266±0.449. p- value for chest expansion at axillary, nipple, xiphisternal level was found out to be 0.000 with $p<0.005$ which is considered to be significant. Table 1.3 shows pre and post intervention mean±SD variance of PFT for Group B. Wilcoxon Signed Ranks Test was used for analysis of data. The pre- intervention mean±SD value for FVC was 1.771±0.589, post intervention mean±SD value for FVC was 1.834±0.653, pre- intervention mean±SD value for FEV1 was 1.038±0.411, post intervention mean±SD value for FEV1 was 1.225±0.562, pre- intervention mean±SD value for FEV1/FVC was 57.992±10.843, post intervention mean±SD value for FEV1/FVC was 66.399±14.870. p-value for FVC, FEV1, FEV1/FVC was found out to be 0.000 with $p < 0.05$ which is considered to be significant. Table 1.4 shows pre and post intervention mean±SD variance of chest expansion for Group A. Wilcoxon Signed Ranks Test was used for analysis of data. The pre- intervention mean±SD value for axillary level was 1.2333±0.40965, post intervention mean±SD value for axillary level was 2.116±0.536, pre- intervention mean±SD value for nipple level was 1.483±0.463, post intervention mean±SD value for nipple level was 2.550±0.461, pre- intervention mean±SD value for xiphi-sternal level was 1.850±0.511, post intervention mean±SD value for xiphi-sternal level was 3.026±0.532. p- value for chest expansion at axillary, nipple, xiphisternal level was found out to be 0.000 with $p<0.005$ which is considered to be significant.

BETWEEN GROUP ANALYSIS OF GROUP-A AND GROUP- B FOR PFT

Table 1.5 shows the pre and post intervention mean variance of Fvc, FEV1, FEV1/FVC for Group A and B. Mann-Whitney Test was used for analysis of data, pre and post-test mean ±SD value for group A was 0.18±0.25, 0.37±0.16, 14.48±7.33 and for group B was 0.06±0.24, 0.187±0.203,8.40±6.12 p-value for FEV1 was found to be 0.000 with $p<0.05$. post intervention both the groups showed significant improvement but FEV1 was more improved in Group A compared than Group B.

BETWEEN GROUP ANALYSIS OF GROUP-A AND GROUP- B FOR CHEST EXPANSION

Table 1.6 shows the pre and post intervention mean variance of Axillary, Nipple, Xiphisternal level for Group A and B. Mann-Whitney Test was used for analysis of data, pre and post-test mean ±SD value for group A was 1.01±0.35, 1.10±0.35, 1.20±0.48 and for group B was 0.88±0.25, 1.06±0.50, 1.17±0.32 p-value for FEV1 was found to be 0.000 with $p<0.05$. post intervention both the groups showed significant improvement but FEV1 was more improved in Group A compared than Group B. In present study, within group analysis showed that there was statistically significant improvement in all Parameters of PFT (FVC, FEV1, FEV1/FVC) with ($P<0.05$) in Group A and Group B. The findings of present study showed that after implementation of both the treatments There was a statistically significant change in dynamic ventilatory measures in FEV1 (P0.000), FEV1/FVC% ($P<0.002$) in both the Groups. Clinically there was changes in FVC, Nevertheless, no statistically significant difference was seen in FVC. ($P>0.05$).

DISCUSSIONS

The current study aimed to compare the immediate effect of intercostal stretch along with thoracic expansion exercise and pursed lip breathing along with thoracic expansion exercise on pulmonary function and thoracic expansion on mild to moderate COPD subjects. The improvement in pulmonary function and chest expansion can be explained by **Dangi Ashwini ET al.** "Intercostal stretch may improve chest wall elevation and thus increase expansion to improve intra-thoracic lung volume.[10] This may contribute to an increase in ventilatory capacity, such as tidal volume, minute ventilation, and oxygen status, improving chest expansion, hyperinflation, and air trapping, and thus reducing breathlessness." [10] "The changes in ventilatory parameters could be attributed while giving passive stretch which activates stretch receptors in the chest wall which are linked to the medulla via efferent nerve cells.[10] Intercostal muscles aid in the upward and outward movement of the ribs, resulting in an increase in the anterior posterior diameter of the thoracic cavity.[10] It is beneficial for both inspiration and forced expiration." [10]
The findings of our study, which were substantiated by **Mohan V, Bdlisyah, et al.** (2012), examined the "effect of intercostal stretch on pulmonary function parameters.[14] The experimental group in this study received intercostal stretching with breathing control, while the control group received breathing control exercise.[14] The study's findings revealed that FEV1/FVC% and FEV1 in the experimental group significantly improved with $P=0.017$ ($P<0.05$). However, there were no significant differences in FEV1 or FVC." [14] When the respiratory muscles, which are crucial to pulmonary function, are treated similarly to skeletal muscles, they not only improve muscle strength and endurance, but they can also enhance maximum inspiratory pressure, maximum expiratory pressure, and pulmonary function.[11] Our study were supported by Seong-Dae Woo et al. (2016), "To measure and verify any changes in chest and pulmonary functions when breathing with primarily inspiration or expiration was performed, and to propose a suitable intervention and exercise method for patients with lung disease." [11]

"A comparison of the BMIG and BMEG results before and after exercise revealed that the BMIG had significant differences in CSI, CEV, FVC.[11] breathing primarily with inspiration contracted not only the diaphragm, which is an inspiratory muscle, but also the inspiratory accessory muscles such as the sternocleidomastoid, scalenus, trapezius, pectoralis major, pectoralis minor, and serratus anterior, resulting in chest expansion.[11] Because breathing with primarily expiration contracts the rectus abdominis, transversus abdominis, obliques, and internal intercostals.[11] Prior to the experiment, there were no significant differences between the groups; however, changes in the measured variables after the experiment revealed that the BMEG showed significantly different increases in CSE, CEV, FEV1/FVC. Because breathing primarily with expiration activated abdominal muscles that are not used during normal breathing." [8] Our study was supported by **Sharp, J.T.; Cluzel, P.; et al.** (2020) reported that "improvement in chest expansion was greater at the level of the axilla than the xiphisternum. Inspiratory muscle stretching has no effect on lung structure; thus, the increase in chest expansion could be due to improved chest wall mobility. Increased chest wall mobility is frequently asynchronous with abdominal motion, either due to diaphragm weakness or increased excursion."[15] "Pursed lip breathing enhances oxygenation, muscle relaxation thus it has a significant impact on increasing lung capacity and respiratory muscle strength.[16]The airway's forces from the exhalation flow are resisted by the positive pressure that is produced.[16] Therefore, pursed-lip breathing aids in

breathing by expanding the airways during exhalation and promoting the excretion of volatile acids in the form of carbon dioxide, which prevents or relieves hypercapnia." [16] So, if any future study intended to analyse the immediate effect of intercostal stretch along with thoracic expansion exercise on pulmonary functions (FVC, FEV1, FEV1/FVC%) then it can be implemented. Chest expansion at (axillary, nipple, xiphisternal levels) can be used as a part of outcome assessment to predict the expansion of lungs in COPD subjects.

CONCLUSION

The present study concluded that there is statistically improvement on pulmonary function and chest expansion after immediate application of intercostal stretch and pursed lip breathing along with thoracic expansion exercise. But after immediate application of intercostal stretch along with thoracic expansion exercise there is more improvement on pulmonary function and chest expansion.

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Table 1 shows about distribution of age of both Group A and Group B.

AGE	GROUP A	GROUP B	TOTAL
40-45	4	7	11
46-50	6	6	12
51-55	7	4	11
56-60	13	13	26
Total	30	30	60

Table: 2 - pre-post comparison of pft value of group A

GROUP A	MEAN	±SD	Z VALUE	P VALUE	TEST
PRE FVC	1.95	0.74	3.21	0.000	Wilcoxon Signed Ranks Test
POST FVC	2.14	0.89			
PRE FEV1	1.23	0.47	4.79	0.000	
POST FEV1	1.60	0.57			
PRE FEV1/FVC	62.89	0.89	4.79	0.000	
POST FEV1/FVC	77.38	11.22			

Table: 3– pre-post comparison of chest expansion value of group A

GROUP A	MEAN	±SD	Z VALUE	P VALUE	TEST
PRE CE AL	1.21	0.36	5.20	0.000	Wilcoxon Signed Ranks Test
POST CE AL	2.23	0.40			
PRE CE NL	1.68	0.44	4.90	0.000	
POST CE NL	2.78	0.38			
PRE CE-XL	2.06	0.46	4.74	0.000	
POST CE XL	3.26	0.44			

Table: 4- pre-post comparison of pft value of group b

GROUP A	MEAN	±SD	Z VALUE	P VALUE	TEST
PRE CE AL	1.23	0.40	5.00	0.000	Wilcoxon Signed Ranks Test
POST CE AL	2.11	0.53			
PRE CE NL	1.48	0.46	4.86	0.000	
POST CE NL	2.55	0.46			
PRE CE-XL	1.85	0.51	4.89	0.000	
POST CE XL	3.02	0.53			

Table: 5- inter-group comparision of fvc, fev1, fev1/fvc

PFT	GROUP	MEAN	±SD	Z-VALUE	P-VALUE	TEST
FVC	A	0.18	0.25	1.43	0.153	Mann-Whitney Test
	B	0.06	0.24			
FEV1	A	0.37	0.16	3.55	0.000	Mann-Whitney Test
	B	0.18	0.20			
FEV1/FVC	A	14.48	7.33	3.06	0.002	Mann-Whitney Test
	B	8.40	6.12			

Table: 6- inter-group comparisionofaxillary, nipple, xiphisternal level

CHEST EXPANSION LEVEL	GROUP	MEAN	±SD	Z-VALUE	P-VALUE	TEST
AXILLARY LEVEL	A	1.01	0.24	2.03	0.042	Mann-Whitney Test
	B	0.88	0.25			
NIPPLE LEVEL	A	1.10	0.35	0.79	0.428	Mann-Whitney Test
	B	1.06	0.50			
XIPHIISTERNAL LEVEL	A	1.20	0.48	0.32	0.744	Mann-Whitney Test
	B	1.17	0.32			

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RESEARCH ARTICLE

Odd-Prime Graceful Labelling and Odd-Even Prime Graceful Labelling

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ABSTRACT

Prime Labeling, Graceful Labeling, Prime Graceful Labeling, Odd-Graceful Labeling and Odd-Even Graceful Labeling were investigated in this research. The new labeling techniques Odd-Prime Graceful Labeling and Odd-Even Prime Graceful Labeling are proposed along with the subsequent results. The result concerning Odd-Prime Graceful Labeling of Star and Bistar graph and Odd-Even Prime Graceful Labeling of Path Graph, Star Graph and Pan Graph were presented. Furthermore, the efficacy of the new Labeling Techniques are evaluated using the compatible examples.

Keywords: Prime Graceful Labeling, Odd-Graceful Labeling, Odd-Prime Graceful Labeling, Odd-Even Graceful Labeling, Odd-Even Prime Graceful Labeling .

INTRODUCTION

This paper focused on finite simple undirected graphs. The set of vertices V(G), set of elements E(G) and its incidence relation make up the graph G. To obtain a comprehensive list of terms used in graph theory, the following book [1] is considered. Graph Labeling was first developed by Rosa [6] who also provided several graph labeling methods and specifically came up with the phrase β -labeling and it was renamed by Solomon.W.Golomb [4] as graceful labeling. Later, Roger Entringer introduced prime labeling where Tout et.all [10] analyzed a few different kinds of graphs to find the ones that allows for prime labelling. Gnanajothi [3] defined odd-graceful graphs and identified some of the graphs that allows odd-graceful labelling. Furthermore, Sridevi et.all [9] instigated odd-even graceful graphs and found some graphs which admits odd-even graceful labeling. The survey of graph labelling conducted by Gallian J.A[2] is also referred. In 2018 Selvarajan. T.M, Subramoniam. R [8] combined prime and

graceful labelling and introduced a new labeling technique Prime Graceful Labeling and demonstrated the existence of prime graceful labelling in some graphs. Sayan Panma and Penying Rochanakul [7] also generated prime-graceful graphs and introduced prime-graceful number. In addition to applying the prime graceful labeling to certain graphs, Nandhini. S.P. and Pooja Lakshmi. B [5] generalized the cardinality of the edges for the triangular snake graph. In this paper, the new labeling technique odd-prime graceful labeling and odd-even prime graceful labeling are introduced and analyzed for some connected graphs.Star, Bistar, Path and Pan graphs have been taken into consideration.

PRELIMINARIES

Definition: 2.1
For a Graph G = (V, E) process of assigning labels to the vertices or the edges of a graph is known as **labeling**. Labels are often represented by integers.

Definition: 2.2
For a graph G = (V, E)with p vertices and q edges, if the mapping ω:V(G) → {1,2,3…p} are used to label the vertices of a graph with vertex set V in such a way that the labels given to distinct vertices x and y are relatively prime, (i.e) gcd { ω (x), ω (y)} = 1 then the graph is said to have a **prime labeling.**

Definition: 2.3
A graph G with p vertices and q edges is referred to have **graceful labeling** if the map depicts a one to one function ω from the vertices of G to {0,1, 2, …p}and the map reflect the induced one-to-one function ω * from the edges of G to {1,2,…p} defined by$\omega^*((v_i),(v_j))$= | ω (v_i) - ω (v_j)|. So that the resulting edge labels are distinct.

Definition: 2.4
A graph G with p vertices and q edges is referred to as having **prime graceful labeling** if the map depicts a one to one function ω from the vertices of G to {1, 2, …k}. In this instance, thevalue k = min {p, q} such that the GCD (ω (v_i) , ω (v_j))) = 1 and the map reflect the induced one-to-one function ω* from the edges of G to {1,2,…k-1} defined by$\omega^*(v_i , v_j)$= | ω (v_i) - ω (v_j) |. Thus, edge labels are different.

Definition: 2.5
A graph G with p vertices and q edges admits **odd-graceful labeling** if the injective function ω from V(G) to {0,1, 2, …2q - 1} and the map reflect the induced function ω * from the E(G) to {1,3,5,…2q - 1} defined by$\omega^*((v_i),(v_j))$= | ω (v_i) - ω (v_j)|.

Definition: 2.6
A graph G with p vertices and q edges admits **odd-prime graceful labeling** if the injective function ω from the V (G) to {1, 2, …2q} in such a way that GCD of (ω(v_i) , ω(v_j)) = 1 where $v_iv_j \in E(G)$and the map reflect the induced function ω* from E(G) to {1,3,5,…2q-1} defined by$\omega^*((v_i),(v_j))$= | ω (v_i) - ω (v_j)|. Odd-Prime Graceful graph refers to the graph that allows odd-prime graceful labeling**.**

Definition: 2.7
A graph G with p vertices and q edges admits **odd-even graceful labeling** if the injective function ω from V(G) to {1, 3,5 …2q+ 1} and the map reflect the induced function ω * from the E(G) to {2,4,6…2q} defined by$\omega^*((v_i),(v_j))$= | ω (v_i) - ω (v_j)|.

Definition: 2.8
A graph G with p vertices and q edges admits **odd-even prime graceful labeling** if the injective function ω from the V (G) to {1, 3,…2q + 1} in such a way that GCD of (ω (v_i) , ω(v_j)) =1 $v_iv_j \in E(G)$and the map reflect the induced

function ω* from E(G) to {2,4,6,…2q} defined by$\omega^*((v_i),(v_j))$= | ω (v_i) - ω (v_j)|. Odd-Even Prime Graceful graph refers to the graph that allows odd-even prime graceful labeling**.**

Odd-Prime Graceful Labeling of Starand Bistar graph

Theorem: 3.1

For any positive integers n, the star graph $K_{1,n}$ admits odd-prime graceful labeling.

Proof

The Star graph of order n is taken into consideration. Let { $v_1, v_2, v_3, \ldots . v_n$} be the vertices of the star graph.V ($K_{1,n}$) = { v_i :1 ≤ i ≤ n + 1}. Then, $K_{1,n}$ is a graph with | V (G) | = n + 1 vertices and | E(G) | = n edges.Define a labeling ω for vertex set as, ω : V (G) → { 1, 2, 3, …., 2q} where q is the total number of edges.Label the vertex of degree n with 1 and the n-pendant vertices are designated as 2,4,6….2q.For 1 ≤ i ≤ n , ω (v_i) = 2i. The adjacent vertices can be demonstrated as relatively prime.GCD (ω (v_i) , ω (v_j))= GCD (ω (v_i) , 1) = GCD (2i, 1) = 1

Since among these two numbers one is odd and other is even.

Define a labeling ω*for edge set as, ω * : E (G) → { 1, 3, 5…., 2q - 1} where q is the total number of edges.For 1 ≤ i ≤ n , ω * (E (G)) = 2i– 1. It is determined by

$\omega^*((v_i),(v_j))$= | ω (v_i) - ω (v_j)| = | ω (v_i) - ω (v_1)| = | 2i – 1| = 1,3,5,…..2q – 1.Consequently the edge labels are distinct.Thus, ω is odd-prime graceful labeling.

Therefore, $K_{1,n}$ is a odd-prime graceful graph.

Theorem: 3.2

For any positive integers n, the bistar graph $B_{n,n}$ admits odd-prime graceful labeling.

Proof

The Bistar graph of order n is taken into consideration. Let { $u_1, u_2, u_3, \ldots . u_{n+1}$, $v_1, v_2, v_3, \ldots . v_{n+1}$} be the vertices of the bistar graph.V ($B_{n,n}$) = { u_i :1 ≤ i ≤ n + 1} ∪{ v_i :1 ≤ i ≤ n + 1}

Then, $B_{n,n}$ is a graph with | V (G) | = 2n + 2 vertices and | E(G) | = 2n + 1 edges.

Define a labeling ω for vertex set as, ω : V (G) → { 1, 2, 3, …., 2q} where q is the total number of edges.Let u_1 and v_1 be the apex vertices of the bistar graph and label the vertex u_1 as 1 and v_1 *as* 2. Since the adjacent vertices $u_1$and v_1 are 1 and 2, GCD (ω (u_1) , ω (v_1))= 1.

The pendant vertices of u_i are designated as 6,8,10….2q

For 2 ≤ i ≤ n , ω (u_i) = 2(i+ n). The adjacent vertices can be demonstrated as relatively prime.

GCD (ω (u_i) , ω (u_1))= GCD (ω (u_i) , 1) = GCD (2(i + n), 1) = 1

Since among these two numbers one is odd and other is even.

The pendant vertices of v_i are designated as 3,5,7….q.

For 2 ≤ i ≤ n , ω (v_i) = 2i +1, The adjacent vertices can be demonstrated as relatively prime.

GCD (ω (v_i) , ω (v_1))= GCD (ω (v_i) , 2) = GCD (2i +1, 2) = 1

Since among these two numbers one is odd and other is even.

Define a labeling ω*for edge set as, ω * : E (G) → { 1, 3, 5…., 2q - 1} where q is the total number of edges.For 1 ≤ i ≤ n , ω * (E (G)) = 2i– 1.

It is determined by $\omega^*((u_1),(v_1))$= | ω (u_1) - ω (v_1)| = |1 - 2| = 1

$\omega^*((u_i),(u_1))$= | ω (u_i) - ω (u_1)| = | 2(i + n) – 1|

$\omega^*((v_i),(v_1))$ = | ω (v_i) - ω (v_1)| = | 2i + 1 – 2| = | 2i -1|

It forms the consecutive odd integers. Consequently the edge labels are distinct.

Thus, ω is odd-prime graceful labeling. Therefore, $B_{n,n}$ is a odd-prime graceful graph.

Odd-Even Prime Graceful Labeling of Path, Pan and Star graph

Theorem: 4.1

For any positive integers n, the path graph P_n admits odd-even prime graceful labeling.

Proof

The Path graph of order n is taken into consideration. Let $\{ v_1, v_2, v_3, \ldots . v_n \}$ be the vertices of the path graph.V (P_n) = $\{ v_i : 1 \leq i \leq n \}$. Then, P_n is a graph with $| V(G) | = n$ vertices and $| E(G) | = n - 1$ edges.Define a labeling ω for vertex set as, $\omega : V(G) \rightarrow \{ 1, 2, 3, \ldots, 2q + 1 \}$ where q is the total number of edges.

If n is odd, label the vertex $\left(\frac{n+3}{2}\right)^{th}$ with 1. If n is even, label the vertex $\left(\frac{n}{2} + 1\right)^{th}$ with 1.

The adjacent vertices of vertex label 1 is designated as 3,5,7….2q + 1

For $1 \leq i \leq n$, $\omega(v_i) = 2i + 1$. The adjacent vertices can be demonstrated as relatively prime.

$GCD(\omega(v_i), \omega(v_{i+1})) = GCD(2i + 1, (2(i + 1) + 1)) = GCD(2i + 1, (2i + 1) + 2) = 1$

Since these two numbers are consecutive odd integers.

Define a labeling ω* for edge set as, $\omega^* : E(G) \rightarrow \{ 2,4,6\ldots, 2q \}$ where q is the total number of edges.For $1 \leq i \leq n$, $\omega^*(E(G)) = 2i$. It is determined by

$\omega^*((v_i),(v_j)) = |\omega(v_i) - \omega(v_{i+1})| = |2i + 1 - (2(i + 1) + 1)| = 2, 4, 6\ldots\ldots 2q$

As the difference of two odd numbers is even. Consequently the edge labels are distinct.

Thus, ω is odd-even prime graceful labeling. Therefore, P_n is a odd-even prime graceful graph.

Theorem: 4.2

For any positive integers $n \geq 3$, the pan graph admits odd-even prime graceful labeling.

Proof:

The Pan graph of order n + 1 is taken into consideration. Let $\{ v_1, v_2, v_3, \ldots . v_{n+1} \}$ be the vertices of the pan graph.V (G) = $\{ v_i : 1 \leq i \leq n + 1 \}$. Then, pan graph consist of $| V(G) | = n + 1$ vertices and $| E(G) | = n + 1$ edges.Define a labeling ω for vertex set as,ω: $V(G) \rightarrow \{ 1, 2, 3, \ldots, 2q + 1 \}$ where q is the total number of edges.The vertex with the highest degree in the pan graph designated as 1.The adjacent vertices of vertex label 1 is designated as 3,5,7….2q + 1

For $1 \leq i \leq n$, $\omega(v_i) = 2i + 1$. The adjacent vertices can be demonstrated as relatively prime.

$GCD(\omega(v_i), \omega(v_{i+1})) = GCD(2i + 1, (2(i + 1) + 1)) = GCD(2i + 1, (2i + 1) + 2) = 1$

As these given two numbers are consecutive odd integers that follows one another.

Define a labeling ω* for edge set as, $\omega^* : E(G) \rightarrow \{ 2,4,6\ldots, 2q \}$ where q is the total number of edges.For $1 \leq i \leq n$, $\omega^*(E(G)) = 2i$. It is determined by

$\omega^*((v_i),(v_j)) = |\omega(v_i) - \omega(v_{i+1})| = |2i + 1 - (2(i + 1) + 1)| = 2, 4, 6, \ldots 2q$

Since there is an even difference between two odd numbers. Consequently the edge labels are distinct.Thus, ω is odd-even prime graceful labeling.

Therefore, n-pan graph is a odd-even prime graceful graph.

Theorem: 4.3

For any positive integers n, the star graph $K_{1,n}$ admits odd-even prime graceful labeling.

Proof

The star graph of order n is taken into consideration. Let $\{ v_1, v_2, v_3, \ldots . v_n \}$ be the vertices of the star graph.V ($K_{1,n}$) = $\{ v_i : 1 \leq i \leq n \}$. Then, $K_{1,n}$ is a graph with $| V(G) | = n + 1$ vertices and $| E(G) | = n$ edges.Define a labeling ω for vertex set as, $\omega : V(G) \rightarrow \{ 1, 2, 3, \ldots, 2q + 1 \}$ where q is the total number of edges.

Label the vertex of degree n with 1. The n-pendant vertices are designated as 3,5,7….2q+1.

For $1 \leq i \leq n$, $\omega(v_i) = 2i + 1$. The adjacent vertices can be demonstrated as relatively prime.

$GCD(\omega(v_i), \omega(v_{i+1})) = GCD(2i + 1, (2(i + 1) + 1)) = GCD(2i + 1, (2i + 1) + 2) = 1$

As these given two numbers are consecutive odd integers that follows one another.

Define a labeling ω*for edge set as, ω* : E (G) → { 2,4,6…., 2q} where q is the total number of edges.For $1 \le i \le n$, $\omega^*(E(G)) = 2i$. It is determined by

$\omega^*((v_i),(v_j)) = |\omega(v_i) - \omega(v_{i+1})| = |2i + 1 - (2(i+1)+1)| = 2, 4, 6 \ldots 2q$

Since there is an even difference between two odd numbers.

Consequently the edge labels are distinct.

Thus, ω is odd-even prime graceful labeling.

Therefore, $K_{1,n}$ is a odd-even prime graceful graph.

CONCLUSION

The most advantageous area of graph theory is graph labeling which has numerous applications. It is demonstrated that odd-prime graceful labeling is admissible for star graph, bistar graph and odd-even prime graceful labeling is admissible for the path graph, pan graph, and star graph. Furthermore, the newly developed labeling techniques are illustrated with examples. We would also investigate thoroughly other graphs which permits odd-prime graceful labeling and odd-even prime graceful labeling.

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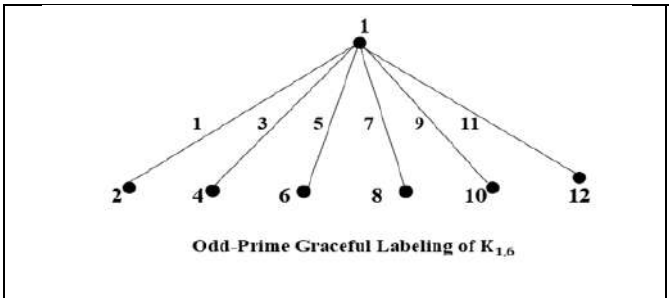


Figure 1:Analytical Evaluation of the Star graph

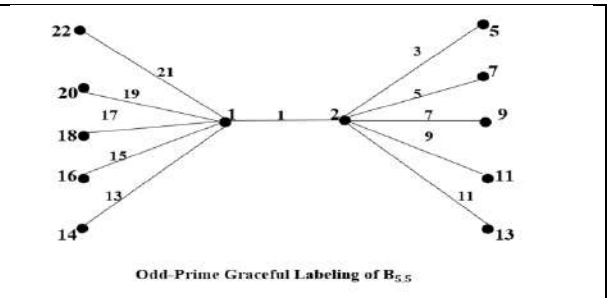
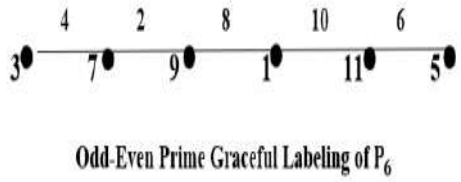
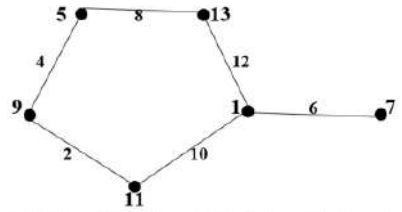


Figure 2:Analytical Evaluation of the Bistar graph



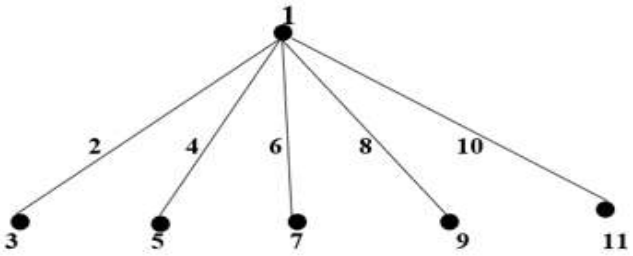
Odd-Even Prime Graceful Labeling of P_6

Figure 3: Analytical Evaluation of the Path graph



Odd-Even Prime Graceful Labeling of 5 – Pan Graph

Figure 4:Analytical Evaluation of the Pan graph



Odd-Even Prime Graceful Labeling of $K_{1,5}$

Figure 5: Analytical Evaluation of the Star graph

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RESEARCH ARTICLE

Effectiveness of Pre and Post Test Model of Learning in Dental School

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ABSTRACT

Conventional lecture is one of the most widely practiced method in teaching – learning. Due to vast syllabus and restricted time allocated per module, makes it difficult to receive feedback and provide necessary corrective actions. Objective was to evaluate knowledge of attendees of lecture using Pre and Post questionnaire model. Faculty, PG students and Interns, after acquiring their consent for participation were provided with pre-test questionnaire and the questionnaire were given as post test to evaluate the effectiveness of teaching as well as receptive power of attendees by comparing pre and post valuation. There was significant improvement in attendees' knowledge after the lecture. Also, there was improvement in median scores from pre to post lecture by 5. Out of 43 participants, 40 got positive ranks indicating improvement in knowledge in post test. Such pre and post test model will help evaluate effectiveness of teachers teaching skills and amount of knowledge gained by attendees.

Keywords: students, lecture, knowledge, scores.

INTRODUCTION

Didactic lectures been widely used as teaching – learning method. A pre – post evaluation of participants help evaluate the knowledge gained. Some of the active learning strategies help gain the grasp on three major domains of analysis, synthesis and evaluation. Dental education keep undergoing re-modeling phases based on vis-à-vis basis and in tandem with National Education Policy, 2020. NEP, 2020 mandates using of multiple knowledge dissemination tools and also help implement the evaluation strategies [1]. Dating back to 1899, Sir Osler emphasized the complexity of medical care and challenges for teachers to teach everything that student need to know.[2]And traditional methods of teaching and learning (T – L) methods are no longer sufficient enough. Current Gen Z generation dental students and dentists have grown – up in Social Medica Civilization and it is insufficient and unreasonable to teach them using methods deployed decades ago.

Research in healthcare is at its peak importance currently in both developed and developing countries, especially after Covid -19 outbreak. With increasing knowledge and expertise requirement; the study was intended to deliver a didactic lecture on the same topic which not only will be of interest but also will help in achieving at most concentration during the lecture. The current study was undertaken to evaluate the effectiveness of didactic lecture using Pre-Post test model among dental faculty, dental post-graduates and interns of dental institute irrespective of their demographics.

Need for the study

Didactic lecture was designed with pre and post-test method to assess the effectiveness. This sort of a test method was first of a kind in our institute and was believed to be increasing the receptive capacity along with improvement in thinking, understanding and attention of participants.

Aim and Objectives

This assessment method was employed on faculty, post graduates and interns to check the possibility of inculcating the Pre-Post test method for undergraduate training program in dentistry.

MATERIALS AND METHODS

This study was conducted in a dental institute in Western Maharashtra. Total of 180 participants were invited for didactic lecture through circulars well in prior, with an intent to gather their consent to be part of this exercise. None of the circulars mentioned anything related to test planned during lecture to avoid bias, if any. Total of 60 individuals turned up for the lecture comprising of faculties, post graduate students and interns. Out of which, 43 agreed to be part of the study with their written consent. Before commencement of study, Institutional Ethical Committee approval was obtained.

Before beginning of the lecture, written consent was obtained and pre-test copy was distributed to participants comprising of pre – formed 5 questions of objective nature. The lecture was delivered for about 40 minutes, following which post – test comprising of same questions were administered to participants. This was a pre – tested questionnaire for validity. Scoring was done by single subject expert for both pre and post test, other than the lecturer. Scoring was ranging from 0 to 15 for both pre and post test.

Statistical analysis

Collected data was compiled using Microsoft Excel and Wilcoxon Signed Rank Test was used to assess the statistical difference between paired scale data. P – value was considered significant at $P < 0.05$.

RESULTS

A total of 43 participants were part of the study. among those, Pre – test showed 7 meadian whereas, Post – test showed median of 11. (Table 1) (Graph 1) This shows marked improvement in scores after lecture. However, to check the statistical significance between Pre and Post test, Wilcoson Signed Rank Test was used, where statistical significant improvement was observed in Post – Test (Positive ranks>Negative ranks, P<0.001) (Table 2). Also, the total of 40 participants showed positive ranks indicating direct improvement post lecture; with only 2 participants showing negative ranks and 1 with tie between pre and post test.

DISCUSSION

A prospective study was conducted to assess the pre – test before lecture on the same topic selected improves the performance of the participants in immediate post – test. Majority of the participants felt that conducting pre – test was helpful in improving their attentiveness and understanding of the subject. The reason could be self-realization towards inability to answer pre-test to satisfactory level, which is in tandem with previously conducted similar study [3]. These discernments from participants regarding pre – test was confirmed with statistical significant post – test improvement in scores (P<0.001).[4-5]In post – test, the improvement in scores by median of 5 (Table 1). This type of self evaluation immediately by participants was encouraging and stimulating to study and concentrate more during didactic lectures. These pre and post test measurements are widely used for assessing the impact of interventions and are of great use in behavioural research.[6] Thus, it is apt to say that, such pre and post test models will be helpful in achieving the learning objectives and help better disseminate the knowledge.

CONCLUSION

Conventional didactic lecture been there in practice for decades and will remain viable for foreseeable future. The application of this pre and post test model will be helpful in self – evaluation of students and also aid in formative assessment of teaching – learning methods. Although, the current study was conducted on very less number of participants though covering various strata of dentistry including, dental faculty with various years of experience in teaching, post graduate students of different stream and internship residents. For conclusive evidence, further study with diverse and more number of participants need to be conducted.

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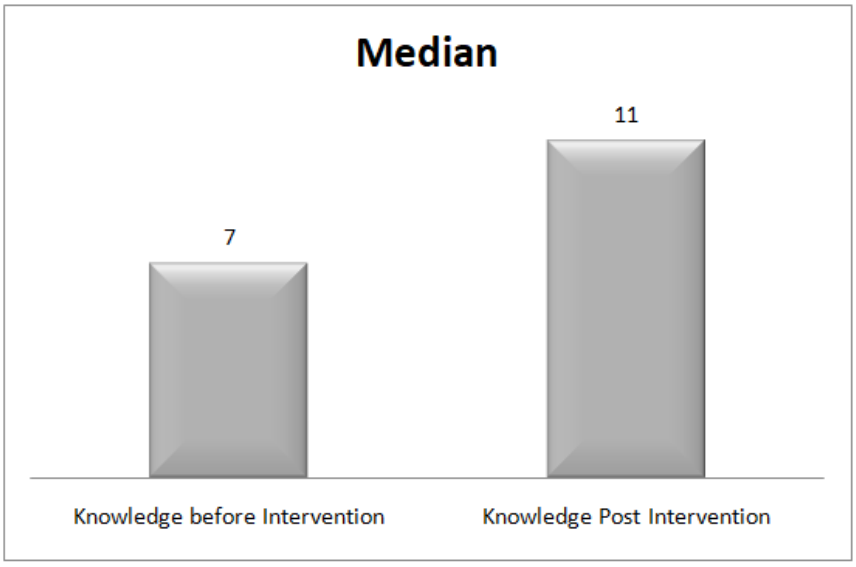
Table 1: Mean, median and standard deviation for Pre test and Post test among participants.

	n	Mean	Median	Standard deviation
Pre – Test	43	7.12	7	3.27
Post – Test	43	11.33	11	2.16

Table 2: Comparison of Pre and Post test scores using Wilcoxon Signed Rank Test

		N	Mean Rank	Sum of Ranks	Z	P value
Knowledge post lecture - Knowledge prelecture	Negative Ranks	2	3.5	7	-5.57	**0.001***
	Positive Ranks	40	22.4	896		
	Ties	1				
Negative Ranks: Knowledge post lecture< Knowledge before lecture						
Positive Ranks: Knowledge post lecture> Knowledge before lecture						
Ties: Knowledge post lecture = Knowledge before lecture						

*Statistical significance set at 0.05; **N:** Number of samples



Graph 1: Median for Pre and Post test among participants

RESEARCH ARTICLE

Tele – Rehabilitation in the management of post modified radical mastectomy patients

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ABSTRACT

Breast Cancer is a leading cause of women death in India and it is measured to have one out of every 28 Indian women are under risk of developing breast cancer. And as a part of treatment, Modified Radical Mastectomy can be considered as a best treatment procedure. But that to have some complications like Decreased Shoulder ROM, Pain & Disabilities. To overcome these complications we can have physiotherapy protocol. But In India it is tough to have a physiotherapist in every rural area. So, this study is mainly focuses on the tele physiotherapy protocol and helps us to find out weather tele physiotherapy is helpful or not. So, after having this research study we have found out that the tele physiotherapy is helpful for reducing the complications like pain, ROM & Disabilities. So, for the patients who resides in rural area where physiotherapy facilities are not available, those patients can be benefited by having tele physiotherapy than compared to No Physiotherapy at all.

Keywords: Breast Cancer, Modified Radical Mastectomy, Tele – Physiotherapy

INTRODUCTION

Breast cancer is a growing concern in India, with increasing incidence and mortality rates[1].According to recent studies, breast cancer is the leading cause of mortality among women in India[1]. In fact, it is estimated that one in every 28 Indian women is at risk of developing breast cancer in her lifetime[2]. In light of the growing concern of breast cancer in India, it is essential to explore treatment options that can offer the best chance of recovery and long-term survival. One such option is the Modified Radical Mastectomy, a surgical procedure involving the removal of the entire breast, including the breast tissue, nipple, and sentinel lymph nodes[3]. After undergoing a Modified

Radical Mastectomy, individuals may experience various complications that could impact their recovery and long-term well-being4. These complications can include lymphedema, a condition characterized by swelling in the arm on the side of the surgery, as well as limited mobility and discomfort[4]. Additionally, some individuals may experience psychological distress, body image issues, and emotional challenges following the removal of the breast[4]. In conclusion, physiotherapy after a Modified Radical Mastectomy is an essential component of comprehensive care for individuals diagnosed with breast cancer in India[5]. It plays a vital role in improving physical function, emotional well-being, and overall quality of life after the surgery[5]. By integrating physiotherapy into the post-operative care plan, healthcare providers can support individuals in their journey towards recovery and long-term well-being[6]. Tele physiotherapy has emerged as a valuable option for individuals undergoing post-operative care, especially in the current global health crisis[7]. In India, tele physiotherapy offers a convenient and effective way for individuals to receive physiotherapy services remotely[8]. Through virtual consultations and guided exercises, individuals can access professional support from experienced physiotherapists without the need for in-person visits[8].Tele physiotherapy sessions can include guided exercises, movement assessments, and educational resources to empower individuals in actively participating in their recovery process[9]. In conclusion, tele physiotherapy has emerged as a valuable tool for individuals undergoing post-operative care, particularly those recovering from breast cancer treatment in India[9]. It provides convenient access to professional support, especially for those in rural or remote areas[10]. Furthermore, it reduces the burden of travel and promotes a comfortable recovery environment at home[10]. The use of tele physiotherapy in India has proven to be a significant advancement in delivering comprehensive care to individuals undergoing breast cancer treatment[11].

METHODOLOGY

Here we have conducted this study to check about the effectiveness of tele physiotherapy in terms of ROM, Pain & Disability for the patients underwent for modifiedradical mastectomy. For this study we have selected patients underwent for modified radical mastectomyin the Amreli district of Gujarat during the period of Mar 2021 to Feb 2023. We have found total of 162 patients who underwent for the modified radical mastectomy but among of them we have selected only 138 patients as 24 patients either didn't match the inclusion criteria or they have denied participating in the study. Patients were selected for the study if they fulfil the following criteria. Female at the age of 25 to 70 years suffering with stage I -III breast cancer that was treated by modified radical mastectomy within last 3 months of period. Subjects were excluded from the study if they had a history of previous shoulder and neck surgery, neuro muscular skeletal conditions that may affect the shoulder and neck function, mental illness, subjects having any legal issues patients who did not understand the communication languages selected for the study (Gujarati, Hindi English) patient having cognitive defects that may interfere with the intervention and outcome.

Before starting the study, we have given an introduction to all participants about the research and had taken written consent to participate in the study. A total of 138 patients had participated in the study and they had been given 2 choices;

1. They can stay at their home and can join the tele physiotherapy session regularly for 1 hour – Tele Physiotherapy Group – Group A
2. They can stay at home and perform a physiotherapy protocol as given in the pamphlet - Control group – Group B . So, among of those 138 patients, 70 patients have selected to join group A and 68 patients have selected to perform physiotherapy as per the pamphlet and joined group B.

INTERVENTION

Group A – Tele Physiotherapy Group

1. Active exercise and active mobilization to reduce lymphedema and active muscle contraction of upper limb muscles.
2. Active Exercises to improve the shoulder range of motion that includes Flexion, extension and hyper extension exercises either in sitting or in standing position.
3. Strengthening of the muscles of the shoulder girdle was provided either by using dumbbell and Thera bands.

4. Functional activities were been educated for the upper limb like shifting objects from the floor to the cupboard, grooming activities, dressing activities, occupational activities and all other decided activities of the patient's choice which are feasible.
5. General aerobic exercises were provided to increase the cardio respiratory endurance and also to increase the chest wall expansion which might be altered following the surgery.
6. Endurance exercises were provided with less weight and more frequency of movement for of the upper limb.

Group B – Control Group

We have provided a pamphlet contain full physiotherapy treatment protocol similar to the physiotherapy protocol we given to tele physiotherapy group.

1. Self mobility exercise to reduce lymph edema in the form of active muscle contraction of upper limb muscles.
2. Self exercises to improve the shoulder range of motion that includes scapular mobility, stretching of the Latissimus dorsi, Serratus anterior, Deltoid and Pectoralis major.
3. Self strengthening of the muscles of the shoulder girdle was provided either using thera bend or dumbbell.
4. Functional activities was be educated for the upper limb like shifting objects from the floor to the cupboard, grooming activities, dressing activities, occupational activities and all other decided activities of the patient's choice which are feasible.
5. General aerobic exercises were provided to increase the cardio respiratory endurance and also to increase the chest wall expansion which might be altered following the surgery.
6. Endurance exercises were provided with less weight and more frequency of movement for of the upper limb. The treatment duration is for 60 minutes concentrating equally all the components for 10 minute each and 5 times in a week. Rest was incorporated on a case-to-case basis as per the expertise of the researcher. – for both the groups. For the group A – A tele physiotherapy session has been conducted by zoom meeting every time. We have asked both the group patients to visit the physiotherapy clinic at the end of 1 month for the further assessment.

ANALYSIS

Here in this research, we have analysed the data by means of withing group analysis to check the effectiveness of treatment protocol and between group analysis to check which treatment protocol is superior among of two. For both the groups we have measured 3 different outcome measures of Pain, Flexion ROM & SPADI Score at 2 different intervals:

i. Baseline, before starting the treatment – Pre-Test
ii. 1 month post treatment – Post Test

Paired Sample t test had been performed for within group analysis for the pain in tele physiotherapy group and control group and it showed the significant difference between Pretest & Post test in both the groups with having p value of < 0.005 in both the group at every interval. Above result of within group Analysis shows that both the treatment protocol of tele physiotherapy & control group is effective for the treatment of pain in the patients underwent for the modified radical mastectomy

Within group analysis – ROM

Paired Sample t test had been performed for within group analysis for the flexion ROM in tele physiotherapy group and routine physiotherapy group and it showed the significant difference between Pretest & Post test. In both the group p value of < 0.005 is found. Above result of within group analysis shows that both the treatment protocol of tele physiotherapy & Control Group is effective for the treatment of improving flexion ROM in the patients underwent for the modified radical mastectomy

Within Group Analysis – SPADI

Paired Sample t test had been performed for within group analysis for the SPADI Score in tele physiotherapy group and Control group and it showed the significant difference between Pretest & Post test in both the group with p value of < 0.005 in both the group. Above result of within group comparison shows that both the treatment protocol of tele physiotherapy & Control Group is effective for the treatment of improving SPADI Score in the patients underwent for the modified radical mastectomy

Between Group Analysis – Pain

Independent Sample t Test had been performed to compare the effectiveness of treatment by means of reducing pain in both the groups and found no significance of difference in the value of pain at Pretest analysis with having F value of 2.74 and p value of > 0.005. Independent Sample t Test had been performed to compare the effectiveness of treatment by means of reducing pain in both the groups and found a significance of difference in the value of pain at Post test with having F value of 2.09 and p value of < 0.005. Above mentioned result showed that the Tele physiotherapy group was much more effective in reducing the pain than compared with Control group.

Between Group Analysis – Flexion ROM

Independent Sample t Test had been performed to compare the effectiveness of treatment by means of improving ROM in both the groups and found no significance of difference in the value of ROM at Pretest analysis with having F value of 0.68 and p value of > 0.005. Independent Sample t Test had been performed to compare the effectiveness of treatment by means of improving ROM in both the groups and found a significance of difference in the value of ROM at Post Test with having F value of 5.15 and p value of < 0.005. Above mentioned result showed that the tele physiotherapy group was much more effective in improving the ROM than compared with tele physiotherapy group.

Between Group Analyses – SPAD Score

Independent Sample t Test had been performed to compare the effectiveness of treatment by means of reducing SPADI Score in both the groups and found no significance of difference in the value of ROM at Pretest analysis with having F value of 0.54 and p value of > 0.005. Independent Sample t Test had been performed to compare the effectiveness of treatment by means of reducing SPADI Score in both the groups and found a significance of difference in the value of SPADI Score at Post Test 2 with having F value of 0.19 and p value of < 0.005. Above mentioned result showed that the tele physiotherapy group was much more effective in reducing the SPADI Score than compared with tele physiotherapy group.

DISCUSSION

Here in this study, we have collected the data and analysed it with having within group analysis and between group analysis and found that both the treatment protocol were effective by means of improving in Pain, ROM & SPADI score but while compared both the group result post treatment, we have found the tele physiotherapy group was much more effective than compared to Control group. In a developing country like India, we are facing a huge lack of healthcare workers especially in the rural areas. So, patients suffering from many conditions like having post operative complication of modified radical mastectomy couldn't receive a proper treatment because they don't have proper medical facility available at their home town So, in the era of 21st century, when we are having a proper technology like tele medicine and when the health & family welfare department of government of India is also promoting the tele physiotherapy. Then why can't we as a physiotherapist take a step forward in this direction & provide a tele physiotherapy to patients who are unable to come at clinic regularly. So, these types of patients can have a batter life ahead. This study was to check the effectiveness of tele physiotherapy in the patients underwent the modified radical mastectomy and had been proved that tele physiotherapy can be a batter option for the patients who can't go to the physiotherapy clinic regularly than having a no physiotherapy treatment at all. No doubt a tele

physiotherapy can't be as much beneficial as the routing physiotherapy at physiotherapy clinic. But we can provide batter life for those patients who can't come for the routine physiotherapy at clinic regularly.

CONCLUSION

The results of the study suggest that, Tele Physiotherapy and Control Group both are beneficial for reducing pain, improving ROM and Reducing disability index for the patients underwent for modified radical mastectomy. Before starting the physiotherapy treatment, at Pretest analysis, we have found both the group were similar and have not found significantly different in the terms of pain, ROM & SPADI. Tele physiotherapy group was quite more beneficial while compared to Control group at Post Treatment analysis. According to the result we got after having data analysis, routine physiotherapy would always be having an upper hand than compared to tele physiotherapy, and it is preferred for the patients to take the physiotherapy regularly at physiotherapy clinic whenever itis possible. But while it is not possible for the patients to come at physiotherapy clinic regularly, it is preferred to have a tele physiotherapy at home and make a regular follow up at physiotherapy clinic whenever asked.

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Table:1 Paired Samples Test – TelePhysiotherapy Group

Paired Samples Test – TelePhysiotherapy Group								
	Paired Differences					T	Df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pre-test - Post Test	24.914	6.900	1.166	22.544	27.285	21.362	34	.000

Table:2 **Paired Samples Test – Control Group**

Paired Samples Test – Control Group								
	Paired Differences					t	Df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pretest - Post Test	40.618	8.038	1.378	37.813	43.422	29.466	33	.000

Table:3 Paired Samples Test – Tele physiotherapy Group

Paired Samples Test – Tele physiotherapy Group								
	Paired Differences					T	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pretest - Post Test	-46.314	8.109	1.371	-49.100	-43.529	-33.791	34	.000

Table:4 Paired Samples Test – Control Group

Paired Samples Test – Control Group								
	Paired Differences					T	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pretest - Post Test	-32.324	10.92	1.873	-36.134	-28.513	-17.259	33	.000

Table:5 Paired Samples Test – Tele Physiotherapy Group

Paired Samples Test – Tele Physiotherapy Group								
	Paired Differences					t	Df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pretest - Post Test	39.771	6.044	1.022	37.695	41.848	38.927	34	.000

Table:6 Paired Samples Test – Control Group

Paired Samples Test – Control Group								
	Paired Differences					t	Df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pretest - Post Test	62.618	8.038	1.378	59.813	65.422	45.425	33	.000

Table 7: Independent Samples Test

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Pretest	Equal variances assumed	2.738	.103	-.418	67	.677	-.680	1.625	-3.924	2.565
Post Test	Equal variances assumed	2.097	.152	14.26	67	.000	15.024	1.054	12.921	17.126

Table:8 Independent Samples Test

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper

Pretest	Equal variances assumed	.684	.411	-.962	67	.339	-2.046	2.126	-6.290	2.197
Post Test	Equal variances assumed	5.152	.026	6.144	67	.000	11.945	1.944	8.064	15.825

Table 9: Independent Samples Test

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Pretest	Equal variances assumed	.054	.817	-2.167	67	.034	-2.658	1.227	-5.107	-.209
Post Test	Equal variances assumed	.189	.665	14.959	67	.000	20.188	1.350	17.494	22.882

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RESEARCH ARTICLE

Green Manuring: A Miracle Solution for Reclaiming Saline and Sodic Soil

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ABSTRACT

One of the most significant challenges in modern agriculture is producing enough high-quality food grains to feed an ever-increasing population while safeguarding soil quality, fertility, and productivity. Now-a-days, many farmers use these agrochemicals and pesticides indiscriminately, resulting in loss of soil fertility and productivity as well as a harmful impact on human health. Gypsum has a long history of being used to control salt-affected soils; however, major barriers to its use, such as transportation, cost, and availability, prevent small and marginal farmers from adopting it. In this scenario, using green manure provides a glimpse of hope. Green manuring is a simple, cost-effective and environmentally friendly approach to managing these soils. Globally, there are several types of green manure crops that support soil nutrient dynamics and improve soil health.

Keywords: Fertility, Green manure, Gypsum, Soil health, Soil quality

INTRODUCTION

Current world population (7.3 billion) is further projected to increase to 8.5 and 9.7 billion during 2030 and 2050, respectively which is expected to stabilize at around 11.2 billion by the end of the twenty-first century. To achieve nutritional security, this growing population will necessitate increased food grain production from limited land and water resources. Food grain production expanded dramatically at the worldwide level during the twentieth century, leading in a massive yield rise due to a surge in net cultivable land. Additionally, the use of short-duration high-yielding cultivars, synthetic fertilizers, and pesticides is unavoidable (Sihag *et al*. 2015). This technique has resulted in the slow deterioration of soil organic matter as stable soil aggregates break down and organic matter decomposes.

Consequently, soil health has deteriorated in terms of reduction in the water-holding capacity of soils, surface and groundwater pollutionand multiple nutrient deficiencies. Overuse of nitrogenous fertilizer to boost agricultural productivity endangers the ecosystem. The use of chemical fertilizers in agriculture and different industrial units has caused an increase inatmospheric concentrations of reactive forms of nitrogen (e.g., NO, NO, N_2O, NH, etc.)by around 100%(Meena *et al*., 2018). This scenario leads us to reexamine the role of biological nitrogen fixation, and the addition of legumes to green manure appears to be a viable response.

What is green manure crop?

Green, undecomposed plant material used as manure is called green manure. Green manuring is the technique of ploughing and incorporating undecomposed green plant tissue into the soil to improve soil fertility and production. It boosts soil fertility by adding nitrogen directly to the soil via symbiosis, as well as improving soil structure, water holding capacity, and microbial population through the addition of humus or organic matter.The green manuring practices are of two types- in-situ green manuring (short-duration - 45 to 60 days, crops are grown and incorporated into the soil at the same site) and ex-situ green leaf manuring (foliage and tender parts of green manuring crops collected from nearby forests, shrubs, and trees are incorporated into the soil at 15-30 days before the sowing of main crops). The herbaceous leguminous crops, namely dhaincha, sunhemp, cowpea, green gram, black gram, etc., and woody legumes, namely- subabul, gliricidia, karanja etc. can fix the atmospheric N in their root nodules.

Effect of green manure on salinity and sodicity

A significant number of soluble salts, such as Ca++, Mg++, and Na+ present in saline soil which affects plant growth, development, yield, and deteriorates seed quality owing to osmotic stress in the root zone (Shirale*et al*., 2018).The use of green biomass raises the partial pressure of carbon dioxide and organic acids, triggering a spike in the release of salts into soil solution as an outcome of mineral dissolution. This allows salts to leach below the root zone, establishing an ideal environment for crops to thrive. When GM is introduced to salt-affected soil, it substantially boosts the levels of N, organic C, organominerals, and total carbohydrates in the soil(Zubair *et al*., 2012).Soil pH decreases when organic acids (amino acid, glycine, cysteine, and humic acid) are produced during heterotrophic mineralisation of organic materials and autotrophic nitrification. During decomposition, the applied green manures release CO_2, which absorbs in water to form carbonic acid. This acid boosts the solubility of calcium carbonate minerals and increases the concentration of Ca+2 in soil solutions, which replaces Na+ on exchange complex and reduces the exchangeable sodium percentage (ESP) by lowering pH, dissolving calcium carbonate, and generating several kinds of complex calcium ion pairs. Because the sodium carbonate and sodium bicarbonate salts in the solution breakdown humus, especially the fulvic and humic acid portions, sodic soil has a low organic content(Khan *et al*., 2000).Additionally, they facilitate the exchange sites' calcium-to-sodium ion exchange(Kumar *et al*., 2020).

Sodic soil usually contains lime as insoluble calcium carbonate; hence it has lower calcium ionic activity. It has been demonstrated that two especially effective green manures (GM) and green leaf manures, respectively, to rehabilitate sodic soils are Sesbania aculeata and Delonixelata, both of which are resistant to sodicity stress(Baig and Zia, 2006; Chandrasekaran *et al*., 2010). The following order was followed by the various green manures' levels of reclamation potential: dhaincha>sunhemp> cowpea > green gram (Shirale*et al*., 2017). Sesbania aculeata may assist in replace sodium from sodic soils since it contains 34% calcium on a dry weight basis. Additionally, using green manure reduces the concentration of a number of cations and anions, such as Cl^-, SO_4^{2-}, HCO^{3-}, and CO_3^{2-}(Shirale*et al*., 2018).

Conclusion: Using organic amendments to recover from salt stress strengthens soil health and food security. Green manure releases nutrients more quickly, is easier to decompose, has a higher N content and a lower C/N ratio, and minimises the risk of N immobilisation for subsequent crops. After decaying, exchangeable sodium in green manure crops is replaced with calcium, which reduces the pH of the soil, stimulates nutrient absorption, and boosts soil health for higher yields of crops. In order to restore soil fertility and production in saline and sodic soils, green manuring crops offer an economical and ecologically responsible solution.

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RESEARCH ARTICLE

Unexpected Consequences: Facial Nerve Paralysis in Mandibular Trauma Cases: A Case Report

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ABSTRACT

Mandibular fractures are the second most common fracture in the face region. The main causes for this fracture are car accidents, personal violence, falls or bike falls. Facial nerve paralysis occur very commonly in head injuries where trauma to the temporal bone causes fracture of facial canal which can cause compression on nerve or may be tearing of nerve leading to paralysis. Despite this high prevalence, there is still controversy on how to manage it. Here we are reporting a rare case of facial nerve injury in a minimally displaced fracture of mandible. An 83-year-old female, involved in a road accident a month prior, presented with a history of unconsciousness. Initial examination revealed subdural hematoma (SDH) and facial fractures. The patient, initially managed with carbamazepine and no mandibular intervention, later developed neurological deficits. A month post-accident, she exhibited difficulty in eating, inability to close her left eye, and impaired facial expressions. CT imaging indicated a minimally displaced mandibular fracture. Prednisolone was prescribed without mandibular intervention. Facial nerve injury in minimally displaced mandibular fractures is a rare occurrence. Understanding the mechanisms and etiologies is crucial for appropriate management and prognosis assessment.

Keywords: Mandibular fractures; facial nerve injuries;facial paralysis

INTRODUCTION

Mandibular fractures are the second most common fracture in the face region, second only to nasal fractures. The main causes for this fracture are car accidents, personal violence, falls or bike falls. Despite this high prevalence, there is still controversy on how to manage it. The literature reviews different ways to manage facial nerve injury post trauma is a rarely identified complication as facial nerve paralysis occur commonly in fracture of skull base, which is associated with other life threatening injuries. There have been only a few cases reported of facial nerve injury post mandibular trauma which is not associated with cranial injuries. Here we are reporting a rare case of facial nerve injury in a minimally displaced fracture of mandible

Case report

A 83 year old female patient reported to the department of OMFS, SGT University. Patient's relative gave a history of fall when she was hit a by a vehicle on road 1 month ago. Patient became unconscious for 10 min. Patient was taken to PGIMS Rohtak where clinical examination and CT was done. CT revealed SDH and facial fracture. Patient was put on carbamazepine 200mg twice daily and was referred home without any intervention for mandibular trauma .Patient became neurologically deficit and was not identifying family and relatives after accident. 1 month later patient was bought to OMFS OPD in SGT university with a complain of inability to eat food and inability to close left eye by relatives only. The patient was not oriented to time, place and person and was barely following commands. On clinical examination, the occlusion was not disturbed, but patient was complaining of difficulty in chewing food. Patient was not able to close left eye or was not able to frown. (Fig-1: A, B, C) Salivary drooling was present from corner of mouth A repeat CT face and head was advised which revealed minimally displaced fracture of body of mandible and zygomatic arch. (Fig-2) No evidence of SDH was seen in the CT. Patient was advised a tapering dose of prednisolone without any intervention for facial fractures.

DISCUSSIONS

Facial nerve paralysis occur very commonly in head injuries where trauma to the temporal bone causes fracture of facial canal which can cause compression on nerve or may be tearing of nerve leading to paralysis. But, Facial nerve injury in mandibular fractures is rarely encountered due to its course and impact received by the mandible. Only a handful of cases of unilateral facial nerve palsy secondary to isolated mandibular fractures, i.e without associated temporal bone fractures, have been reported to date. Absence of neurological and otological findings as well as a normal CT scan suggested a peripheral cause for the lower motor neuron type of facial nerve palsy in this patient. Delayed onset of facial palsy has been reported after mandibular fractures. BRUSATI & PAINI authored vascular disturbances consequent upon oedema are probably the cause of delayed onset of facial paralysis[1]. In the present case, the facial palsy was noted on about 9th -10th day postoperative day. The mechanism of facial nerve injuries in mandibular fractures without associated temporal bone fractures or associated otological causes has been variously cited as:

1. oedema in the fallopian canal[2];
2. oedema and haemorrhage around the facial nerve in the region of the parotid gland[3];
3. traction injury to the nerve trunk at its exit from the stylomastoid foramen[1];
4. direct trauma from fractured stump ends[4];
5. vigorous manipulation for fracture reduction[5].

In this case the sudden splaying of the body fracture may have lead to cause traction injury to the facial nerve which might have caused facial paralysis. Although paralysis of all 5 branches of facial nerve is a rare entity in mandibular fracture. Other investigations including MRI, HIV and blood investigations were done to rule out other causes but none of them were associated with aetiology of this case. Secondary facial palsy, similar to other etiologies of facial paralysis, is considered to diminish by itself in a period of 3 to 6 months, with almost no permanent paralysis cases [6,7]. But regular follow ups are required to trace the recovery of nerve function and to identify etiology of paralysis

in such cases. Scuotto A, S. Cappabianca in a case report presented delayed post-traumatic facial nerve palsy without radiological evidence of temporal bone fractures, in which magnetic resonance was crucial for diagnosing the nerve impairment. Radiological findings in accordance both with electrodiagnostic tests and clinical presentation suggested the successful conservative management. They stated that delayed FNP is usually due to the pressure effect of a reversible edema within the fallopian canal, best managed by medical treatment. Important prognostic factors are the severity of FNP and timing of onset, with the degree of palsy (based on the House and Brackmann scale and electric testing) having a greater influence on recovery of function than the time of onset.[8,9] Some authors postulate a similar mechanism for this facial weakness as in Bell's palsy with a possible inflammatory reaction in and around the nerve, or a swelling of the nerve in the canal which could lead to ischemia. The vascular damage such as delayed arterial spasm, arterial or venous thrombosis, external compression from bony fragment or soft tissue edema are other etiological causes [10,11].

CONCLUSION

Facial nerve injury in minimally displaced mandibular fractures is a rare occurrence. Understanding the mechanisms and etiologies is crucial for appropriate management and prognosis assessment. Regular follow-ups and comprehensive assessments are essential for tracking nerve function recovery and identifying underlying causes of paralysis.

PATIENT CONSENT

Written informed consent was taken from the patient for the investigations, treatment and publication of their details.

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CONFLICT OF INTEREST

We declare that we do not have any commercial or associative interest that represents a conflict of interest in connection with the work submitted.

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(Fig-1) (A) (B) (C) : Frontal, left and right side profiles of the patient.

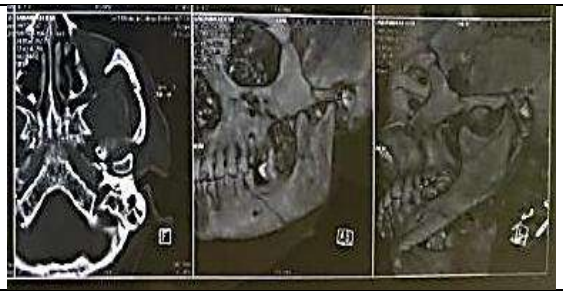


Fig-2: NCCT Head and face radiographs of the patient revealing minimally displaced fracture of body of mandible and zygomatic arch

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RESEARCH ARTICLE

Integrating Human Rights Education with Technological Ethics: Empowering Responsible Innovation and Societal Transformation

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ABSTRACT

This paper explores the integration of human rights education with technological ethics to propel responsible innovation and societal transformation. By examining the role of human rights education in the context of science and technology, the paper highlights how ethical considerations can be embedded in technological development to ensure that advancements contribute to social justice and human dignity. The study concludes with recommendations for educators, policymakers, and technologists on leveraging educational frameworks to promote human rights within the rapidly evolving technological landscape.

Keywords: Human Rights, Education, Innovation, Societal Transformation

INTRODUCTION

Human rights education plays a crucial role in building more equitable, just, and free societies, while fostering transformative societal change. It encompasses a range of educational practices and initiatives aimed at raising awareness, enhancing understanding, and cultivating respect for human rights principles and values. The importance of human rights education in nurturing a culture that respects human rights and in developing active, informed citizenship cannot be overstated. Its impact is evident in the dissemination of knowledge about rights and the development of skills necessary to defend and advocate for these rights. The significance of human rights education is widely recognized by international organizations and scholars within the human rights field. The United Nations has emphasized the importance of human rights education through various resolutions and declarations. Educational systems globally are often anchored in the principles of the Universal Declaration of Human Rights

(UDHR); Article 26 specifically addresses education, stating that it "shall be directed to the full development of the human personality and to the strengthening of respect for human rights and fundamental freedoms" (United Nations, 1948). The United Nations Declaration on Human Rights Education and Training, adopted on December 19, 2011, further underscores the necessity of human rights education as essential for "achieving individual and collective life in dignity" and as a means to "promote equality, justice, sustainable development, social harmony, and peace" (United Nations, 2011). Human rights education can be delivered through both formal and non-formal approaches. Formal education systems, such as school curricula and educational institutions, provide a structured framework for imparting human rights knowledge and values. Non-formal methods, on the other hand, extend beyond traditional educational settings and include community-based initiatives, advocacy campaigns, online platforms, and grassroots efforts. These approaches aim to reach individuals in diverse contexts, including marginalized communities, addressing specific human rights issues and incorporating technological advancements to enhance learning (Osler & Starkey, 2005). Despite its potential, human rights education faces several challenges in its implementation. Obstacles such as conservative societal attitudes, political resistance from certain governments, and a lack of political will continue to hinder its inclusion in official curricula. Additional challenges include a lack of standardized approaches, inadequate teacher training, and limited resources (Andreotti, 2011; Bajaj, 2011). Overcoming these challenges requires concerted efforts and a multi-stakeholder approach involving governments, educational institutions, civil society organizations, and international bodies. Integrating technological ethics into human rights education can also play a crucial role in addressing these challenges by equipping learners with the tools to navigate the ethical implications of emerging technologies, thereby reinforcing the relevance of human rights in today's digital age

Conceptual Framework

Human rights education is a progressive endeavour aimed at instilling an understanding of fundamental human rights principles and values, fostering reverence for the inherent worth of every individual, and enabling people to actively advocate for and protect human rights. This comprehensive approach transcends the mere dissemination of information by cultivating critical thinking, acquiring practical skills, and fostering viewpoints and behaviors that align with human rights principles. The framework is presented in Figure (a).

Principles of Human Right Education

Human rights education is guided by fundamental principles that prioritize a rights-based approach to education. These principles aim to advance understanding, respect, and the implementation of human rights values across educational systems. The following key principles underpin human rights education, particularly in the context of technological advancement (Figure b)

- **Universality and Inalienability:** Human rights education emphasizes that human rights apply to every individual, regardless of race, gender, nationality, or any other distinguishing characteristic. These rights are inherent and cannot be revoked or denied, even as technology evolves. (UDHR, Article 1; United Nations, 1948)
- **Equality and Non-Discrimination:** Human rights education promotes equality and non-discrimination, highlighting the need for technologies that are inclusive and accessible to all, challenging discriminatory practices in their design and application. (Convention on the Rights of the Child, Article 2)
- **Participation and Empowerment:** Human rights education encourages active participation and engagement in decision-making processes, both in educational settings and the broader society. It empowers individuals to exercise their rights, promote social justice, and advocate for ethical technological innovation. (UNESCO, 1974)
- **Interconnectedness and Inseparability:** Human rights education emphasizes the interconnectedness of rights, ensuring that technological advancements do not infringe upon or compromise other human rights. Education should address the full spectrum of human rights to promote a holistic understanding and implementation. (World Conference on Human Rights, 1993)
- **Active Learning & Critical Thinking:** Human rights education employs active learning methodologies to engage learners in critical thinking and reflection, particularly regarding the ethical implications of technology.

It promotes analysis of real-life human rights issues, fosters empathy, and develops skills for the peaceful resolution of conflicts. (UNESCO, 2017)

- **Respect for Diversity and Intercultural Dialogue:** Human rights education fosters respect for diversity and encourages intercultural dialogue, emphasizing the need for technology to respect cultural differences. It aims to develop an appreciation for different cultures, religions, languages, and perspectives, promoting tolerance, understanding, and the celebration of diversity. (Framework for Action on Education for Sustainable Development, UNESCO, 2014)
- **Social Responsibility & Global Citizenship:** Human rights education emphasizes social responsibility and global citizenship, encouraging individuals to recognize their role in creating a just and sustainable world. It advocates for the responsible use of technology to promote solidarity, active citizenship, and global engagement. (UNESCO, 2013)

These principles form the foundation for human rights education and guide its implementation in creating highly inclusive, equitable, and rights-respecting educational environments, particularly in an era of rapid technological change.

Importance of Integrating Human Rights Education across Educational Systems

Integrating human rights education across educational systems is of utmost importance, particularly in the context of technological advancements, for several reasons:

Respect for Human Dignity

Human rights education ensures that education itself respects and upholds the dignity of all individuals. It promotes a learning environment that is inclusive, non-discriminatory, and supportive of diversity, fostering a culture of respect for human dignity in the face of evolving technologies.

Empowerment of Individuals

Human rights education empowers individuals by equipping them with knowledge about their rights, enabling them to exercise agency, make informed choices, and advocate for themselves and others. It fosters critical thinking, empathy, and a sense of responsibility for promoting human rights, particularly in the ethical development and application of technology.

Promoting Social Justice and Equality

Integrating human rights education into educational systems helps to address systemic inequalities, discrimination, and social injustices. It equips learners with the tools to challenge oppressive structures and advocate for equal rights and opportunities for all, especially as technology reshapes societal norms.

Global Citizenship

Human rights education nurtures global citizenship by promoting understanding, empathy, and solidarity with individuals and communities beyond one's own national or cultural boundaries. It fosters a sense of shared responsibility for addressing global challenges, including those posed by emerging technologies, and promoting human rights worldwide.

Sustainable Development

Human rights Education shares a strong connection with the Sustainable Development Goals (SDGs) set forth by the United Nations. Integrating human rights principles into education contributes to achieving goals such as quality education, gender equality, peace and justice, and strong institutions, with an emphasis on the responsible use of technology in sustainable development. Integrating human rights education across educational systems is crucial for fostering a culture of respect, empathy, and active citizenship. It empowers individuals, promotes social justice, and nurtures a generation committed to upholding human rights and transforming societies toward a more inclusive, equitable, and technologically responsible future.

Empowering Individuals through Human Rights Education

Impact of Human Rights Education on Knowledge, Awareness, and Understanding

Human rights education plays a pivotal role in equipping individuals with the knowledge of human rights principles, techniques, and approaches. It raises awareness of their own rights and the rights of others, fostering a deeper appreciation of the universality and indivisibility of human rights (Freire & Macedo, 1987). Through human rights education, individuals gain a comprehensive understanding of the historical, social, cultural, and technological factors that influence human rights breaches, enabling them to recognize and address systemic injustices (Pashby, 2017). Empirical research has demonstrated the positive impact of human rights education on knowledge and awareness. For instance, a study conducted in South Africa found that participation in human rights education programs significantly enhanced students' understanding of human rights, including specific rights such as the right to education and the right to a clean environment (Smit & Rensburg, 2019). Similarly, Merryfield (2011)revealed that human rights education led to significant improvements in students' understanding of human rights concepts, including discrimination and social justice, especially in contexts involving technological advancements.

Development of Critical Thinking, Empathy, and Respect for Diversity

Human rights education fosters the development of critical thinking skills, enabling individuals to analyze complex social and technological issues from a human rights perspective. It encourages individuals to critically reflect on their own beliefs and biases, challenging stereotypes and prejudices (Tibbitts, 2002). By examining real-life instances of human rights violations, particularly those exacerbated by technology, and actively participating in discussions and debates, individuals gain a more profound understanding of the underlying causes and impacts of discrimination, injustice, and technological inequalities. Furthermore, human rights education promotes empathy and respect for diversity. By learning about the experiences of marginalized and oppressed groups, including those affected by technological disparities, individuals develop a sense of empathy and a greater appreciation for the rights and dignity of all people (Briggs, 2008). Human rights education encourages individuals to embrace diversity and challenge discriminatory practices and attitudes in their communities, institutions, and the development of technology (Lombardo, 2011). Research has shown that human rights education enhances critical thinking, empathy, and respect for diversity. A study conducted in the Netherlands revealed that students who participated in human rights education programs demonstrated higher levels of critical thinking and empathy compared to those who did not receive such education (Kwakman, 2018). Similarly,McDonald & O'Connor (2018)found that human rights education programs positively influenced students' attitudes toward diversity, respect for human rights, and their understanding of technology's role in either perpetuating or alleviating inequality.

Promotion of Active Citizenship and Social Engagement

Human rights education empowers individuals to become active citizens who are engaged in addressing social issues and promoting positive change, particularly in the context of technology-driven societies. It encourages individuals to participate in civic activities, advocate for human rights, and contribute to the development of just, inclusive, and technologically responsible societies (Andreotti, 2006). Through human rights education, individuals develop the skills and confidence to take action at the local, national, or international level to uphold human rights principles and challenge violations, including those related to digital rights and technological ethics (Osler & Starkey, 2006). Studies have highlighted the transformative impact of human rights education on active citizenship and social engagement. For example, research conducted in Canada demonstrated that human rights education programs enabled students to critically examine social issues, develop leadership skills, and engage in community-based initiatives to promote human rights, particularly in addressing the ethical challenges of new technologies (Ghosh & Abdi, 2013). Minkenberg (2015)found that human rights education contributed to young people's engagement in civil society organizations and activism, including those focused on technological justice.

Application of Human Rights in Everyday Life

Human rights education seeks to bridge the gap between theory and practice by enabling individuals to apply human rights principles in their everyday lives, including in their interactions with technology. It equips individuals with the knowledge and skills to identify human rights violations, assert their own rights, and support others in

exercising their rights, particularly in digital and technological contexts (Owens & Murphy, 2012). Human rights education emphasizes the importance of respect, tolerance, and non-violence in interpersonal relationships, workplaces, communities, and online environments (Fuentes, 2018). Research has shown that human rights education enhances the application of human rights in various contexts. A study carried out in Sweden discovered that human rights education played a significant role in fostering democratic values and attitudes among students, leading to a stronger dedication to human rights in both their personal and professional lives, including their approach to technology use and development (Rosenberg, 2019). A study by Jain (2017) demonstrated that human rights education positively impacted individuals' attitudes and behaviors concerning gender equality and women's rights, with an emphasis on the role of technology in either supporting or hindering these rights In summary, human rights education empowers individuals by enriching their knowledge, awareness, and understanding of human rights. It cultivates critical thinking abilities, empathy, and respect for diversity, promotes active citizenship and social involvement, and facilitates the application of human rights principles in everyday situations, including those involving technology. By embracing these empowering principles, human rights education aims to foster a fairer, more inclusive, and technologically responsible society.

Transforming Societies through Human Rights Education

The Role of Human Rights Education in Challenging Discriminatory Practices and Systems of Oppression

Human rights education plays a crucial role in challenging discriminatory practices and dismantling systems of oppression within societies, especially in a world increasingly shaped by technology. By promoting an understanding of equality, dignity, and non-discrimination, human rights education empowers individuals to challenge and confront prejudices, stereotypes, and discriminatory behaviors, both online and offline (Andreotti, 2006). It encourages critical reflection on the structural and systemic barriers—including those embedded in technological systems—that perpetuate discrimination and inequality, fostering a commitment to social justice and human rights. Human rights education provides individuals with the tools and knowledge necessary to advocate for the rights of marginalized and oppressed groups, particularly in contexts where technology may exacerbate existing inequalities. It equips individuals with the skills to identify, address, and prevent human rights violations, working towards the creation of inclusive and just societies (Mertens & Jorna, 2018). Through awareness-raising, education, and community mobilization, human rights education empowers individuals to challenge discriminatory practices and advocate for systemic change, including ethical considerations in the design and application of technology.

Fostering Inclusive and Democratic Learning Environments

Human rights education fosters inclusive and democratic learning environments that prioritize the principles of equality, participation, and respect for diversity, while integrating these principles into the realm of technological ethics. By embedding human rights education into educational systems, institutions can create spaces where all individuals feel valued, respected, and included, regardless of their background or access to technology (Osler & Starkey, 2010). Human rights education promotes dialogue, critical thinking, and active participation, encouraging students to engage in meaningful interactions and collaborative problem-solving, including in digital and technologically mediated environments. In inclusive and democratic learning environments, human rights education enables individuals from diverse backgrounds to learn from one another, challenge biases, and build empathy. It nurtures a sense of belonging and ownership, empowering individuals to become active contributors to their communities and agents of change (UNESCO, 2016). By providing students with opportunities to voice their perspectives, particularly in the context of technological development and use, human rights education strengthens democratic principles and cultivates a culture of open dialogue, tolerance, and understanding.

Creating a Culture of Human Rights and Social Cohesion

Research has demonstrated the positive impact of human rights education on developing a culture of human rights and social cohesion, including in technologically driven societies. For instance, a study found that human rights education programs contributed to reducing prejudice and enhancing intergroup understanding among students from different religious and ethnic backgrounds (Dillenbourg et al., 2019). A study showed that human rights education initiatives in schools enhanced students' sense of belonging, acceptance, and inclusivity, leading to

improved social cohesion (Navarro-Varas et al., 2020). Human rights education also plays a crucial role in addressing historical injustices and promoting reconciliation in post-conflict societies, as well as in addressing technological disparities that may contribute to new forms of injustice. By providing a platform for truth-telling, acknowledgment of past wrongs, and fostering empathy and understanding, it helps societies heal and move forward (Simic, 2014). For example, in South Africa, human rights education programs such as the Truth and Reconciliation Commission have been instrumental in promoting social cohesion and reconciliation in the aftermath of apartheid (Dugard, 2000). Furthermore, human rights education encourages individuals to actively engage in promoting human rights and social justice, including advocating for equitable access to technology and the ethical use of digital tools. It empowers individuals to confront institutional disparities, prejudice, and injustices using peaceful means (Friedman, 2018). By creating a sense of agency and a commitment to social change, human rights education develops a culture where individuals are driven to confront social challenges, including those related to technology, and contribute to building a more equal and inclusive society. In conclusion, human rights education is a significant instrument for developing a culture of human rights and social harmony, particularly in the context of a rapidly evolving technological landscape. It promotes values of equality, decency, and respect, enhances intergroup understanding and discussion, and contributes to correcting historical injustices and encouraging reconciliation. Human rights education provides individuals with the tools to actively engage in fostering a collective dedication to human rights, thereby establishing a framework for a society that upholds principles of justice, solidarity, and social cohesion, with a focus on ethical technological advancement.

Challenges and Opportunities in Human Rights Education

Challenges

Lack of Comprehensive Implementation

Despite global recognition of its importance, many countries struggle to fully integrate human rights education into their formal education systems. This limits opportunities for learners to engage deeply with human rights principles and leaves significant gaps in knowledge, particularly in areas such as digital rights and technological ethics (Amnesty International, 2016).

Inadequate Teacher Training

Teachers often lack the necessary training and resources to effectively incorporate human rights education into their teaching practices. This gap is particularly pronounced in areas related to the ethical use of technology, where educators may be unfamiliar with the rapidly changing landscape of digital rights and responsibilities (Office of the UN High Commissioner for Human Rights, 2012).

Cultural and Contextual Sensitivity

Balancing universal human rights concepts with cultural and local issues remains a significant challenge. Ensuring that human rights education remains relevant and accepted across diverse cultural contexts is crucial, especially as technology introduces new dimensions to cultural and societal interactions (UNESCO, 2019).

Lack of Evaluation and Monitoring

The absence of comprehensive evaluation and monitoring frameworks hinders the ability to assess the impact and effectiveness of human rights education programs. This is particularly challenging in the digital space, where the outcomes of educational interventions may be less tangible and harder to measure (Human Rights Education Associates, 2011).

Opportunities

Integrating Human Rights across the Curriculum

There is a significant opportunity to integrate human rights education into various subjects and disciplines, including science, technology, and digital literacy. By doing so, learners can explore human rights issues within diverse contexts, fostering a more holistic and interdisciplinary understanding of these principles (Amnesty International, 2016).

Technology and Digital Learning

The rapid advancement of technology provides unique opportunities for innovative approaches to human rights education. Digital platforms, online courses, interactive resources, and virtual simulations can make human rights education more accessible, engaging, and relevant, especially for younger generations who are digital natives (UNESCO, 2020).

Community Engagement and Participatory Approaches

Involving learners in decision-making and action-taking processes empowers them to become agents of change within their communities. Technology can facilitate this engagement by providing platforms for collaboration, advocacy, and civic participation, allowing learners to take an active role in promoting human rights locally and globally (UNESCO, 2019).

Partnership and Collaboration

Collaboration among various stakeholders—including educational institutions, civil society organizations, technology companies, and governments—can enhance the implementation of human rights education. By sharing expertise, resources, and best practices, these partnerships can strengthen the global impact of human rights education and ensure it remains relevant in a technologically advanced world (Amnesty International, 2016).

Empirical Evidence and Case Studies in Human Rights Education

Research Studies on the Impact of Human Rights Education on Individuals and Communities

Numerous research studies have explored the effects of human rights education on individuals and communities, providing empirical evidence of its effectiveness. These studies indicate that human rights education positively enhances knowledge, awareness, attitudes, and behaviors related to human rights issues, including those in the context of technological advancements. For instance, a study by Bringle and Hatcher (2012) examined the impact of human rights education on college students' attitudes and behaviors. The findings revealed that students who received human rights education demonstrated increased awareness of human rights issues and reported higher levels of engagement in activities promoting human rights, particularly in digital and technological contexts. In a meta-analysis conducted by Juvonen et al. (2020), the impact of human rights education on students' knowledge, attitudes, and skills was investigated. The findings showed that interventions in human rights education significantly enhanced students' knowledge and understanding of human rights, promoted greater empathy towards marginalized groups, and nurtured a stronger dedication to social justice, especially in relation to emerging technologies and digital rights.

Successful Examples of Integrating Human Rights Education in Educational Institutions

Several educational institutions have successfully integrated human rights education into their curricula, offering valuable insights into effective implementation strategies. These examples highlight the transformative potential of human rights education in fostering a culture of rights, social responsibility, and ethical technological engagement.

One such example is the Raoul Wallenberg Comprehensive High School in Sweden. This school has embedded human rights education across all subjects, incorporating human rights themes into the curriculum, classroom activities, and school policies. This approach has led to improved student engagement, critical thinking skills, and a school culture rooted in respect for human rights, including an understanding of the ethical implications of technology (Nygren, 2018). Another successful case is the Human Rights Friendly Schools project in South Africa. This initiative supports the integration of fundamental rights education through teacher training, curriculum development, and the establishment of democratic and inclusive learning environments. The project has been associated with increased student participation, improved school atmosphere, and enhanced knowledge and comprehension of human rights principles, including those related to technological access and equity (Human Rights Friendly Schools, n.d.).

Lessons Learned and Key Findings from Empirical Research and Case Studies

Empirical research and case studies in human rights education have provided valuable lessons and key findings for effective implementation, particularly in the context of technology. Firstly, it is essential to adopt a learner-centered approach that encourages active engagement and participatory learning. Empirical evidence consistently highlights the positive impact of interactive and experiential teaching methods in enhancing knowledge, attitudes, and skills related to human rights, including digital rights and technological ethics (Freire, 2018). Furthermore, the integration of human rights education across different subjects and grade levels facilitates a comprehensive understanding of human rights and their applicability in diverse contexts, including technological ones. By incorporating human rights themes into various disciplines, students gain a multidimensional understanding of human rights and recognize their interrelationships with various facets of life, including technology (Bourn, 2020). Moreover, establishing partnerships and fostering collaborations among educational institutions, civil society organizations, and government entities is crucial for the sustained integration of human rights education. These collaborative efforts enable the sharing of resources, capacity-building, and the exchange of successful approaches, thereby bolstering the effectiveness of human rights education initiatives, particularly in adapting to technological challenges (UNESCO, 2017). Empirical evidence and case studies offer valuable perspectives on the influence of human rights education and effective implementation approaches. Research findings reveal the beneficial outcomes of human rights education on individuals and communities, while case studies present exemplary models of integrating human rights education within educational institutions. These studies provide important lessons learned and key insights that inform the design and implementation of impactful human rights education programs, with a focus on the ethical use of technology.

Recommendations for Policy and Practice in Human Rights Education

Policy Implications for Integrating Human Rights Education in Educational Systems

Integrating human rights education into educational systems requires supportive policies and frameworks that prioritize its inclusion. Policymakers play a crucial role in creating an enabling environment for the effective implementation of human rights education. One key policy recommendation is the development of national curricula that explicitly incorporate human rights education across all levels of education. This ensures a systematic and comprehensive approach to teaching human rights principles, values, and skills (Council of Europe, 2018). Policymakers should also allocate adequate resources for the development of relevant educational materials, teacher training programs, and evaluation mechanisms (Biswas, 2017). Additionally, policies should promote inclusive and participatory approaches to education, fostering a culture of respect for diversity, equality, and human rights within schools. This includes addressing discriminatory practices, promoting inclusive learning environments, and empowering students to participate in decision-making processes (UNESCO, 2015).

Strategies for Teacher Training and Professional Development in Human Rights Education

Teacher training and professional development are vital for developing the willingness of educators to effectively incorporate constitutional rights education throughout their teaching practice. Firstly, pre-service and in-service teacher training programs should incorporate comprehensive modules on human rights education, providing teachers with the necessary knowledge, skills, and pedagogical approaches. This training should focus not only on theoretical foundations but also on practical strategies for implementing human rights education in diverse classroom settings (OHCHR, 2012). Furthermore, professional development opportunities should be provided to educators on an ongoing basis. This can include workshops, seminars, and collaborative learning platforms that facilitate the exchange of best practices, resources, and experiences. Peer support networks and mentorship programs can also contribute to the professional growth of teachers in the field of human rights education (Bourn, 2020).

Collaborative Efforts and Partnerships to Advance Human Rights Education

Collaboration and partnerships among various stakeholders are crucial for advancing human rights education and creating a sustainable impact. Firstly, a collaboration between educational institutions, civil society organizations, and government agencies is essential. These partnerships can facilitate the development of joint initiatives, resource-sharing, and the coordination of efforts to integrate human rights education into policies and programs (United

Nations, 2011). Additionally, collaboration with international organizations and networks can provide valuable support and expertise in advancing human rights education. These partnerships can contribute to the development of global standards, sharing of best practices, and advocacy for the importance of human rights education on the international stage (Council of Europe, 2010). Moreover, fostering collaboration at the local level, including community organizations, human rights advocates, and parents, can help create a supportive environment for human rights education. Engaging the wider community in dialogue, awareness-raising campaigns, and participatory activities can strengthen the impact of human rights education beyond the confines of the classroom (Biswas, 2017). Recommendations for policy and practice in human rights education include the development of supportive policies, comprehensive teacher training, and collaborative efforts among stakeholders. These recommendations emphasize the importance of integrating human rights education into national curricula, providing teachers with the necessary skills, and fostering partnerships to advance human rights education at all levels of society. Human rights education has emerged as an empowering tool that brings about transformative change, fostering a culture of respect for human rights and empowering individuals. This summary highlights the crucial discoveries and contributions in the field, emphasizing the importance of ongoing research, evaluation, and collective action.

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rights education into policies and programs, including those related to technology and digital rights (United Nations, 2011). Additionally, collaboration with international organizations and networks can provide valuable support and expertise in advancing human rights education. These partnerships can contribute to the development of global standards, sharing of best practices, and advocacy for the importance of human rights education on the international stage, especially in addressing the global challenges posed by technology (Council of Europe, 2010).

Moreover, fostering collaboration at the local level, including community organizations, human rights advocates, and parents, can help create a supportive environment for human rights education. Engaging the wider community in dialogue, awareness-raising campaigns, and participatory activities can strengthen the impact of human rights education beyond the confines of the classroom, particularly in promoting ethical technology use and digital citizenship (Biswas, 2017).

Importance of Ongoing Research and Evaluation in Human Rights Education

Ongoing research and evaluation efforts are crucial for understanding the impact and effectiveness of human rights education initiatives, especially in the rapidly evolving technological landscape. Through rigorous investigations and assessment mechanisms, scholars and practitioners have provided valuable insights into the outcomes, methodologies, and recommended approaches of human rights education. Research has established that human rights education positively improves knowledge, understanding, attitudes, and behaviors related to human rights concerns. It develops critical thinking abilities, empathy, respect for diversity, and active citizenship among learners, with significant implications for digital literacy and ethical technology use. Successful case studies have demonstrated strategies for integrating human rights education in educational institutions, highlighting the transformative potential of such programs in both traditional and digital environments. Ongoing research and evaluation contribute to improving and refining human rights education practices. They identify effective teaching methods, curriculum design, and assessment approaches, paving the way for evidence-based pedagogical strategies that address the challenges of integrating technology and human rights. Evaluation frameworks enable practitioners to assess intervention impacts, identify areas for improvement, and ensure accountability and quality assurance, particularly in digital learning contexts.

Call to Action for Promoting Human Rights Education as a Transformative Tool

The findings and contributions in human rights education necessitate collective action to promote its integration and advancement as a transformative tool, especially in the context of technological change. Firstly, policymakers should prioritize human rights education in national agendas, curriculum frameworks, and educational policies. Recognizing human rights education as a fundamental aspect of quality education is essential, ensuring its inclusion and integration at all educational levels, with a focus on digital rights and technological ethics. Adequate resources should be allocated to support the development of human rights education materials, teacher training programs, and monitoring mechanisms that address both traditional and digital learning environments. Secondly, educators and teacher training institutions play a critical role in promoting human rights education. They should actively engage in professional development opportunities, ensuring their competencies in delivering human rights education, particularly in relation to technology. This includes incorporating human rights principles and values into teaching practices, creating inclusive learning environments, and adopting participatory and experiential teaching methods that integrate digital literacy. Furthermore, coordination among stakeholders is vital for advancing human rights education. Partnerships between educational institutions, civil society organizations, governments, and international organizations can enhance knowledge sharing, capacity-building, and advocacy for the importance of human rights education, particularly in the face of technological challenges. Through joint actions, stakeholders can magnify their impact, promote systemic change, and create a broader influence in promoting human rights in both physical and digital spaces. In conclusion, the significance of continuous research, evaluation, and collaborative action in human rights education cannot be overstated. Continuous research enhances our understanding of its impact, while evaluation ensures ongoing development and adaptation to new challenges, particularly those posed by technology. Policymakers, educators, and stakeholders are urged to prioritize, integrate, and promote human rights education as a transformative instrument. By doing so, we can empower individuals, reform societies, and build a culture of respect for human rights, both in the physical world and in the digital age.

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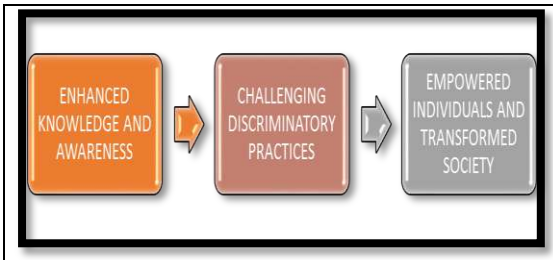


Figure 1:(a) Empowering individual and transforming society with Human Rights Education



Figure 1 b: Key Principles of Human Rights Education

RESEARCH ARTICLE

Watershed Cerebral Infarct Specific Physiotherapy Intervention – A Case Report

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ABSTRACT

Watershed cerebral infarct is a rare type of ischemic stroke involving the border zones of brain which could be cortical/external infarct or subcortical/internal infarct. Internal watershed cerebral infarct has a poor prognosis clinically. Specific physiotherapy intervention with action observation priming and task oriented approach have shown better recovery in rehabilitation of stroke patients. This case report analyzes the effect of specific physiotherapy intervention with action observation priming and task oriented training following internal watershed cerebral infarct.

Keywords: watershed cerebral infarct, physiotherapy, task oriented training, action observation priming.

INTRODUCTION

Watershed cerebral infarct is an ischemic stroke that occurs in the brain tissues bordering two main arteries such as the anterior cerebral artery (ACA) and the middle cerebral artery (MCA) or MCA and posterior cerebral artery (PCA). These areas are known as border zones and are located far away from the main arteries in brain [1]. It accounts for approximately 5-10% all the cerebral infarctions which occurs mainly in the elderly age groups [2]. Two types of watershed/ border zone infarct have been identified - external (cortical) & internal (subcortical) where external infarct is caused by embolism and internal border zone infarct is caused by hypoperfusion in presence of severe arterial stenosis or occlusion leading to an increased susceptibility to ischemia.[3,4].The typical clinical presentation is progressive, fluctuating or episodic decrease of motor control of upper limb and lower limb, motor aphasia associated with focal seizures which is more frequent in cortical watershed infarct than sub cortical infarct

[5,6]. Bilateral border zone infarctions between the ACA/ MCA territories can produce predominantly proximal muscle weakness in the upper limb ("man in the barrel" syndrome), which is caused by bilateral symmetric damage isolated to the upper extremity motor fibers in the motor cortex, corona radiata, internal capsule, and basal ganglia [7]. Although the symptoms are similar to that of other ischemic stroke, it is very challenging to diagnose watershed infarcts as they develop slowly with milder symptoms over a period and are probably underestimated. Prognosis of the watershed stroke is rarely fatal but can cause severe disability and literature has shown poor prognosis for the internal watershed infarct clinically, at 3months [8,9]. Motor recovery following stroke is enhanced by various therapeutic interventions but specific physiotherapy intervention strategies such as task oriented approaches bring about better motor recovery following stroke at individual territories [10,11]. This case report analyses the effect of specific physiotherapy with Action Observation Priming (AOP) and Task-Oriented Training(TOT) intervention following MCA-ACA internal watershed cerebral infarct.

CASE REPORT

A 71 years old female, with right hand dominance was admitted in Neuro-ICU, Sri Ramachandra Hospital, Chennai. She had presented with the complaints of difficulty in using right upper and lower limb and difficulty in speaking and difficulty in performing activities of daily living. The subjective history of patient from the family members showed that patient was apparently normal till the day of stroke. On the day of stroke occurrence, when her daughter woke her up, she did not respond for a while after which blood pressure reading was taken using a home kit and found to have decrease in BP. Her daughter observed difficulty in changing her position in lying involving her right upper and lower limb. Immediately she was taken to a nearby hospital and admitted in emergency department. CT/MRI brain was taken to confirm the diagnosis and emergency medications were given. After getting the suggestion of consultant physician, she was brought to Sri Ramachandra Hospital, Chennai for further treatment. She had a past medical history of systemic hypertension with irregular medication and recently she was diagnosed as type 2 diabetes mellitus. As soon as she was stabilized with medications and found clinically normal, she was shifted to Sri Ramachandra Rehabilitation centre for further rehabilitation.

CLINICAL FINDINGS

On observation, right shoulder was adducted, internally rotated, elbow extended and wrist and hand was in neutral position; right hip adducted, knee extended and ankle was in plantar flexion in lying position. On palpation, muscle consistency was firm with no gross abnormalities. On examination of higher mental functions, the patient was alert, comprehending, oriented to time, place and person, level of attention and memory was good but showed motor aphasia. Motor examination components of Tendon jerks, muscle tone using Modified Ashworth Scale and Stage of voluntary control were assessed on the first day and findings are mentioned in the Table 1,2 and 5 respectively.

In the first week of admission into the rehabilitation centre, postural control in sitting was poor and was able to assume only chair-sitting posture. Transition of positions from lying to sitting and standing was done with maximal assistance. Walking ability was poor. Her upper limb motor control and hand functions were poor. Outcome measures like Motor Assessment Scale, Brunnstrom stages of recovery were evaluated pre and post -intervention as shown in Table 4 & 5

CLINICAL INVESTIGATIONS

MRI-brain revealed multiple acute infarcts in left parasagittal frontal, parietal, temporal and occipital lobes suggestive of left internal watershed cerebral infarct of ACA/MCA territory. CT-angiogram showed complete non-opacification of left internal carotid artery from origin to the petro-cavernous segment suggestive of occlusion with delayed opacification in the cavernous supra clinoid segment and middle cerebral artery from the Circle of Willis.

PHYSIOTHERAPY INTERVENTION

The specific intervention protocol was designed according to the patient's needs and limitations. It included conventional physiotherapy exercise along with AOP and TOT. AOP was added prior to TOT in order to have better understanding of the movement to be performed and to enhance the motor performance. AOP was delivered as live demonstration of functional task to be trained in front of the patient by the therapist. Only one task per day was

practiced with sufficient number of repetitions of AOP by the therapist. Each session lasted for about 50 minutes including the 20 minutes of conventional physiotherapy. Task was observed for two minutes in the observation phase of live demonstration by the therapist, followed by three minutes of action phase where the patients imitates and tries to execute the task with her paretic limb. This sequence was repeated for three times followed by rest and repetition of the entire sequence again. Motor learning was enhanced by verbal feedback given appropriately to maximize the performance. Complexity of the task increased as the patient improved and the same protocol was continued for 8 weeks. The tasks provided in various positions during the interventions are described in Table 3

RESULTS

Motor Assessment Scale (MAS) showed significant improvement in the gross motor activities and recovery in affected upper limb and lower limb after eight weeks of intervention. Pre and post intervention scores of MAS showed a change of 20 point difference. Brunnstrom recovery stages of arm, hand and leg showed significant improvement as shown in Table4 and 5

DISCUSSIONS

Watershed cerebral infarct is one of the ischemic type of stroke affecting the border zones of the tissues supplied by the anterior, middle and posterior cerebral arteries [12] The causes of watershed infarct might be an embolic or due to hypoperfusion and studies show that age group, impaired cardiac wall contractility, presence of cardiac thrombus and ulcerative cardiac plaque could determine the cause and type of watershed cerebral infarct [13]. Studies reveal that prognosis of internal watershed infarcts are poor than the external watershed infarcts at 3 months of duration [14]. AOP and TOT intervention enhances neuroplasticity by promoting activation of damaged motor circuits and creating new areas of cortical control and thereby improving motor learning process and performance of activities [15,16]. In addition, AOT provides a standard method of performing the task which acts as reference preventing compensation and demanding the use of maximal motor control with adequate visual feedback. Prognosis of our patient with internal watershed cerebral infarct of left (MCA-ACA) territory with right side involvement was fairly good at eight weeks with voluntary movements on Brunnstrom staging showing isolated movement patterns in upper limb, lower limb and hand. Motor assessment scale showed considerable change in performance of activities which could be attributed to improved motor learning with AOP and TOT approach. Though the activities of daily living were not measured quantitatively, patient was able to transform slowly from complete dependency to partially independent level.

CONCLUSION

We conclude that providing the specific intervention of AOP and TOT improves motor recovery of affected limbs by the enhancing motor control and motor relearning process which could absolutely result in increased functional performance. In this internal border zone case analysis, the outcomes became favourable after eight weeks of physiotherapy interventions which encourages to plan and incorporate AOP and TOT strategies for appropriate patients.

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CONFLICTS OF INTEREST

None declared

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Table 1: Deep Tendon Refexes

DEEP TENDON REFLEXES	RIGHT	LEFT
BICEPS	Brisk	Normal
TRICEPS	Brisk	Normal
BRACHIORADIALIS	Brisk	Normal
KNEE	Exaggerated	Normal
ANKLE	Brisk	Normal

Table 2: Muscle Tone - Modified Ashworth Scale

MUSCLE TONE	RIGHT	LEFT
Shoulder flexors	1+	Normal
Elbow flexors	1+	Normal
Wrist and finger flexors	1	Normal
Hip flexors	1+	Normal
Knee flexors	1+	Normal
Ankle plantar flexors	1	Normal

Table 3: Physiotherapy Intervention

	TASKS TO BE PERFORMED
Upper limb	• Wiping the table with an extended elbow using towel • Turning a page • Stacking cups one over the other • Grasping & releasing a tennis ball • Unscrewing a lid of bottle • Holding and bringing the glass to the mouth • Eating with spoon
Lower limb	Sitting - ball kicking using paretic lower limb Standing - inside the parallel bar then placing the foot on the ball and down. - kicking the ball using her paretic lower limb - Placing the foot in forward, backward and Sideways Walking - Over the foot marks labelled on the ground - On various surface levels - Obstacle crossing - Gait training using cones and ladder - Stair climbing upwards and downwards

	
Figure:1 Kicking the ball	**Figure:2 Wiping the Table using Towel**

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RESEARCH ARTICLE

In vitro and *In silico* Study of the Plant Extract of *Sauropus androgynous* with the Evaluation of It's Antibacterial and Antioxidant Properties

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ABSTRACT

This study's objective was to use a disc diffusion assay to ascertain the in vitro antibacterial activity of the chloroform extract of Sauropus androgynous leaves against various harmful bacterial strains. Comparing the zone of inhibition created by plant chloroform extracts to standard antibiotic discs revealed marginally significant antibacterial activity. MIC has also been assessed. Additionally, the total phenol content has been quantitatively estimated using the Folin-Ciocalteu method, which employed gallic acid as the reference. The peroxide approach has also been used for antioxidant research. The formulation of herbal extract gel took into account its physicochemical properties. Biovia Discovery Studio was used to investigate the reported phytochemicals' molecular docking with the enzyme. With the aid of the HDOCK server, the interaction's strength was assessed. After the docking process, the lowest score values and most significant confidence values demonstrated a good ligand receptor binding process.

Keywords: In-silico study, HDOCK, Phenolic content, Folin- Ciocalteu method, *Sauropus androgynous.*

INTRODUCTION

Indian traditional medicine is renowned for its long history of employing therapeutic herbs. A number of ethnomedicines have been discovered as a result of years of research into good health, long life, and relief from pain and discomfort. Various medical systems, including Ayurveda, Unani, Allopathy, and Homoeopathy, use plants as remedies [1,2]. Numerous novel therapeutically effective medications, such as anticancer medications or antimicrobials, have been developed from these medicinal plants [3-6]. Compared to current chemotherapeutic methods, the use of plants for healing and as a source of antimicrobials has many advantages [6, 7]. According to studies [8–11], a variety of medicinal plants are an excellent source of bioactive substances like peptides, glycosides, alkaloids, saponins, terpenoids, flavonoids, and phenols, the majority of which have antibacterial activity. The hunt for novel medicinal/bioactive molecules, particularly from plants, has been sparked by the antibiotic resistance of infections and the severe side effects of antibiotic use [12]. Biofilm development is one of the pathways that can lead to antimicrobial resistance. The antibiofilm activity of numerous plant-based compounds has been investigated, and the alternative usage of natural antibiofilm agents has grown in significance [13, 14].Plant extracts have been proven in studies to limit the growth of harmful bacteria or prevent the formation of biofilms [15, 16]. Due to their safety and lower toxicity, chemicals produced from plants have been discovered to have potential applications in medicines [14–17]. The multivitamin plant, Sauropus androgynous, is a good source of carotenoids, vitamins A, B, C, and K. Many conditions are widely treated with various portions of S. androgynous, including fever, diabetes, cancer, high cholesterol, allergies, UTIs, and earaches [18–20]. Since the diverse therapeutic characteristics of these plants may have an additive or synergistic effect on one another, extracts of them are frequently used to make raw medicines [12]. A review of the literature reveals that no studies about the antibiofilm activity of S. androgynous leaf extracts have been published to yet. In order to assess the phytochemical components, antioxidant and antibacterial capabilities of S. androgynous leaf extracts, the current study effort was created.

MATERIALS AND METHODS

Materials

Methanol (Merck, India), Ethanol (Lobachem, India), Chloroform (Lobachem, India) were used during the extraction process. Gallic Acid (Lobachem, India) and Folin- Ciocalteu Reagent (Lobachem, India) had been used for the phenolic content estimation of the extract and Hydrogen Peroxide (Merck, India) was used for the antioxidant study by peroxide method. Hydroxy Propyl Methyl Cellulose (Lobachem, India), Propylene Glycol (Lobachem, India), Propyl Paraben (Lobachem, India), Methyl Paraben (Lobachem, India) were used for the formulation of herbal extract. Chloroform extracts were tested against a panel of 4 pathogenic bacterial strains including Staphylococcus aureus MTCC 96, Bacillus subtilis MTCC 441, Escherichia coli MTCC 443 and Pseudomonas aerugenosa MTCC 424 were purchased from Institute of Microbial Technology, Sector 39, Chandigarh, India.

Collection and Extraction of plant material

The plant sample i.e. leaves was collected from an herbal garden situated on Shyamnagar, West Bengal and were air dried under shade at room temperature, ground with electric grinder into fine powder and stored in air tight container for further use. Powdered sample was mixed with methanol: water of 4:1 ratio (solvents) for extraction in 1:1 ratio. After that the material was filtered by using Whatman No.1 filter paper and the filtrate was mixed with (2-3) drops of 2M HCl and then mixed with the equal volume of chloroform as same as of filtrate. After the formation of bottom organic layer, it was taken and separated followed by evaporation of the solvent for obtaining the dried residue. The resulting chloroform extract solution was used for further antibacterial and antioxidant activity [21].

Phytochemical screening of Extract

Terpenoids Test: The Salkowski test determines the presence of triterpenoid by forming a reddish-brown colour at the interface when dry extract is combined with water and a few drops of concentrated H_2SO_4.

Alkaloids Test

A good outcome is indicated by the production of a reddish-brown precipitate after adding 1 ml of Dragandroff's reagent to 2 ml of the filtrate.

Wagner's test

When 2 ml of extract are combined with a few drops of Wagner's reagent, a reddish brown precipitate forms to indicate a successful reaction.

Hager's test

A positive result is shown by the production of a yellow-colour precipitate when 2 ml of extract is combined with a few drops of Hager's reagent.

Mayer's test

A positive result is confirmed if a creamy precipitate forms after mixing 2 ml of extract with a few drops of Mayer's reagent.

Glycosides Test

If the extract yields a positive result in either of the Fehling (Fehling test A and Fehling test B) solutions, glycosides are present.

Flavonoids Test

Ammonium test: Layer separation was possible when the extract filtrate was combined with a diluted (1 ml, 1% v/v) ammonia solution. A favourable outcome is indicated if the ammonia layer is yellow.

Alkaline test

A favourable outcome is indicated by the dark yellow substance that turns colourless when diluted hydrochloric acid is added to the extract (2 ml) after being treated with a few drops of a 20% (w/v) sodium hydroxide solution.

Steroids Test and Salkowski test

A positive result was achieved when 2 ml of extract, 2 ml of chloroform, and 2 ml of concentrated sulphuric acid were added. If the chloroform layer was red and the acid layer was yellow-green fluorescence, the test was successful. Ferric chloride test for phenols: If the extract was treated with 3–4 drops of a 10% (w/v) ferric chloride solution and the appearance of a black green colour was noted, phenolic compound was present [22].

Quantitative analysis of total Phenolic content

Quantitative analysis of total phenolic in extracts was determined with the Folin- Ciocalteu reagent. Standard used for the analysis was Gallic acid. Concentration of (10-50) mg/ml of gallic acid was prepared in methanol. Concentration of 1mg/ml of plant extract was prepared in methanol and from that 0.5ml of sample was introduced into test tubes and mixed with 2 ml of Folin- Ciocalteu reagent and 2ml of 10% of sodium carbonate solution. The tube was covered and allowed to stand for 30 min at room temperature before the absorbance was measured at 760 nm spectrometrically. The Folin- Ciocalteu reagent is sensitive to reducing compounds including polyphenols, thereby producing a blue colour upon reaction. This blue colour is measured spectrophotometrically. Accordingly, total phenolic content was determined [23].

Antioxidant activity of the plant extract

The ability of plant extracts to scavenge hydrogen peroxide can be estimated according to the peroxide method. A solution of hydrogen peroxide (40 mM) is prepared in phosphate buffer (50 mM pH 7.4). The absorbance of hydrogen peroxide is determined by absorption at 230 nm using a spectrophotometer. Extract (100µg/mL) in distilled water is added to hydrogen peroxide and absorbance at 230 nm is determined after 10 min against a blank solution

containing phosphate buffer without hydrogen peroxide. The percentage of hydrogen peroxide scavenging is calculated as follows:

% scavenged (H_2O_2) = ($A_0 - A_1$)/$A_0 \times 100$

Where $A_0$is the absorbance of the control and $A_1$the absorbance of the sample [24].

Antimicrobial assessment

Broth dilution method

The minimum inhibitory concentration (MIC) was determined using the broth dilution method as described by a specific method [25] Concentrations of extracts (1-9 mg mL-1) dilutions were prepared using tubes containing 9 ml of double strength broth. In all test tubes, test antimicrobial compound is added except uninoculated (negative control) and control (positive) tube. The positive control tube is to check for the suitability of the test microorganism and the viability of the inoculums. The final volume was adjusted in all tubes by using sterile water. The tubes were inoculated with the suspension of standardized inocula (0.5 McFarland standard) and incubated at 37°C for 24 h. MIC was recorded as the lowest concentration of extract showing no visible bacterial growth.

Disc diffusion method

The disc diffusion assay was used to screen for antibacterial activity as described by the scientists [26]. The standard inoculum was introduced onto the surface of the sterile agar plates and a sterile glass spreader was used for even distribution over the media. Blank sterile paper discs (6 mm) were placed on the inoculated Mueller-Hinton agar surface and impregnated with 50 µL of the different extracts. A concentration of 10 µg/disc of Streptomycin (Sigma Aldrich, India), was used as a standard. The procedure was repeated for all the selected bacterial species used. The plates were incubated at 37°C for 24 h. All tests were performed in triplicate and the antibacterial activity was expressed as the mean diameter of inhibition zones (mm) produced by the extracts.

***In-silico* study**

Molecular docking method has been used to identify the phytochemical from the plant extract that act as a ligand and form a strong covalent bond with the microbial protein to successfully inhibit the microbe. The discovery studio module of the biovia software is using for identify molecular interaction and perform molecular docking. In this process, first the pdb files for the phytochemicals (Kaempferol) found in the *Sauropus androgynous*plant were downloaded from the website drug bank .The protein DNA helicaseCrystal structure of the N-terminal domain of Staphylococcus aureus single-stranded DNA-binding protein forms complex with a small molecule inhibitor data base code (5XGT) was collected from RCSB protein data bank. Molecular docking was done using the HDock Server. The enzyme molecule was treated as the receptor molecule and the phytochemical was treated as the ligand. The high positive value of those indicators presented a good interaction between the ligand and the receptor. Thus, the interaction with high values might indicate the major phytochemical responsible for curing the disease. Kaempferol inhibit the activity of *S. aureus* by blocking the potential effect of DNA helicaseCrystal structure of the N-terminal domain of Staphylococcus aureus single-stranded DNA-binding protein[27].

Method of formulation of herbal extract gel

The required amount of gelling agent was accurately measured and dispersed in a small amount of water with continuous stirring to produce a uniform dispersion. Then the drug was dissolved in a suitable solvent here using propylene glycol and added to the above dispersion. Other substances such as methyl paraben and propyl paraben were also added with continuous stirring. The final weight of the gel formulation was adjusted to 10 g with distilled water. The gel was stored in container with wide mouth.

Evaluation of gel formulation

Physical Characterizations

The composition of gel using different gelling agents tested for colour, odour, homogeneity, in which the gels were placed in containers.

Measurement of Surface pH

The pH formation of gel was measured using a digital pH meter. 1 g of gel was dissolved in 25 ml of distilled water in a beaker. The electrode was then immersed in the beaker solution and allowed to simmer for 1 minute and further reading was observed.

Spreadability

Indicates the level of area where the gel spreads easily when applied to the affected skin. The therapeutic potential of the gel also depends on its spreading value. It is periodically displayed in seconds taken by two slides to move from the gel placed between the slides under the direction of a specific load (20 g).

The formula for calculating gel spreadability is: S = M * (L / T)

Where,

M = Weight tied to the top slide (20 g)

L = Length of the glass slide slipped

T = Time taken to split the slides.

Tube Extrudability

In this experiment was taken a closed folding tube containing the composition of the ciprofloxacin gel. The gel was pressed tight at the end and a clamp was placed at the end of the tube to prevent any loosening. A weight of 500 g was placed on tube and removed from the cap. The gel was pulled out.

The formula for calculating tube extrudability is: E = (M / A)

Where,

E = Tube extrudability

M = Weight applied on tube (500 g)

A = Extrude gel area [28].

RESULTS AND DISCUSSIONS

Phytochemical Screening

D= Dragandroff's reagent M= Mayer's reagent

H= Hager's reagent W= Wagner's reagent

(+) signify positive result

(-) signify negative result

The result showed that the chloroform extract has primarily flavonoids and phenolic part which is generally important for antibacterial and antioxidant activity. *Ocimum tenuiflorum* was used as positive control to find out the validity of the reagent used for phytochemical screening.

Quantitative estimation of phenolic content

The absorbance value of the plant material is 0.852

Now by plotting the value on the equation the conc. was found out to be is 77.45 ug/ml.

Antioxidant assessment

Percent Scavenged; % (H_2O_2) = [(A_0– A_1)/A_0× 100]

A_0 = absorbance of Control = 0.518

A_1 = the absorbance of plant sample = 0.36.

0.518-0.36/0.518=0.3050X100= 30.50%.

Antibacterial Assessment

Note: The control disc used for solvent had no zone of inhibition, so there data was omitted from the above data. Inhibition zones including the diameter of the paper disc (6 mm). Results are expressed as the mean ± SEM of triplicate measurements. The MIC of chloroform extract of *Sauropus androgynous*were 5 mg/ml and 4 mg/ml against S. aureus and E.coli. 6 mg/ml and 4 mg/ml against B. substilis and P. aerogenosa. The MIC determination was

performed in triplicate for each organism. The chloroform extract exhibited (Table 4) potent anti-bacterial activity against S. aureus (12.12 ± 0.43 mm), B. subtilis (11.15 ± 0.30 mm), E.coli (10.33 ± 0.36 mm) and P. aerugenosa (12.50 ± 0.33 mm). The same for the standard drug was found to be 9 ± 0.12 mm, 10 ± 0.13 mm, 10 ± 0.21 mm and 10 ± 0.23 mm against S. aureus, B. subtilis, E. coli and P. aerugenosa respectively. The chloroform extracts of *Sauropus androgynous*was produced antibacterial activity against all the tested organisms i.e. gram negative bacteria (E. coli and P. aerugenosa) and gram positive bacteria (S. aureus and B. subtilis).

In-silico Study

Binding site shows that the ligand molecule (golden yellow lines) bind with the THR93 and VAL 92 amino acid fragments of the 5XGT receptor surface.

Expected Confidence score- 0.5-0.7. Table 6: In silico assessment. These are docking score of 10 modules involving docking of ligand and receptor. Module 1 shows the least value so it could be judge as the best fit.

Evaluation of gel formulation

Physical characterizations

ACKNOWLEDGEMET

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CONCLUSION

The results of this study indicate that the chosen plant entity's chloroform extract has a considerable amount of antibacterial activity against two separate pathogenic species. Additionally, the plant extract exhibits spectrophotometrically determined antioxidant activity, which may result in the scavenging of free radical forms inside biological systems. It has been determined that the total phenolic content may affect the antioxidant and antibacterial properties. An investigation has been conducted for a particular pathogenic bacteria enzyme whose activity may be inhibited by known phytoconstituents that have antibacterial properties. Formulations for herbal extracts have been created after careful consideration of their physicochemical properties.

In the future, if the protein or enzyme structure of the pathogenic entity, responsible for the various types of diseases, is known, the herbal formulation can be tested for the antibacterial activity and further Insilico study can be done with different phytoconstituents responsible for the different activities.

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Table 1: Composition of Gel Formulation

INGREDIENTS	FORMULATION (g)
Plant extract (dry)	1
Hydroxy propyl methyl cellulose	1
Propylene glycol	2 ml
Methyl paraben	0.1
Propyl paraben	0.2
Distilled water	upto 10

Table 2: Phytochemical Screening

Plant Name	Terpenoids	Alkaloids				Glycoside	Flavonoids	Steroids	Phenolic content
		D	H	M	W				
Putranjiva roxburghii	-	+	-	-	-	-	+	-	+
Ocimum tenuiflorum	+	+	-	-	+	+	+	+	+

Table 3: Uv-Spectroscopic analysis of gallic acid

Conc. of gallic acid(ug/ml)	Observed Absorbance
10	0.077
20	0.186
30	0.271
40	0.430
50	0.611

Table 4: Assessment of Antibacterial activity of the plant extract

Microorganisms	Diameter of inhibition zone (mm)		MIC (mg/ml)
	Chloroform extract	Streptomycin	Chloroform extract
S. aureus	12.12 ± 0.43	9 ± 0.12	5
B. subtilis	11.15 ± 0.30	10 ± 0.13	6
E. coli	10.33 ± 0.36	10 ± 0.21	4
P. aerugenosa	12.50 ± 0.33	10 ± 0.23	4

Table 5: In silico study of the phytoconstituents

Plant name	Reported isolated compound (Ligand)	Activity	Microorganisms	Protein/Receptor name	Protein/Receptor specifications
Sauropus androgynous	Kaempferol (Flavonoids)	Antibacterial	*S. aureus*	DNA helicase	Crystal structure of the N-terminal domain of Staphylococcus aureus single-stranded DNA-binding protein (5XGT)

Table 6: In silico assessment

Summary of the Top 10 Models

Rank	1	2	3	4	5	6	7	8	9	10
Docking Score	-143.03	-140.89	-139.73	-138.41	-137.79	-137.57	-137.36	-137.01	-136.70	-136.40
Confidence Score	0.4652	0.4546	0.4488	0.4423	0.4393	0.4382	0.4371	0.4354	0.4339	0.4324
Ligand rmsd (Å)	50.17	49.16	45.01	40.82	51.30	34.43	51.04	56.33	43.11	49.22
Interface residues	model_1	model_2	model_3	model_4	model_5	model_6	model_7	model_8	model_9	model_10

Table 7: Physical Characterizations of Gel formulation: Physical characterizations

FORMULATION	COLOUR	ODOUR	HOMOGENECITY
F1	Yellowish white	Pleasant	Homogenous

Table 7: Surface pH of Gel formulation: Measurement of surface pH

FORMULATION	SURFACE pH
F1	**6.2**

Table 8: Spreadibility of Gel formulation: Spreadability

FORMULATION	SPREADIBILITY (g.cm/sec)
F1	12.5

Table 9: Tube Extrudability of Gel formulation: Tube extrudability

FORMULATION	TUBE EXTRUDABILITY (g/cm^2)
F1	78

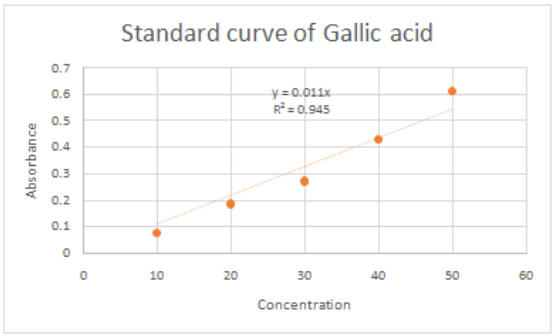


Fig 1: Standard curve of gallic acid



Fig 2: Standard drug on S. *aureus*



Fig 3: Standard drug on *P. aeruginosa*

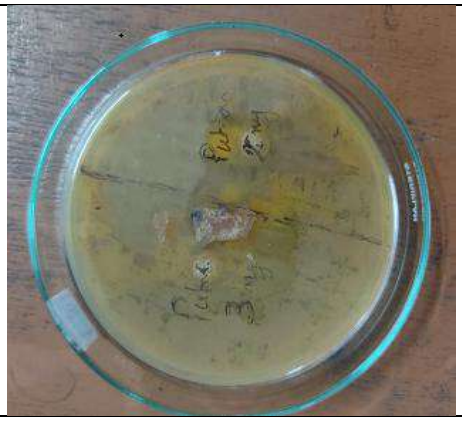


Fig 4: Plant extract on S. *aureus*

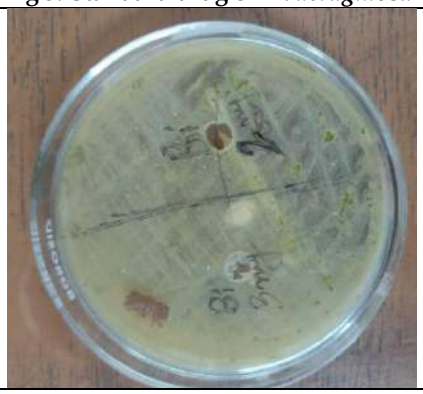


Fig 5: Plant extract on *P. aeruginosa*

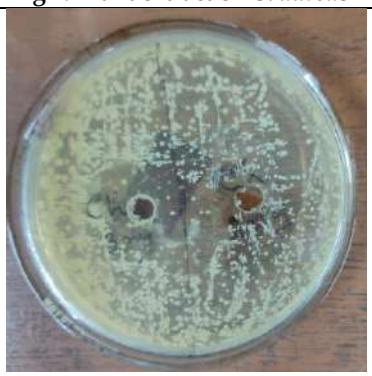


Fig 6: Standard drug on *B. subtilis*



Fig 7: Standard drug on *E.coli*



Fig 8: Plant extract on *B. subtilis*

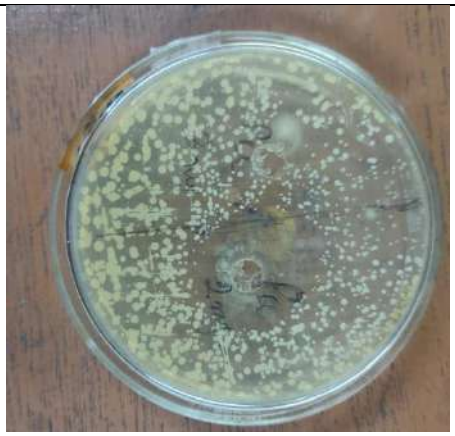


Fig 9: Plant extract on *E. coli*

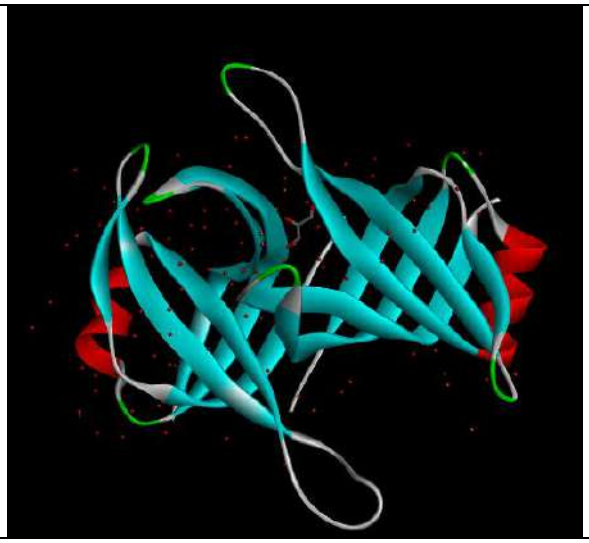


Fig 10: Protein structure of binding site of data base code (5XGT)

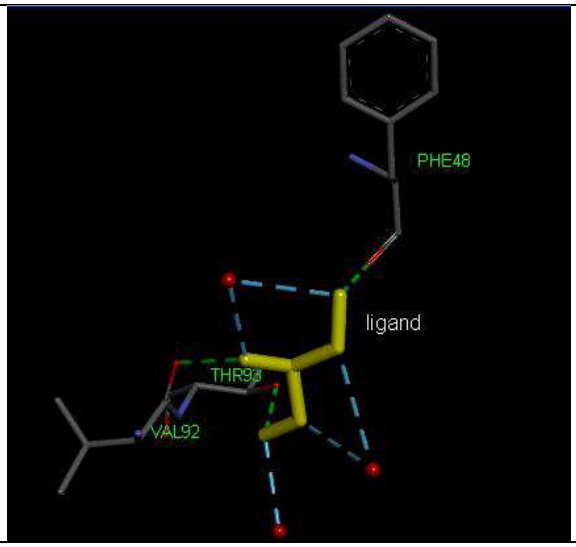


Fig 11: 3D Binding site of ligand in enzyme structure

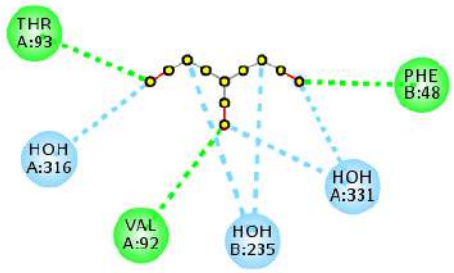


Fig 12: 2D Binding site of ligand in enzyme structure

RESEARCH ARTICLE

The Growing Scope of Telerehabilitation in Spinal Cord Injury: A Feasibility Trial

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ABSTRACT

SPINAL CORD INJURY (SCI) is a terrible and debilitating condition that affects all regions of the world. In India, around 1.5 million individuals live with SCI. In low- and middle-income countries patients who sustain spinal cord injuries are more likely to have major consequences after being discharged from the hospital. Telerehabilitation emerged as a means of addressing theunfilled requirements of persons with SCI.The study aimed to evaluate the effectiveness of telerehabilitation in spinal cord injury patients, to improve the functional status of a person, and to provide psychological support to the patient. A feasibility trial was conducted in the e-OPD of the College of Physiotherapy in PGIMS Rohtak. 480 patients were recruited from 2021-23. The discharged patients having spinal cord injuries who were admitted to the Paraplegic unit and other orthopedic units of PGIMS Rohtak were taken for the study. The patients were provided with telerehabilitation services at their convenient locations. The common age group of patients was 17- 40 years of age. 125, 143, and 178 SCI cases were recorded with telerehabilitation services for years 2021,2022 and 2023 respectively. SCI patients were either bedridden or wheelchair-bound or use assisted or orthosis-dependent ambulation. For those patients, telerehabilitation had opened the doors for hope and possibilities as a feasible intervention.

Keywords: Spinal cord injury, telerehabilitation services, Institution-based rehabilitation

INTRODUCTION

Most of the cases of spinal cord injury (SCI) can be divided into two types complete spinal cord injury and incomplete spinal cord injury Complete spinal cord causes permanent damage to the area of the spinal cord. Paraplegia or tetraplegia are result of complete spinal cord injury.[1]SCI is a severe disorder that impacts every part of the world.[2]Compared to their contemporaries without impairment, people with SCI are two to five times more likely to pass away too soon and have worse general health.3 An estimated 10.4 to 83 cases of SCI per million people worldwide are reported each year, with a majority of males.[4]In India, around 1.5 million individuals live with SCI. Every year, over 20,000 new cases of SCI are reported. Most of them are males between the ages of 16 and 30, indicating a greater occurrence among the young, energetic, and economic segment of society.[5] In low- and middle-income countries, patients who sustain spinal cord injuries are more likely to have major consequences after being discharged from the hospital. Common complications include pressure ulcers, respiratory and urinary tract infections, depression, fecal and urine incontinence, and autonomic dysreflexia. These consequences may be life-threatening.[6]Cardiovascular disease is one of the primary cause of early mortality in patients with spinal cord injuries. Exercise and physical activity may help persons with spinal cord injuries maintain or enhance their muscular strength and flexibility as well as decrease pain and the chance of developing cardiovascular disease[7].

Medical issues such as loss of mobility, autonomy, bowel and bladder function, and neuropathic pain, as well as social concerns such as strained spouse relationships and poor social adjustments all contributed to a reduced quality of life. To reduce the probability of poor QoL following SCI, these issues might be addressed by a more complete rehabilitation program[8]. Telerehabilitation emerged as a means of addressing the unfilled requirements of persons with SCI. Individuals with SCI have used telerehabilitation to obtain remote consultations, guidance with exercises and therapy, and even access educational materials suited to their requirements. When the COVID-19 pandemic was at its worst and in-person visits were restricted, the advantages of telerehabilitation for those with SCI became even more evident. Telerehabilitation provided ease and flexibility by eliminating the need for extensive travel and enabling patients to receive treatment from the comfort of their homes. Telerehabilitation also preserved patient and healthcare professional safety by reducing the risk of virus transmission.[9] The present study aims to evaluate the effectiveness of telerehabilitation in spinal cord injury patients, to improve the functional status of a person, to provide psychological support to the patient, and to provide time-to-time guidance for bed-related complications and management of pressure sores.

MATERIAL AND METHODS

A feasibility trial was conducted in the E-OPD of the College of Physiotherapy in PGIMS Rohtak. 480 patients were recruited from 2021-23. The discharged patients having spinal cord injuries who were admitted to the Paraplegic unit and other orthopedic units of PGIMS Rohtak were subjects of taken under the study. The patients were provided with telerehabilitation services at their convenient locations.The patient's and their caregiver’s burden was assessed by structured telephonically conversation every month. Patient chief complaints were discussed and were asked about regular inspection of skin. Individualized exercises suitable for people with SCI were filmed and shared individually with participants through WhatsApp and a general physiotherapy advice template was also shared along with patient education. For passive SCI patients’ education and exercise programs were made to understand their respective caregivers. Diaries were reviewed remotely by the physiotherapist who contacted patients by phone every 2 weeks. The progress was discussed and updates to exercise programs were made, as appropriate, by adding/removing exercises or changing the difficulty or number of repetitions/sets. A Type of a telephone conversation shared by patients is presented in Table 1.

RESULT

The common age group of patients was 17- 40 years of age. 125, 164, and 178 reported SCI cases were provided with telerehabilitation services for years 2021,2022 and 2023 respectively as shown in Figure 3. The patients were assessed twice weekly initially and then periodic sections every 2 months and then follow-ups after 6 months were conducted. After that ,the patients were allowed to contact as per their needs. The periodic telephonic conversations resulted in self-reported improvement in quality of life and enhanced confidence among patients. One of the such conversation was as follows:"

मुझेपीजीआईई –ओपीडीकेद्वाराआनेवालीकालसेकाफीफायदाहोरहाहैऔरमैंइससुविधासेकाफीजुड़ा हुआमहसूसकरताहूंमुझेअपनीसमस्या केसमाधानकेलिएपीजीआईआनानहींपड़ताजोकिइसमहामारीकेदौरमेंबहुतमुश्किलहै".

The patients have reported that these periodic calls have alleviated their sense of social isolation, improved satisfaction, and assisted them in remembering techniques for SCI management. These periodic calls not only help patients but also help the caregivers of SCI patients. Caregivers have a degree of perceived burden that is closely linked to the increased need for psychological support and lack of social conditioning and mental and physical health.

DISCUSSION

This study reveals that telerehabilitation is a feasible and effective approach for providing exercise to patients with SCI. The follow-up talk indicated that the videos were simple to use, engaging to watch, beneficial for health and well-being, and cost-effective for SCI patients during the COVID-19 pandemic. Telerehabilitation is an increasingly popular method of expanding access to care in low- and middle-income countries, particularly where care delivery is difficult or in remote geographical places. Telerehabilitation includes utilizing information and communication technology to offer rehabilitation services and patient education. People with SCI confront additional challenges than able-bodied people. During the pandemic, telerehabilitation began to thrive to properly provide health care. It served as a safe, viable, and cost-effective approach to treating individuals with spinal cord injury. The method is useful for providing care in low- and middle-income nations where healthcare delivery is difficult. The most commonly related conditions observed in SCI patients were bladder and bowel issues, pain spasticity, and pressure sore injuries. For pressure sore injuries and general mobility of bed-ridden patients, the transfer training included education and training was accompanied by videos. Straater et al. (2014) and Sechrist et al. (2018) also found that video telerehabilitation was an effective and convenient way to discuss bowel and bladder concerns, as well as alleviate pressure sores and chronic pain issues. Furthermore, video telerehabilitation demonstrated a potential benefit to caregivers of SCI patients throughout the transition from acute rehabilitation to home.[10,11] However, some of the major challenges faced while providing telerehabilitation services were a lack of acceptance and a skeptical approach.Similar concerns were described by Mandriola et al. in (2019), and Leochio et al. in (2020). Patients were concerned about sluggish internet speeds and other technological difficulties. [12,13,14] In our study, these difficulties were resolved via phone calls and text messages. Other challenges experienced were a lack of awareness for which patients and caregivers were first given counselling and assurance through long telephonic conversations and a lack of manpower to regulate technical issues and provide a wide network for telerehabilitation services. Taking into consideration, the effectiveness of telerehabilitation services, there are several ongoing efforts by the government to expand the use of telerehabilitation; still, there is a long way to go.

Limitations

The current study was only a feasibility trial so it is difficult to evaluate the true intervention effects and quantify the outcome measures.

Future research

The present study may be replicated using a controlled trial design. SCI-tailored and personalized programs with sufficient outcome measures evaluating quality of life and other parameters should be incorporated.

CONCLUSION

This was a feasibility trial conducted to report the benefits and challenges faced by physical therapists, patients, and caregivers as it is the first study to be conducted in the College of Physiotherapy, E-OPD PGIMS Rohtak regarding the effectiveness of telerehabilitation services provided to Spinal cord injury patients. SCI patients were either bedridden or wheelchair-bound or use assisted or orthosis-dependent ambulation. For those patients, telerehabilitation had opened the doors for hope and possibilities as a feasible intervention. However, it is recommended thatspecific interventions with proper follow-ups should be implemented bythe future potential researcher.

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Table 1: A structured telephonic conversation was made to assess the SCI patient

रोगी से संबंधित प्रश्न

पिछले महीने के दौरान

क्या आपको कठिनाई हुई है

- अपना ख्याल रखना जैसे खाना, ड्रेसिंग या स्नान करना हाँ नहीं
- बिस्तर से अंदर या बाहर जाना हाँ नहीं
- घर के अंदर चलना, जैसे कि आपके घर के आसपास हाँ नहीं

- **पिछले महीनों के दौरान**

- आप एक खुश व्यक्ति है हाँ नहीं
- क्या आप नर्वस व्यक्ति रहे हैं हाँ नहीं
- क्या आप खुद से घृणित करते हैं हाँ नहीं
- क्या आप डेप में इतना नीचे महसूस करते हैं कि कुछ भी आपको खुश नहीं कर सकता ह हाँ नहीं
- पिछले महीने के दौरान आप हाँ नहीं
- अपने आस-पास के लोगों से खुद को अलग कर लिया हाँ नहीं
- अन्य के प्रति स्नेह प्रभावित हाँ नहीं

पिछले महीनों के दौरान

- पिछले महीने के दौरान आप क्या आपको मल मूत्र विसर्जन के प्रबंध में सहायता की अवश्यकता पड़ी है हाँ नहीं
- क्या आप को अपने मल मूत्र विसर्जन पर पूरा कंट्रोल है हाँ नही

Caregiver के लिए सवाल

शारीरिक बोझ संबंधित सवाल

- क्या आपको पीठ में दर्द रहता है ? हाँ नहीं
- क्या आप बिमार महसूस करते हैं ? हाँ नहीं
- क्या आप काम और परिवार के प्रति जिम्मेदारी के बीच तनाव महसूस करते हैं ? हाँ नहीं
- क्या आप गोपनीयता की हानि और व्यक्तिगत समय की हानि महसूस करते हैं हाँ नहीं
- क्या रिश्ते की देखभाल की वजह से आपकी नींद खराब हो गई थी ? हाँ नहीं
- क्या मरीज की देखभाल की वजह से आपके सबंध दूसरे परिवार के लोगों , रिश्तेदारो और दोस्तो से प्रभाव हो रहे हैं ?
- क्या आपको लगता है कि आपका रिश्तेदार उसकी जरूरत से ज्यादा मदद मांगता है? हाँ नहीं
- क्या आपको लगता है कि आप अपने रिश्तेदार की लंबे समय तक देखभाल नहीं कर पाएंगे ? हाँ नहीं

आर्थिक बोझ से संबंधित प्रश्न

- क्या वर्तमान में आप कार्य है हाँ नहीं
- क्या आपने अपने रिश्तेदारो की स्थिति के कारण अपने काम के घंटे कम कर दिए हैं हाँ नहीं
- जब आप काम कर रहे थे तो आपके रिश्तेदारो की बीमारी या स्थिति ने आपके काम आपकी उत्पादकता को प्रभावित किया हाँ नहीं
- क्या आपने अपने रिश्तेदार की स्थिति के कारण काम करना बंद कर दिया
- क्या आपके पास अपनी जरूरतों की पूरा करने के लिए पर्याप्त पैसा है हाँ नहीं

Table 2 Typically presents an overview of general physiotherapy advice given to SCI patients.

General Physiotherapy Advice
• PROM or AROM exercises of upper limb and lower limb as per patient's condition
• Advice for maintaining proper bronchial hygiene
• Advice for bowel and bladder care
• Proper Positioning and Bed care
• Strengthening exercises if patient has weakness

- Psychologicalcounseling





Figures 1. Depicts photos sent by a caregiver for skin inspection









Figure 2: Illustrates the training for turning provided to caregiver through videos for bed ridden SCI patients.

Figure 3: Graphical representation of the SCI patients given Telerehabilitation showing increased services over the years.

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RESEARCH ARTICLE

Mathematical Fuzzy Modelling for the Secretion of Cortisol Due to Human Stress based on Symmetric Trapezoidal Fuzzy Numbers

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ABSTRACT

The aim of this work is to present a novel mathematical fuzzy model for the secretion of cortisol in response to human stress. The model is based on the use of closest symmetric trapezoidal fuzzy numbers. Frequency distribution is used to partition intervals of varying lengths. By converting trapezoidal fuzzy numbers into the closest symmetric trapezoidal fuzzy numbers, we provide a case study on classification with severely unbalanced data sets. Linguistic fuzzy rule-based systems have been shown to exhibit superior performance compared to other strategies in this scenario. The novelty of this work is to develop a mathematical fuzzy model to analyze cortisol secretion, resulting in human stress, using symmetric trapezoidal fuzzy numbers. And applied through a fuzzy rule-based system with unbalanced data sets to study the secretion of cortisol due to human stress on symmetric trapezoidal fuzzy numbers.

Keywords: Cortisol, Surgery, F-transform

2000 Mathematics Subject Classification: Primary 90B22 Secondary 90B05; 60K30

INTRODUCTION

Empirical evidence consistently demonstrates that fuzzy logic surpasses traditional mathematical and statistical modelling methods in several applications that include the representation of real-world data[2]. We are engaged in the examination of the Direct Set Assignment (DSA) extrapolative forecasting technique. The DSA technique is a non-linear extrapolative forecasting approach that was created using the Mamdani Development Framework. It is aimed to imitate the structure of a fuzzy logic control system [3] [4]. Research aimed at enhancing the precision of extrapolative techniques should prioritize the creation of statistically straightforward approaches that possess the quality of being resilient to the variations present in real-world data caused by both random and non-random occurrences.

Elective surgery is a significant cause of stress for the patient [11], [12]. Several endeavors have been undertaken to adequately prepare patients before to surgery in order to diminish stress and enhance the final result. Medical research has determined that our video preparation effectively reduces anxiety and stress, as evidenced by a decrease in systolic blood pressure during surgery and a decrease in cortisol excretion. Additionally, it has been found to reduce the need for pain medication after hip replacement» surgery. The assessment of preoperative locus of control yielded contrasting findings. A study by [10] highlighted that in the context of surgical intervention, the capacity to relinquish control may be more advantageous than a controlling approach. The F-transform of function f is a vector that consists of weighted local mean values of f as its components. The first stage in defining the F-transform of f: X →R involves choosing a fuzzy partition of the universal set X using a finite collection of fundamental functions.

$A_1(x) \geq 0, \ldots, A_n(x) \geq 0$ (1)

which are continuous and satisfy the condition $\sum_{i=1}^{n} A_i(x) = 1$.

METHODOLOGY

Fuzzy transform

Basic functions of respective fuzzy sets are often referred to as basic functions, or alternatively, granules, information chunks, etc. Their selection demonstrates the kind of ambiguity that is associated with the understanding of x. After selecting the fundamental operations, we proceed to define the F-transform of a continuous function f : X → R as a vector ($F_1, \ldots, F_n$), where

$F_i = (\int f(x).A_i(x)dx)/(\int A_i(x)dx)$. (2)

F-transform «satisfies the following properties:

(i) y= F_i minimizes $\int_a^b (f(x) - y)^2 A_i(x)dx$

(ii) for a twice continuously differentiable function f, $F_i = f(x_i) + O(h_i^2)$, where h_i is the length of the support of A_i.

The F-transform is used in applications as a skeletal representation. This model generates a compressed representation of an image when f is an image[7], extracts trend values when f is a time series [8], and produces a numeric model when f is utilized in numeric calculations such as integration or differentiation [9]. Once we have determined the components Fi of the F-transform, we may (roughly) restore the original function f as $\bar{f}$ (x) =

$\sum_{i=1}^{n} F_i A_i(x)$ (3)

The formula (3) is referred to as the F-transform inversion formula in reference [1]. The formula (3) denotes a continuous function that provides an approximation of f. Under certain acceptable assumptions, a series of functions denoted by (3) converges uniformly to» f.

EXAMPLE

A total of one hundred patients were included in the trial after the provision of written informed permission. The inclusion criteria for the study were individuals aged 18 years or older, diagnosed with osteoarthritis of the hip joint, and without a history of previous hip replacement surgery. Anxiety and pain levels were assessed daily for a period of 5 days, starting from the day before the surgery. Additionally, the use of painkillers and sedatives after the surgery was documented. Cortisol levels in urine were measured in 12-hour samples obtained throughout the night for 5 consecutive nights, starting from the night before the surgery. The preparation group consisted of 46 randomly assigned patients, whereas the control group consisted of 54 patients. Following the surgery, the average levels of state anxiety dropped in both groups. However, the preparation group maintained lower levels of anxiety throughout the four days after the procedure. The pain rating on the visual analog scales shown an increase from the preoperative day to the morning before to surgery, and then demonstrated a reduction on a daily basis after the operation.

Let us give an example of the F-transform of

$f_1(x) = \frac{2}{2+x}$ and $f_2(x) = \frac{2}{1+x}$ «with respect A_1, …, A_4. For simplicity, we assume that basic functions A_1, …, A_4 are of trapezoidal shape and constitute a uniform partition of [0,8]. Their analytical representation is as follows:

$$A_1(x) = \begin{cases} 0, otherwise \\ 1, x \in [1,2] \\ 3-x, x \in [2,3] \end{cases} \quad A_2(x) = \begin{cases} x-2, x \in [2,3] \\ 1, x \in [3,4] \\ 5-x, x \in [4,5] \\ 0, otherwise \end{cases} \tag{4}$$

$$A_3(x) = \begin{cases} x-4, x \in [4,5] \\ 1, x \in [5,6] \\ 7-x, x \in [6,7] \\ 0, otherwise \end{cases} \quad A_4(x) = \begin{cases} x-6, x \in [6,7] \\ 1, x \in [7,8] \\ 0, otherwise \end{cases}$$

Corresponding Fuzzy function for above figure 1.

The original motivation for F-transform came from fuzzy modeling. For example, in the situation corresponding to the inverse F-transform, we have n rules

If x is A_1 then y = F_1,

If x is A_n then y = F_n (5)

These rules are Takagi-Sugeno (TSK) rules with singleton (constant) right-hand sides. For TSK rules, the value corresponding to a given input x is $\bar{f}(x) = \sum_{i=1}^{n} F_i A_i(x) / \sum_{i=1}^{n} A_i(x)$. Since $\sum_{i=1}^{n} A_i(x) = 1$, we» get formula (3).

Figure2 provides a «graphical representation of the basic functions $A_1, \ldots, A_4$, of the function $f_1(x)$ and $f_2(x)$ of its F-transform components $F_1, \ldots, F_4$, and of the inverse F-transform. By (2) the values of the components F_1, … F_4 of the F-transform.

RESULTS AND DISCUSSION

The Known Probabilistic Interpretation of Fuzzy Modeling Leads to a Probabilistic Interpretation of F-Transform.

This work demonstrates that by modifying the probabilistic interpretation presented in reference [5], we are able to provide a justification for the formulae of F-transform without requiring any extra assumptions about the probability distributions. Mathematically, this adjustment involves using Bayes formulae and assuming prior distributions, which serve as a means to explain previous knowledge in statistics, rather of assuming the actual distributions. Therefore, we have a more inherent probabilistic explanation of the F-transform. More precisely

(i) The paper [5] demonstrates that there is a logical interpretation of the F-transform formulas that is based on probability and is reasonable.
(ii) However, this interpretation allows for the possibility that there are other equally reasonable assumptions about the probability distributions that can result in different formulas.
(iii) In our modified interpretation, we prove that the fundamental probabilistic framework definitively determines the F-transform formulas, without requiring any assumptions about the» probability distributions [6].

CONCLUSION

We provide a revision of a probabilistic interpretation outlined in reference [5]. In this alteration, the associated probabilistic model unequivocally yields the equations of the F-transform. An analogous alteration is delineated within a broader context of fuzzy modeling. The analysis revealed that the use of the videotape resulted in a reduction in worry and tension. This was determined by examining the levels of urine Cortisol excretion and the rise in intraoperative systolic blood pressure. These findings align well with the concepts of Fuzzy Transform and Fuzzy modeling.

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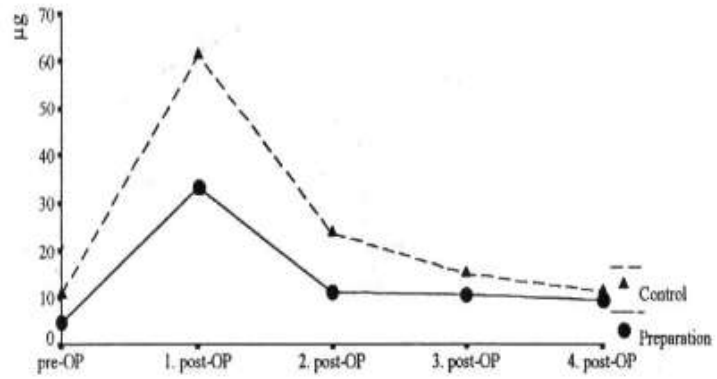


Figure 1 - Plots representing thepain rating on the visual analog scales

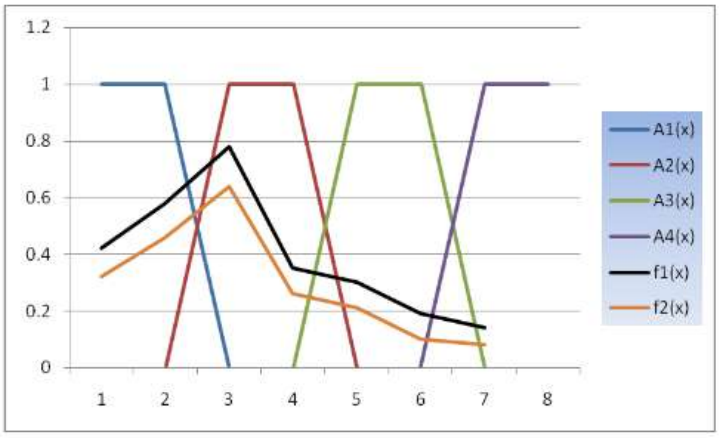


Figure 2 – Plots representing the graphical representation of F-transform

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RESEARCH ARTICLE

Trichoderma - its Role as Biocontrol and Growth Promotor Agent Incrop Production

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ABSTRACT

Despite the slow adoption of biopesticides compared to chemicals, with only 2% of biopesticides currently available, there has been success in commercializing products based on various species of *Trichoderma* in India. These potential *Trichoderma* isolates are formulated using a variety of organic and inorganic carriers through either solid or liquid fermentation technologies. They are applied through methods such as seed treatment, bio-priming, seedling dip, soil application, and foliar spray. Formulations of *Trichoderma* with mixed strains have shown better performance than individual strains in managing pests and diseases of crop plants, as well as promoting plant growth. However, the commercialization of these bioproducts is primarily hindered by their poor shelf life. Therefore, research should focus on increasing the shelf life of these formulations by developing superior strains that support increased shelf life, or by standardizing organic formulations that offer maximum shelf life with minimal contaminants. Despite the limitations of these *Trichoderma* products, they can be addressed by enhancing biocontrol through environmental manipulation, accurate strain identification using molecular approaches, use of beneficial organism mixtures, physiological and genetic enhancement of biocontrol mechanisms, and manipulation of formulations. Presently, formulations with nano compounds are being used to reduce the application of conventional pesticides and fertilizers. Among the most commonly used are nanoparticles (NPs) of copper, zinc, or silver, which are known for their cytotoxicity. Their accumulation can alter the dynamics of microbes present in the soil. In agriculture, *Trichoderma* is extensively used as a safe biocontrol strategy and to boost plant yield. This makes it likely to come into contact with nanomaterials that can affect its viability as well as its biocontrol and plant growth

promotion effects. This study summarizes the key findings regarding the interaction of Trichoderma and nanotechnology, including its use in synthesizing NPs and the potential impact of these compounds on this fungus and its associations.

Keywords: *Trichoderma*, Nanotechnology, Biopesticides, Organic, Inorganic.

INTRODUCTION

Traditional methods of managing plant diseases and improving yields, such as the use of chemical pesticides, herbicides, or fertilizers, are not environmentally friendly. These methods involve substances with various aromatic groups or methylated and ethylated compounds that have significant environmental impacts. Long-term use of chemical pesticides can contaminate water, pollute the atmosphere, and sometimes leave harmful residues that can lead to the development of resistant organisms. To address these issues, researchers are exploring alternative options, such as the use of biocontrol agents (BCAs) for disease control. These can be used either alone or in combination with other chemicals for eco-friendly and sustainable disease control methods. Currently, several BCAs have been identified and are available as bacterial agents, such as *Pseudomonas*, *Bacillus*, and *Agrobacterium*, and as fungal agents, such as *Aspergillus, Gliocladium, Trichoderma, Ampelomyces, Candida*, and *Coniothyrium.* The green revolution has led to intensified agriculture to meet the growing global demands for food and fiber. However, this has also damaged natural ecosystems by polluting groundwater and foodstuffs, and degrading the environment. Plant diseases are a major concern in global cultivation, resulting in the loss of billions of dollars of farm produce. There is an urgent need to manage diseases to ensure a steady and consistent supply of marketable produce for the growing world population. In disease management, the increased use of chemicals has negatively impacted environmental quality and led to the emergence of many organisms that are resistant to these chemicals.

Chemical pesticides, the most common means of shielding plants from diseases, have put tremendous strain on the agricultural environment in recent decades. Despite chemical plant protection products' high efficacy, questions remain regarding their safe usage, effects on the environment, and safety for humans and animals (Ghorbanpour*et al*., 2018). The result of the abuse of chemical pesticides is an increase in the resistance of pathogens to pesticides, and the contamination of soil and ground waters. Furthermore, pesticides have a detrimental effect on non-target organisms (e.g., beneficial insects, including pollinators), soil microbiomes, and the general condition of terrestrial and aquatic ecosystems (Tilman *et al*., 2002. Alizadeh *et al*., 2020). To protect the environment from the negative effects of chemical fungicides, various actions and strategies of sustainable food production systems are taken, including Integrated Pest Management (IPM) and organic farming (Rahman *et al*., 2018, Grasswitz 2019). Biological Control Agents (BCAs) are a tactic used to manage plant pathogen populations. These agents are derived from natural products and living microbes or their metabolites (Rahman *et al*., 2018, Thambugala*et al*., 2020). In an attempt to commercialise non-pathogenic bacteria and fungi as BCAs, the majority of research has been done over the last few decades to assess their viability and efficacy (Subedi*et al*., 2020, Niu*et al*., 2020). Many bacterial and fungal strains, such as *Pseudomonas* spp., *Bacillus* spp., *Streptomyces* spp., *Trichoderma* spp., *Glomus mosseae, Gliocladium virens, Pythium oligandrum,* and *Beauveria bassiana*, have been used as BCAs as a result of the conducted studies. These strains have been successful in controlling soil-borne diseases of valuable crops that are caused by fungi, oomycetes, bacteria, and nematodes (Savita 2019).

TRICHODERMA

Trichoderma, a genus of fungi that belongs to the Hypocreaceae family, is known to comprise over 100 species. Among the various species of Trichoderma, such as *T. viridae, T. haziarum, T. atroviridae*, and *T. asperellum,* only a few have been reported to be useful as biocontrol agents. Trichoderma is known to colonize the root surface or cortex and thrives best in the presence of abundant healthy roots. The fungus Trichoderma has a rich history, with its first report and description dating back to 1794. It was later suggested to be linked with the sexual state of a Hypocrea species.

However, morphologically assigning the genus Trichoderma/Hypocrea proved to be challenging. It was even proposed that Trichoderma viride was the only species in the genus. The first steps towards developing a specific protocol for species identification were taken in 1969. For the past 70 years, *Trichoderma* spp. have been recognized for their ability to produce antibiotics that inhibit the growth of pathogenic organisms, leading to their use as a biocontrol agent. Over time, many new species of Trichoderma were discovered, and by 2013, the genus already consisted of more than 200 phylogenetically defined species based on rpb2 sequence.

Characteristics

Trichoderma, a genus of fungi, is commonly found in various soil types, where it is often the most abundant type of fungus that can be cultured. Trichoderma species are frequently isolated from both forest and agricultural soils, as well as from wood. Some species have even been discovered growing on other fungi. The Trichoderma genus is known to encompass approximately 90 species. This fungus typically thrives in a temperature range of 25–30 °C and does not grow at higher temperatures. The most conducive culture media for its growth are cornmeal dextrose agar, where the colonies appear transparent, and potato dextrose agar, where the colonies appear white. Some species may secrete a yellow pigment into the agar and produce a distinctive sweet or coconut-like odor. Under a microscope, the conidiophores are seen to be highly branched, either loosely or compactly tufted, often forming distinct concentric rings or borne along sparse aerial hyphae. The typical Trichoderma conidiophore with paired branches takes on a pyramidal shape. Most strains of Trichoderma do not have a sexual stage and produce only asexual spores. Trichoderma species that reproduce sexually are known as teleomorphs, and they belong to the ascomycete genus Hypocrea. The development of fleshy stromata in light or dark brown, yellow, or orange hues is what distinguishes them. The bicellular ascospores are frequently green in colour. To far, descriptions of around 200 species of Hypocrea have been made.

Morphology

Trichoderma spp. exhibits rapid growth, maturing within 3–5 days. Initially, the colony appears as fluffy white tufts, which later transition to a greenish color due to conidia production. The presence of concentric rings on the agar plate characterizes it. The colony's reverse side is whitish yellow or light tan, sometimes shifting to yellow or pale orange. Morphologically, this genus features branched conidiophores with coiled, straight, or undulate apices, along with the presence of phialides (Bisset, 1991). To identify the bioagent, cultural and morphological characteristics are compared with those described by Rifai (1969) for *Trichoderma viride.* Factors considered include growth rate, colony appearance, surface color, colony reverse, texture, conidiation, conidiophore branching, shape, and size. These observations were made on potato dextrose agar (PDA). The pure culture of Trichoderma was obtained using the single spore technique. Microscopic examination of culture slides confirmed it as *Trichoderma asperellum*, as documented by the Indian Type Culture Collection (ITCC) at the Division of Plant Pathology, Indian Agricultural Research Institute, New Delhi, India.

Ecology

Trichoderma species are widely distributed and commonly inhabit soil. They play a crucial role in cellulose degradation. Our study focused on the impact of temperature on the linear hyphal growth of *T. viride* under in vitro conditions. Initially, fungal growth was robust within the temperature range of 25–30°C, but beyond that, growth declined. The maximum average dry weight was observed at 30°C. pH also significantly influences fungal growth. The highest dry weight occurred at pH 7, followed by pH 6.5. Conversely, the lowest dry weight was recorded at pH 8.5. Regarding radial hyphal growth, purified Trichoderma performed best on potato dextrose agar (PDA), followed by malt agar, rose Bengal agar, and Sabouraud's agar. However, growth on Czapek's dox medium was suboptimal. Notably, previous research by Pandey and Upadhyay (1997b) highlighted that potato dextrose agar medium, prepared from fresh potatoes, was ideal for radial growth and sporulation of *T. viride.*

Habitats and environmental condition

Trichoderma spp. are commonly found in various environments, including water, decaying wood, soil (especially around plant roots), and even non-natural materials like rubber foam or kerosene tanks. These fungi exhibit rapid growth and are prevalent in agricultural, prairie, forest, salt marsh, and desert soils across different climatic zones. While they are generally present in the litter of humid, mixed hardwood forests, they are more dominant in the H and F horizons. Trichoderma typically act as saprophytes, breaking down organic matter. However, they can also attack other fungi. Interestingly, their presence in soil emits a coconut-like odor, attributed to the volatile compound 6-pentyl-a-pyrone. Different species of Trichoderma thrive in specific temperature ranges: *T. viride* prefers cooler regions, while *Trichoderma harzianum* thrives in warmer climates. These preferences align with their optimal temperature requirements. Overall, *Trichoderma* spp. tend to be more abundant in acidic soils.

IDENTIFICATION OF *TRICHODERMASPP*

Morphological and cultural characteristic, and molecular identification of different species of *Trichoderma*, namely, *T. harzianum, T. asperellum, T. viride, T. atroviride, T. longibrachiatum, T. koningii,* and *T. virens* are described in the following section.

Morphological and cultural characteristic

Trichoderma harzianum

- Mycelium: Changes from watery white to light green in color. Reverse side of petri-plate shows uncolored ring-like zones.
- Colonies: Grow rapidly from 7 to 8 cm in diameter in 5 days, smooth surface, mycelial mat develop with white aerial hyphae.
- Conidiophores: Highly branched and forming loose tufts.
- Phialides: Short-skittle shaped, bulged at the middle, and narrower at the base, arise singly. Phialide size lies within a range of 7.2–11.2 × 2.5–3.1 μm.
- Phialospores: Sub globose or short ovoid often with truncate base, perfectly smooth walled, size ranging from 2.8–3.2 × 2.5–2.9 μm.
- Spore germination time: 12 h.

Trichoderma asperellum

- Mycelium: Forms a smooth hairy yellowish green cotton pattern usually in the form of 1–2 ringed Concentrics.
- Colonies: Changes cottony white to yellowish green and after 2 days from too deep chrysolite green, emitting coconut odor.
- Conidiophores: Arise highly branched in compact form and the phialides arise singly or in opposite pairs along the branches.
- Phialides: Appear in ninepin shape attenuated into long neck, usually 6.8–7.2 × 3.0–3.4 μm.
- Phialospores: Globose or short obovoid in shape, green colored with an approximate size of 3.6–4.0 × 3.4–4.0 μm.
- Spore germination time: 12–13 h.

Trichoderma viride

- Mycelium: Changes green to dark yellowish green after 2–3 days, no odor.
- 230 Microbiology for Sustainable Agriculture, Soil Health, and Environmental Protection
- Colonies: Smooth surface, cottony white mycelial mat with aerial hyphae.
- Conidiophores: Conidia production is less in center than toward the margins with green conidia distributed throughout.
- Phialides: Long, swollen in middle, like slender, and horn shaped with a size range of 6.2–10.5 × 3.1–3.9 μm.
- Phialospores: Usually globose or obovoid often, perfectly smooth walled, with a size ranging from 2.6–3.0 × 2.0–2.4 μm.
- Spore germination time: 13 h.

Trichodermaatroviride

- Mycelium: The mycelium mat appears watery white, submerged composed of translucent smooth and appear floccose on PDA.
- Colonies: The colony color changes after 2 days from yellowish green to artemisia green and reverse remaining dull yellowish and odorless.
- Conidiophores: Highly branched arise in compact form and the phialides solitary paired on the terminals, swollen at the middle and narrow at the tips.
- Phialides: Phialides appear in ampulliform and oblong shaped, curved, and constricted at the base, with a varying size of 5.2–10.5 × 2.4–2.8 μm.
- Phialospores: Globose in shape, green colored with an approximate size of 2.4–3.6 μm.
- Spore germination time: 12–13 h.

Trichodermalongibrachiatum

- Mycelium: Mostly submerged translucent or watery white.
- Colonies: Changes after 2 days from yellowish green to lily green, no smell. Smooth conidiophores arise from substratum and form irregular tufts or arise from aerial hyphae.
- Conidiophores: Smooth conidiophores arise from substratum and form irregular tufts or arise from aerial hyphae.
- Phialides: Arises singly or in verticils of 2–3, usually lageniform, slightly constricted at the base, usually 3.4–5.2 × 2.3–3.0 μm.
- Phialospores: Smooth walled, obovoid to ellipsoidal, dilute green, apex broadly rounded, with an approximate size of 2.4–3.6 μm.
- Spore germination time: 12–13 h.

Trichodermakoningii

- Mycelium: Creamy white charges from white to terreverte in color.
- Colonies: Crysty, compact, and glaucous like.
- Chlamydospores or conidiophores: Formed intercalary or terminally, much branched.
- Phialides: Narrow at the base, alternate to conical apices (Note: Most phialides of *T. koningii* arise singly and laterally and appears Nine-pin bowling shaped singly rather than pyramidal, size range of 3.8–7.6 × 2.5–3.2 μm).
- Phialospores: Ellipsoidal or oblonged, with a rounded apex and acute base, measuring 2.5–4.2 × 1.8–2.6 μm.
- Spore germination time: 14 h.

Trichodermavirens

- Mycelium: Changes watery white to nice green color with dull blackish green shades granules, no characteristic odor.
- Colonies: On potato dextrose agar medium, colonies grow rapidly from 7 to 8 cm in diameter in 5 days at 25°C temperature.
- Conidiophores: Branched irregularly near the apex with each branch terminated by a cluster of 3–6 closely bunched phialides.
- Phialides: Lageniform to ampulliform, swollen at the middle, attenuated to apex, broadly attached to the conidia in ranges between 4.4–12.8 × 2.6–4.2 μm of size.
- Phialospores: Broadly ellipsoidal to obovoid, both ends rounded dark green in color and with a size range of 3.2–5.6 × 2.5–3.9 μm.
- Spore germination time: 13 h.

ENZYMES

Trichoderma, a saprophyte, is adapted to flourish in various environments and produces a broad spectrum of enzymes. Strains that produce specific enzymes can be selected and cultured in suspension to produce these enzymes in industrial quantities. For instance, with their adaptable metabolisms, Trichoderma and the closely related *Gliocladium* spp. can break down a wide variety of plant biomass, including polysaccharides like cellulose, chitin,

inulin, laminaran, pectin, starch, and xylan, as well as oligosaccharides like melezitose, raffinose, and sucrose (Kubicek and Harman, 1998). Particular attention was given to *Trichoderma* spp. when it was discovered that strains isolated during World War II were especially effective in producing a complex of enzymes that attacked crystalline cellulose in very high yields. This realization largely came from the studies of E.T. Reese and M. Mandels at the US Army Laboratories (1939 to 1945), Natick, MA. A specific strain, Trichoderma sp. QM6a, later identified as *Trichoderma reesei* in honor of Elwyn Reese, produced up to 0.5% extracellular cellulase. In a bioenergy program, the production of ethanol was envisioned through the conversion of waste cellulosics, first to glucose, and then by fermentation by yeast. To facilitate the initial hydrolysis of cellulose, hyper cellulolytic mutants were created.

SECONDARY METABOLITES

Trichoderma is a genus that produces a wide variety of secondary metabolites; more than 100 have been identified. These consist of pyrones, terpenoids, polyketides, oxygen heterocyclic compounds, polypeptides, and derivatives of fatty and amino acids. *Trichoderma viride* and certain strains of *Trichoderma hamatum* produce the volatile 6-pentyl-a-pyrone, which is responsible for the coconut smell connected to soils. There are pigments of unknown function, including the anthroquinonespachybasin (1,8-dihydroxy-3-methyl-9,10-anthraquinone), chrysophanol (1,8-dihydroxy-3-methyl-9,10-anthroquinone), and emodin (1,6,8- trihydroxy-3-methyl-9,10-anthroquinone). Some secondary metabolites of Trichothecenes, cyclic peptides, and isocyanide-containing metabolites are the three categories of mycotoxin that the most well-known *Trichoderma* species belong to Trichoderma are hazardous to both plants and animals. Trichothecenes, such as trichodermin, are speculated to be produced in the soil and impair plant growth. Cyclic peptides, including Alamethicin, suzukacillin, trichotoxins, trichopolyns, and trichorianine are lipophilic substances that assault bacterial and eukaryotic cell membranes to induce lysis. Similar to trichoviridin, isocyanides are another family of poisonous metabolites that *T. hamatum* strains are known to produce in large quantities. This species has been linked to sheep's poor thrift by suppressing their cellulolytic rumen microorganisms. It is a prominent soil bacterium in some sheep pastures. Trichoderma products are used in the food business under strict monitoring because to their possible toxicity.

***TRICHODERMA* IN BIOCONTROL OF PLANT FUNGAL PATHOGENS**

Numerous strains of Trichoderma have been engineered as biocontrol agents to combat fungal diseases in plants. The mechanisms employed include antibiosis, parasitism, induction of host-plant resistance, and competition. These species work particularly well as biocontrol agents against soilborne root diseases as verticillium dahliae and Sclerotriasclerotiorum, wilts (Sclerotinia sclerotiorum), damping off (Pythium spp.), and cereal take-all (Gaeumannomycesgraminis), as well as leaf pathogens like gray mold (Botrytis spp.). High-performing biocontrol strains have been identified, and large-scale production of conidiospores and chlamydospores has been established. Specialized methods for delivering these spores are being actively developed. Strains of *T. harzianum, T. viride,* and *T. hamatum*, along with strains of the closely related *Gliocladium*, are particularly effective. Commercial biotechnological products, such as 3Tac, have been developed using *T. harzianum* and have proven useful in treating Botrytis, Fusarium, and Penicillium sp. (Yedidia*et al*., 1999). *T. viride*is another species that serves as an effective biological control agent against plant pathogenic fungi, offering protection against pathogens such as Rhizoctonia, Pythium, and Armillaria. In agriculture, *Trichoderma* species are powerful biocontrol agents and are frequently applied to soils to control soil-borne pathogens and enhance crop yields globally. Over 250 products based on Trichoderma are thought to be available in India (Mendoza-Mendoza *et al*., 2015). Additionally, *Trichoderma* species are easily included into agricultural methods due to their innate tolerance to a variety of pesticides and fungicides used in agriculture (Liu and Zhang, 2015; Ons *et al*., 2020). Numerous metabolites with antibacterial, antifungal, and anticancer activities are produced in large quantities by *Trichoderma* species (Khan *et al*., 2020). Recently, there has been increased awareness of the function of volatile compounds produced by rhizobacteria in controlling plant growth and development. According to Ryu *et al*. (2003), certain strains of plant growth-promoting rhizobacteria (PGPR) generated a mixture of volatile organic compounds (VOCs) that promoted the growth of Arabidopsis thaliana seedlings. Additionally, airborne compounds from specific strains of *Bacillius* sp. have been shown to have a growth-enhancing impact by Gutiérrez-Luna *et al*. (2010). Farag *et al*. (2013) found that during their in vitro evaluation of

rhizobacteria, bacterial volatile chemicals contribute to plant development. Numerous studies have examined the capacity of Trichoderma to regulate soil phytopathogens via a variety of intricate mechanisms, including mycoparasitism, competition for nutrients and space, pathogen cell wall disintegration, and induction of plant resistance. VOCs seem to be a good strategy. The majority of research has been on the effects of VOCs emitted by PGPR on the interactions between pathogens and plants. However, nothing is known about how PGPF that produces VOCs promotes plant growth and resilience (Tilocca*et al*., 2020).

TRICHODERMA AS BIOCONTROL AGENT FOR DIFFERENT CROP DISEASES

Cereal crops

Rice (Orya sativa L), the most extensively grown food crop worldwide, faces production challenges due to diseases of fungal, bacterial, and viral origins. Several species of Trichoderma, including *T. harzianum, T. viride, T. reesei, T. longibrachitum,* and *T. koningii*, have been evaluated by numerous researchers and found to be effective against these diseases when used in conjunction with chemical control. Sheath blight of rice, caused by *Rhizoctonia solani*, is a common and destructive disease in India. Wheat (Triticum spp. L.) is a globally significant cereal crop and a vital source of carbohydrates, proteins, vitamins, and minerals. Smut diseases are among the biotic constraints causing substantial yield loss and grain quality deterioration. The first report of biocontrol of a seed-borne disease, specifically loose smut of wheat, was demonstrated by Aggarwal *et al*. (1991), who used *T. viride* as a seed treatment. *Trichoderma* species such as *T. viride* (TV- 5), *T. koningii, T. hamatum, T. harzianum,* and *T. lignorum* were found to inhibit the germination of chlamydospores of the wheat pathogen *U. segetum var. tritici* (Mondal *et al*., 1995). Maize (Zea mays L.), another crucial cereal crop, is affected by soil-borne and foliar pathogens. Efforts have been made to use Trichoderma against significant diseases of maize. Research conducted by Sankar and Sharma (2001) clearly demonstrated the effectiveness of *T. viride* in both *in vitro* and *in vivo* conditions in suppressing the charcoal rot disease caused by *Macrophomiaphaseolina* and enhancing crop growth. A decade later, Khedekar *et al*. (2010) evaluated the efficacy of *T. harzianum* against leaf blight caused by *Helminthosposiumturcicum* and found comparable results.

Pulse crops

Chickpea (Cicer arietinum L.) is a highly consumed pulse in numerous regions globally, accounting for 50% of the major pulse production in India. It is frequently affected by wilt caused by *Fusarium oxysporum f. sp. ciceri*, stem rot by *Sclerotinia sclerotiorum,* and damping off caused by *R. solani,* which are distributed worldwide. Initial investigations into the utility of Trichoderma as a biocontrol agent were conducted by Kaur and Mukhopadhay (1992), who reported the successful combination of *T. harzianum* with fungicides like Vitavax 200 and Ziram in combating chickpea wilt. Sharma *et al*. (1999) identified *T. harzianum* and *Absidiacylindrospora*as the most effective in inhibiting the mycelial growth of *S. sclerotiorum*, which causes stem rot in chickpea. Prasad and Rangeshwaran (2000) discovered that a modified wheat bran-kaolin granular formulation of *T. harzianum* was effective against *R. solani* under field conditions. In a separate field experiment, two antagonistic fungi, *T. harzianum* (PDBCTH 10) and *T. viride* (PDBCTV), were reported to be effective against chickpea wilt and wet root rot by Prasad *et al*. (2002). Black gram (Vigna mungo L.) and green gram (Vigina radiata L.), important pulse crops, have been gaining global importance in recent years. Kehri and Chandra (1991) were the first to report the antagonism of *T. viride* to *M. phaseolina* and its use in controlling dry root-rot of mung bean under greenhouse conditions.

Oilseed crops

Brassica juncea (L.), also known as Indian mustard, is a significant oilseed crop in India. A number of studies have focused on eco-friendly methods to manage its major diseases using Trichoderma. One such in vitro study showed that *T. viride*, in combination with the fungicides mancozeb and carbendazim, was effective against the mycelial growth of Alternaria brassicae (Meena *et al*., 2004). Soybean (Glycine max L.), the third most important oilseed crop, has been the subject of numerous research efforts to develop integrated management strategies for root, seed, and foliar diseases. Singh and Thapliyal (1998) discovered that pre- and post-emergence seedling rot may be successfully controlled by treating seeds with Vitavax 200 combined with *T. harzianum* or *G. virens.* Using biocontrol agents

Gliocladium virens and *T. harzianum*, Pant and Mukhopadhyay (2001) reported successful management of the soybean seed and seedling rot complex induced by *R. solani* in an in vitro investigation. Because to the high incidence of illness, groundnut (*Arachis hypogaea L.*) yields are frequently decreased. A few diseases include early leaf spot (*Phaeoisriopisarichidicola*), late leaf spot (*Phaeoisriopispersonata*), rust (*Puccinia arichidis*), collar rot (*A. niger van tiegham*), and stem rot (*S. rolfsii*), despite the fact that over 55 pathogens have been identified to damage the crop, root rot (*M. phaseolina*) and alfalfa root (*Aspergillus flavus*) are considered economically important and have been biologically managed by deploying *Trichoderma* spp. Sesame (*Sesamum indicum*), one of the oldest oil-seed crops, has been investigated for the ability of gaseous metabolites from *N. sitophila* and *T. harzianum* to prevent the growth of a variety of fungus that cause sesame wilt. According to Tamimi and Hadvan (1985), age differences may have contributed to the variations in inhibition levels. The following represents the highest level of growth inhibition from test fungus ever observed: Three-day-old *N. sitophila* was found to be 51% on a virulent *R. solani*, 48% on *F. oxysporum*, 40% on *M. phaseoli*, and 55% on virulent *R. solani.* Nevertheless, *N. sitophila* outperformed *T. harzianum* and a few other soil-borne fungi in the test conditions.

Sunflower (*Helianthus annuus*), the third-largest edible oil seed crop in the world, is frequently impacted by fungal diseases including *M. phaseolina's* charcoal rot and *Plasmoparahalstedii's* downy mildew. *M. phaseolina*-induced charcoal rot was treated with carbendazim-tolerant *Trichoderma* species (Nagamani and Reedi Kumar, 2011). In comparison to the matching wild type strain TW17 (62.2%), the mutant strain TM17 suppressed the test pathogen's mycelial development by 90%, suggesting that the enhanced antagonistic action is genetically regulated. According to Nagaraju*et al*. (2012), beneficial bacteria encourage plant growth and create systemic resistance in sunflowers against *Plasmoparahalstedii*-caused downy mildew disease. The most prolific vegetable oil source is oil palm, which yields four to six tonnes of oil per hectare annually. *T. harzianum* and *T. koningii* were shown to have greater lignocellulytic capacity than other isolates, suggesting that they could be used as bioagents for the quick bioconversion of lignocellulosic oil palm empty fruit bunches (Mukhlis *et al*., 2013). According to Singh *et al*. (2013), two foliar sprays of mancozeb should be applied after treating seeds with *T. viride* for integrated management of Alternaria blight in linseed.

Cash crops

Tobacco (Nicotiana tabacum) is susceptible to serious diseases caused by various soil-dwelling fungi such as *F. oxysporumf.sp. nicotianae, Pythium spp.,* and *R. solani*, as well as the root-knot nematode, Meloidogyne incognita. Tests have been conducted on *T. harzianum's* antagonistic activity against *P. aphanidermatum* and *P. myriotylum*, which induce tobacco root rot (Devaki *et al*., 1992). In vitro tests have also been performed on *F. oxysporumf.sp*. *nicotinae* (Sumana and Devaki, 2012) and M. incognita (Khan *et al*., 2011). A major commercial crop in tropical and sub-tropical areas, sugarcane is severely yield-depleted by fungi like red rot and smut. Red rot incidents have an impact on the rhizosphere microbiota of sugarcane plants, according to Mishra (1982). Subsequent research revealed that *Colletotrichum falcatum*, the cause of red rot in sugarcane, was suppressed by the secondary metabolites of a Trichoderma isolate that was indigenous to the ecosystem (Joshi and Misra, 2013). According to Malathi and Vishwanathan (2013), *T. harzianum T5 endochitinase* has been found to have antifungal properties against *C. falcatum.* Another study discovered that applying *T. viride* to the soil, either by alone or in conjunction with other treatments, greatly decreased the amount of *C. falcatum*-caused red rot (Reddy *et al*., 2009).

Major diseases like root rot (*M. phaseolina*), wilt (*Fusarium vasinfectum*), root rot (*Rhizoctonia bataticola*), anthracnose (*Collectotricumgossypium*), Alternaria leaf spot, bacterial blight, and damping off (*Pythium ultimum*) cause decreased yields in cotton, a commercial crop that is widely cultivated in India. Applying Trichoderma to the soil was shown to be far more successful than treating it with seeds (Gaur *et al*., 2005). The most devastating disease in the world, corm rot, threatens saffron (*Crocus sativus L.*), a low volume, high value perennial crop valued for its therapeutic properties (Gupta *et al*., 2011). According to a 2011 study by Hassan *et al*., native *T. viride* isolates could control the pathogens that cause corm rot in the field. Tea and coffee, popular beverage crops cultivated in over 50 countries, are impacted by illnesses such *R. solani*-caused coffee collar rot, *Glomerellacingulata*-caused brown blight, and Phomopsis theae-

caused collar canker. Deb *et al*. (1999) examined the phyllosphere and soil mycoflora of an experimental tea plantation located in Cachar. At different stages, it was found that the isolates of *Trichoderma* JPT9 and *Gliocladium JPG1* greatly suppressed the growth of *M. phaseolina's sclerotia* (Bandopadhay*et al*., 2008). One main factor restricting coconut production is the basal stem rot disease produced by *Ganoderma lucidum*, which poses a danger to the coconut (Cocos nucifera L.), an important oilseed and plantation crop in India. For the purpose of multiplying the fungal biocontrol agent, naturally occurring agricultural waste such as coir pith has been recycled using *Trichoderma* spp. (Kumar *et al*., 2000).

Vegetable crops

In the 1990s, it was discovered that applying *T. harzianum* or *P. fluorescens* to seeds or roots along with soil solarization was beneficial in controlling tomato, brinjal, and capsicum infections. The tomato, or *Solanum lycopersicum*, is a major vegetable crop that is grown all over India. However, it is susceptible to a number of diseases, including *Phytophthora infestans*, which causes late blight, *A. solani*, which causes early blight, *Fusarium oxysporumf.sp. lycopersici*, which causes wilt, *Phytophthora aphanidermatum,* which causes damping off, *Sclerotium rolfsii*, which causes collar rot, *Xanthomonas campestris pv. vesicatoria* causes bacterial leaf spot, and *Ralstonia solanacearum* causes bacterial wilt. Allium cepa, a vital vegetable crop in India, is linked to six main diseases: Alternaria alternata causes foliar blight, Alternaria porri causes purple blotch on onions, *Fusarium oxysporumf.sp. cepae* and *Pythium sp*. causes damping-off and basal rot, *S. rolfsii* causes white rot, and *A. niger* causes black mould. The management of *A. porri*, the bacterium that causes purple blotch on onions, has been thoroughly investigated. According to reports, susceptible onions can develop more quickly and have a considerable reduction in disease when exposed to *T. harzianum* isolates Th3, Th-30, and Tv-12, Tv-15 of *T. viride* (Prakasam and Sharma, 2012). One of the most widely grown vegetable crops in the nation, aubergine or brinjal (*Solanum melongena L.*), is harmed year-round by a number of fungi, including *A. solani, F. solani, C. gloeosporioides, B. cinerea, Penicillium sp., Rhizopus niger*, *Curvularialunata*, and *Botryodiplodiatheobromae*. According to a 2009 study by Jadon, *T. viride* is the most efficient in lowering the frequency of *S. rolfsii*-caused collar rot. Chilli (Capsicum annum), another important vegetable crop that is also used as a spice and is rich in vitamins C, A, and B, is widely affected by fungal diseases such as damping off caused by *S. rolfsii, F. oxysporum, Pythium spp., R. solani,* and *Phytophthora sp.* Several studies have revealed that isolates of *T. harzianum, T. viride* (TVC3), and *T. hamatum* are effective bio-control agents against anthracnose, damping-off, and chilli dieback disease. A study suggested that using coco-peat enriched with *T. harzianum* could enhance plant growth and reduce the incidence of tomato wilt and chilli root rot. This approach also helped in raising disease-free and healthy seedlings, which further reduced wilt incidence in tomato (Sriram *et al*., 2010).

Major diseases afflict the two main winter vegetables of India: cabbage (*Brassica oleracea L. var. capitata*) and cauliflower (*Brassica oleracea L. var. botrytis*). *Plasmodiophorabrassicae* causes club root, *Xanthomonas campestris* causes black rot, *Rhizoctonia solani* causes wire stem, *A. brassicae* causes leaf spot, *A. brassiciola* causes leaf blight, and *Pythium, Phytophthora, Corticium*, and *Fusarium* cause damping off. Sugar beet (*Beta vulgaris L. ssp. vulgaris var. altissima* Doll. Chenopodiaceae), a significant sugar-producing tuber crop, suffers from serious diseases like root rot caused by *S. rolfsii* and *Pythium* spp., leading to substantial yield losses. Several reports have highlighted the use of *Trichoderma* spp. as bioagents to combat these pathogens. One such report by Sawant and Mukhopadhyay (1990) discussed the integration of metalaxyl with *T. harzianum* for controlling Pythium damping-off in sugar beet. Many diseases endanger the potato (*Solanum tuberosum*), a vital food crop in the world that lowers its output. These include black scurf, dry rot (*Fusarium* spp.), common scabies (*Streptomyces scabies*), late blight (*Phythophthorainfestans*), and bacterial wilt (*Ralstonia solanacearum*). Potato germination and yield are thought to be significantly influenced by the antagonistic fungus population (Dwivedi, 1988).

Fruit crops

Guava (Psidium guajava), a significant fruit crop in India, is affected by various pre-harvest diseases such as canker, die back, and decline, which impact plant growth and production. Post-harvest diseases like Phytophthora, Macrophomina, and others spoil the fruits in the field, during storage, and in transit. *Gliocladiumroseum* has been

identified as a potent pathogen, along with *F.o.f.sp. psidii and F. solani*. The mycoflora associated with seeds from healthy and rotten fruits of guava was observed by Pandey and Dwivedi (1987). Subsequently, several groups have evaluated and utilized Trichoderma technology to combat diseases in fruits like guava. Sapodilla (Manilkara zapota), a fruit cultivated throughout India, has been the subject of studies testing the antagonistic potentials of five *Trichoderma* species: *T. viride, T. harzianum, T. koningii, T. pseudokoningii,* and *T. virens* against fruit rot pathogens(Bhalle*et al*., 2013). Mango (Mangifera indica), a prominent fruit crop in India, suffers significant economic loss due to various pathogens, including *F. moniliforme var. subglutinans* causing mango malformation. Biocontrol has been used successfully against different pathogens. Bhuvaneshwari and Rao (2001) studied the in vitro interaction of *T. viride* with the postharvest pathogens of mango and found that *T. viride* inhibited the growth of *Pestalotia*sp., *A. flavus, L. theobromae, C. gloeosporioides, R. stolonifer, A. niger,* and *M. phaseolina* by 72.88, 70.74, 62.41, 56.83, 54.60, 52.77, and 51.08%, respectively. Citrus crops are also affected by serious diseases such as root rot by *Phytophthora* spp., dry root rot by *M. phaseoli*, pink disease by *Alternaria citri*, and powdery mildew by *C. gloeosporioides*. The role of phylloplane microflora in managing citrus canker was established by Kalita *et al*. (1996). Later, Singh *et al*. (2000) managed citrus scab caused by *Elsinoefawcettii* and found that *T. harzianum* and *E. purpurascens* reduced the disease incidence in the field by 17.8 and 10%, respectively.

Spices crops

Black pepper (Piper nigrum), often referred to as the king of spices, has a long history of cultivation in India. One of the most severe diseases it faces is foot rot (quick wilt), caused by Phytophthora capsici. Two species of *Trichoderma, T. virens-1*2 and T. harzianum-26, have been identified as potential biocontrol agents against this disease in both greenhouse and field trials (Sarma *et al*., 2000). Small cardamom (Elettaria cardamomum Maton) is another spice that suffers from rhizome rot, a disease caused by *P. vexans, R. solani,* and *F. oxysporum*. This disease is a major issue in India, leading to a 30% loss in yield. The effectiveness of the *T. harzianum* isolate in managing this disease, in combination with chemicals and fertilizers, was later confirmed (Bhai and Thomas, 2010). Cumin (*Cuminum cyminum L.*) is affected by wilt caused by *Fusarium oxysporumf.sp.cumini*, a major disease for this crop. The in vitro and in vivo effectiveness of two *Trichoderma* species, *T. harzianum* and *T. viride*, in suppressing wilt caused by *Fusarium oxysporum f. sp. cumini*has been documented (Chawla and Gangopadhyay, 2009).

Other crops

Bhattiprolu (2008) conducted a study on the antagonism of *T. viride* against Botrytis ricini (castor grey rot). The study found that the optimal pH range was 5.0 to 6.0, with an incubation temperature of 25°C. The isolate was compatible with 10% leaf extracts of several plants and common fungicides, but not with certain others. Carnation (Dianthus caryophyllus Linn.), a valuable cut flower crop, is primarily cultivated in controlled conditions. Its cultivation, like any monoculture, is affected by numerous diseases leading to significant yield losses. It was determined which *Trichoderma* spp. were antagonistic to *Fusarium oxysporumf.sp. dianthi,* which causes carnation wilt. A seasonal but long-lasting cut flower crop, gladiolus (*Gladiolus hortulanus L.H.Bailey*) creates a stable microclimate that is favourable to a number of diseases. In vitro experiments have demonstrated the efficacy of native isolates of *Trichoderma* spp. against *Fusarium oxysporumf.sp. gladioli. Fusarium oxysporumf.sp. gladioli* causes vascular wilt and corm rot, which significantly reduce crop output and lower the quality and quantity of spikes and planting materials (Pan and Das, 2004).

***TRICHODERMA* – A PROMISING PLANT GROWTH STIMULATOR**

Trichoderma is capable of producing plant growth promoters like harzianolide and indoleacetic acid (IAA). By secreting phytase and ferritin, these stimulators encourage the growth and development of plant roots, which in turn improves the absorption of iron (Fe) and phosphorus (P) by plants. Additionally, according to Lombardi *et al*. (2020a), trichoderma breaks down organic matter in the soil, increases the availability of nutrients, raises crop photosynthetic efficiency, improves plant height, stem diameter, and other agronomic features, and increases production. Trichoderma can improve the availability and efficiency of soil nutrient utilisation. Cucumber seedlings injected with Trichoderma MF-2 showed a 39.07% increase in aboveground biomass, indicating a substantial growth-

promoting impact. Additionally, as a result, the soil now contains more advantageous bacteria (Singh *et al*., 2019; Ye *et al*., 2020). The application of Trichoderma wettable powder treatment greatly increased banana production, and different strains of Trichoderma showed variable degrees of antagonism to *F. oxysporum* (Samuelian, 2016; Bubici*et al*., 2019; Damodaran *et al*., 2020). Applying Trichoderma can improve the primary agronomic characteristics of peanuts, raise the SPAD value of chlorophyll in peanut leaves, dramatically increase the activity of protective enzymes in peanut roots, stems and leaves, and lower the amount of MDA (Kovács*et al*., 2021; Al-Askar *et al*., 2022). In comparison to the control, there were increases of 24.63, 20.22, 14.10, 4.86, 7.63, and 12.85% in the number of pods per plant, pod weight, seed kernel weight, 100 fruit quality, 100 fruit kernel quality, and yield per plant of peanut when applied at a rate of 1.5 kg/666.7 m−2 (Al-Askar *et al*., 2022).

Mechanism of Action

Trichoderma can greatly increase the Na+ outflow from Lyciumbarbarum's root system and its movement to the plant's above-ground sections. This lessens the harm that ion toxicity and oxidative stress produce to PSII by guaranteeing K+ absorption and preserving the ion equilibrium in the plant. Additionally, it lessens biomass loss, preserves photosynthetic pigments, and keeps L. barbarum performing as a photosynthetic under salt stress (Brotman*et al*., 2013). One of Trichoderma's main mechanisms is the manufacture of plant growth hormones, including IAA, ABA, ET, GA, and CK (Karuppiah *et al*., 2019b; Wang *et al*., 2021; Degani*et al*., 2021b; Agbessenou*et al*., 2022). Cucumber has been demonstrated to create IAA, GA, and ABA when exposed to *T. asperellum*, which encourages development (Liu H. *et al*., 2022). According to a different study, *T. asperellum* has the ability to significantly promote poplar development by upregulating the expression of xylanase genes (Karuppiah *et al*., 2019b). By increasing the activities of succinate dehydrogenase and glucose-6-phosphate dehydrogenase, *T. harzianum* has been shown to modulate the tricarboxylic acid cycle (TAC) and hexose monophosphate pathway (HMP) to increase tomato growth (Manganiello *et al*., 2018). Trichoderma generates acidic compounds that have the ability to dissolve intractable trace minerals from soil, giving plants additional nutrition (Samuelian, 2016).

***Trichoderma* in Plant Growth**

Recent findings indicate that *Trichoderma* spp. are opportunistic, exhibiting both virulent plant symbiosis and parasitism of other fungi. Certain strains are known to establish durable colonizations of root surfaces, penetrating the epidermis and a few cells beneath. These strains produce or release various compounds that trigger localized or systemic resistance responses, explaining their non-pathogenic nature towards plants. Furthermore, it has been noted that the parasitic relationship between *Trichoderma* spp. and several pathogenic fungi induces the synthesis of specific lytic enzymes (Haran *et al*. 1996). Depending on the strain, *T. hrzianum'*schitinolytic system consists of five to seven different enzymes (Haran *et al*. 1995). The system appears to consist of four endochitinases (52, 42, 33, and 31 kDa) and two β-(1,4)-N-acetylglucosaminidases (102 and 73 kDa) in the best-characterized Trichoderma isolate (isolate TM). It is probable that the various enzyme components of *T. harzianum's* chitinolytic system operate in complimentary ways. Of special significance is the 42-kDa endochitinase (Ech42), which has been demonstrated to hydrolyze the cell walls of Botrytis cinerea in vitro and to prevent the elongation of germ tubes and spore germination in a variety of fungi (Schirmböck*et al*. 1994). When a fungus is grown in the presence of autoclaved mycelia from many fungi or with colloidal chitin as the only carbon source, the corresponding gene (ech42) is substantially stimulated (Carsolio*et al*. 1994).

***Trichoderma* in Stress Tolerance**

Trichoderma spp. are endophytic plant symbionts that are commonly used as seed treatments to control diseases and enhance plant growth and yield. Despite recent research on their ability to alleviate abiotic stresses, there is still a lack of specific knowledge about their mechanisms, their ability to control multiple plant stress factors, and their effects on seeds and seedlings. Under stress conditions, seeds treated with *Trichoderma* spp. germinate faster and more uniformly than untreated seeds, regardless of whether the stress is osmotic, salt, or due to suboptimal temperatures. Biocontrol is often associated with the ability of these fungi to produce antibiotics, establish parasitic interactions, or directly affect pathogens (Howell, 2003, 2006). However, it has become clear that beneficial fungi like *Trichoderma* spp. can induce systemic resistance in many cases, mediated by alterations in plant gene expression (Alfano, 2007,

Shoresh & Harman 2008, Shoresh*et al*., 2010). Reports also suggest that plant growth can be enhanced as a result of the association of Trichoderma strains with plants, especially when plants are under suboptimal conditions or biotic, abiotic, or physiological stresses (Bae *et al*., 2009, Mastouri Harman 2009). Recent reports suggest that these fungi enhance plant tolerance to abiotic stresses during growth (Yildirim *et al*., 2006), partly due to improved root growth, increased water-holding capacity of plants, or enhanced nutrient uptake (i.e., potassium). In the absence of stress, plant growth may or may not be enhanced. Molecular studies indicate greater expression of gene families involved in plant protection against abiotic stresses or oxidative damage (Alfano *et al*., 2006, 2007, Bailey *et al*., 2006) in plants treated with *Trichoderma* spp. However, no experimental evidence has been presented that correlates enhanced tolerance of plants colonized with biocontrol fungi to these changes at the molecular level.

***Trichoderma* in Mycoparasitism**

A *Trichoderma* species engages in a complicated process called mycoparasitism in which it grows chemotropically towards its host, adhering to, coiling around, and occasionally piercing the host hyphae. The antagonistic activities of antibiosis, competition, the generation of enzymes that break down cell walls, or a combination of these could be the cause of *Trichoderma* spp.'s mycoparasitic activity (McGrew & Green 1990). Partial breakdown of the host cell wall is typically seen in the later phases of the parasite infection. Histochemical and/or ultrastructural methods have been used to study the effects of cell wall-degrading enzymes on the host. In addition, other cell wall-degrading enzymes, including those that hydrolyze minor polymers (proteins, b-1,6- glucans, a-1,3-glucans, etc.), may play a role in the effective and complete degradation of the mycelial or conidial walls of phytopathogenic fungi by *Trichoderma* spp. *Trichoderma* spp. are employed as biocontrol agents against several plant pathogenic fungi, including *Rhizoctonia* spp., *Pythium* spp., Botrytiscinerea, and *Fusarium* spp.

***Trichoderma* in Anti-Fungal Activity**

Trichoderma species, known as mycoparasites, are commercially utilized as biological control agents against plant-pathogenic fungi such as *Rhizoctonia solani, Botrytis cinerea, Sclerotium rolfsii, Sclerotinia sclerotiorum, Pythium* spp., and *Fusarium* spp. These are used in various countries including the United States, India, Israel, New Zealand, and Sweden, serving as a promising alternative to chemical pesticides (Howell, 2003). The genus Trichoderma has been widely recognized for its antagonistic activity against *F. solani* and *R. solani* (Lewis *et al*., 1998). *Trichoderma harzianum* has been observed to protect bean seedlings from pre-emergence damping off infection, reducing disease severity and promoting plant growth in the presence of the *R. solani* pathogen (Paula *et al*., 2001). El-Kafrawy (2002) reported that *T. harzianum, T. hamatum, T. pseudoknonningii,* and *T. polysporum* inhibited the radial mycelial growth of *R. solani in vitro,* with inhibition rates ranging from 59.6% to 78.4%. The application of Trichoderma fungi in agriculture offers several benefits: 1) colonization of the root and rhizosphere of the plant, 2) control of plant pathogens through various mechanisms such as parasitism, antibiosis production, and induced systemic resistance, 3) enhancement of plant health by promoting plant growth, and 4) stimulation of root growth (Abd-El-Khair*et al*., 2010)

NANO FORMULATION

Nanotechnology, a swiftly expanding field, has demonstrated significant impact in various sectors including medical sciences, energy, cosmetics, and agriculture. It offers an understanding of antimicrobial properties at the atomic and molecular level, which helps in reducing the cytotoxic effect on cells. Nanoparticles, known for their stability under severe conditions, possess the potential to manage a variety of diseases due to their antimicrobial properties. The application of insecticides, including pesticides and fungicides, can be reduced by agricultural cultivators through the use of nano-delivery systems. Formulations based on nanoparticles could serve as alternatives to fungicides and provide an eco-friendly solution for managing plant pathogenic microbes. Nanoparticles, particularly those composed of metals in oxide form, play a crucial role in magnetism, electrochemistry, and environmental science. These metal oxide-based nano formulations are stable, environmentally friendly, and safe for humans. In the current scenario, the agricultural sector is experiencing a high demand for food products. This necessitates that the soil be enriched with all essential nutrients and possess suitable properties for the optimal growth of crops. Crops are vulnerable to attacks by phytopathogens, necessitating the use of agrochemicals such as fertilizers and pesticides to

mitigate the adverse effects caused by these pathogens. The recent emergence of agrochemicals containing nanostructured materials offers a promising alternative in agriculture. Various methods exist for the synthesis of nanoparticles, including chemical, physical, and physico-chemical techniques. These methods, however, face challenges due to the use of toxic solvents, reducing agents, expensive metal salts, reductants, and costly equipment. Consequently, researchers have turned their attention towards finding simple, eco-friendly, and non-hazardous alternative methods. In this regard, green nano-chemistry has received significant attention for its potential to replace chemical products and develop green synthesis methods that eliminate substances harmful to the environment and human health. Silver, in various chemical forms as well as in green nano form, is highly toxic. Its nanoparticles have attracted considerable interest due to their potent antimicrobial effects. Some studies have found that the toxicity of silver-based nanoparticles is dependent on both dosage and particle size. Certain phytopathogens, which are nonpathogenic in nature, can be used for mass production of green silver nanoparticles (Ag-NPs).

Among the primary nanoparticles (NPs) used in agriculture are zinc oxide NPs (ZnONPs), copper oxide NPs (CuONPs), and silver NPs (AgNPs). These can be acquired by means of chemical, biological, and physical processes. In addition to being costly, physical and chemical processes include ultraviolet radiation, aerosol technologies, lithography, laser ablation, ultrasonic fields, and photochemical reduction involve the use and discharge of hazardous substances that pollute the environment. The biosynthesis of certain metal nanoparticles, on the other hand, provides an easy, affordable, large-scale, and ecologically friendly substitute. According to reports, because biosynthesized NPs are stabilised with organic chemicals and do not produce any hazardous residues during the synthesis process, they are less dangerous than NPs obtained chemically. Better biocompatibility when using NPs is another benefit of these environmentally friendly production techniques. Plant extracts, bacteria, fungi, algae, yeasts, and the byproducts of their metabolism, such as enzymes, agro-industrial waste, and microbial pigments, can all be used in biosynthesis. According to reports, elemental metal biosynthesis is aided in the conversion of ions into secondary metabolites and other substances secreted by bacteria as a defence mechanism. Certain species that exhibit resistance to metals can release molecules that function as stabilising and reducing agents during the creation of metallic nanoparticles. The physicochemical features of the nanoparticle surface interact with their surroundings through the action of these cappings, which are stabilising or protecting substances. It is significant to remember that the pH affects how stable the cappings are: at high pH levels, the NPs stay stable in solution, but at low pH levels, the proteins that make up the cappings denature. Filamentous fungi stand out among microorganisms for nanoparticle (NP) biosynthesis due to their efficiency compared to other biological alternatives. This efficiency stems from the ease of large-scale cultivation and biomass collection, high tolerance to metals, resistance to high pressure and agitation fluxes, and the production of a large number of extracellular proteins. The secretion of these proteins by fungi has been observed to enhance the synthesis of NPs. A key advantage of utilizing fungi over bacterial systems is that NPs precipitate outside the cell, eliminating cellular contaminants. This allows for the direct application of these NPs in various fields. Consequently, fungi have emerged as valuable agents for the biosynthesis of NPs, a process known as mycosynthesis. The primary fungi employed for this purpose include *Fusarium, Aspergillus, Penicillium*, and *Trichoderma.*

Trichoderma as a synthesizer of NPs

Enzymes like reductases can aid in the mycosynthesis of nanoparticles (NPs) mediated by *Trichoderma* by acting as bio-reductive agents throughout the biofabrication process. Based on the qualities and traits of the several metallic nanoparticles that were obtained, it appears that *Trichoderma* may be a reliable source for the biological production of nanoparticles. Furthermore, the production of proteins, enzymes, and secondary metabolites that are involved in the biological control of plant diseases can improve the stability and biological activity of the resultant NPs. The antibacterial activity of NPs produced by *Trichoderma* spp. has been shown against a range of microbes, including phytopathogens including *Fusarium, Aspergillus*, *Pseudomonas,* and *Xanthomonas.* When performing mycosynthesis, it is essential to optimise the mono-dispersity, stability, and biocompatibility of the NPs by taking into account the parameters employed as well as the unique qualities of the fungal strains. It has been observed that the nucleation and subsequent generation of metallic NPs, along with their size and shape, are controlled by variables like temperature, starting pH, reagent concentration, fungal growth conditions, and reaction duration. *Trichoderma*

produces a number of different nickel-based polymers (NPs), each with unique properties and antibacterial properties, such as gold (AuNPs), zinc oxide (ZnONPs), copper (CuNPs) and copper oxide (CuONPs), selenium (SeNPs), and silver (AgNPs).

Biosynthesis of AgNPs

Silver nanoparticles (NPs) are highly sought after due to their extensive antimicrobial spectrum, which includes plant pathogens, and their high bioactivity. The application of silver NPs (AgNPs) can enhance the effectiveness of agrochemicals and decrease the usage of pesticides and biocides. There are two mechanisms for the mycosynthesis of NPs: intracellular and extracellular, with the latter being more commonly used as it eliminates the need for NP extraction from cells. In this process, biomolecules secreted by the fungus catalyze the reduction of the metal precursor (AgNO3 salt), resulting in the formation of AgNPs. The characteristics of the AgNPs produced through mycosynthesis can be varied depending on the fungal culture and production conditions. It has been noted that reductases are the primary enzymes involved in the biosynthesis of metal NPs in fungi. Among these, the nicotinamide adenine dinucleotide (NADH)-dependent nitrate reductase is prominent, playing a key role in the reduction of metal ions. For instance, *T. reesei* produces extracellular enzymes capable of reducing silver ions to AgNPs, with the NADH-dependent nitrate reductase facilitating the reduction of Ag+ metal ions into metallic AgNPs. This reduction is facilitated by the transfer of an electron from NADH, with the nitrate reductase serving as the electron carrier. Proteins can also bind to NPs, enhancing their stability. Additionally, it has been described that the reduction of silver to NPs can also be achieved by anthraquinones, naphthoquinones, and quinine derivatives, which can act as electron carriers in the reaction (Khan *et al*., 2023).

Biosynthesis of SeNPs

Selenium (Se) is known to have positive effects on plant and animal metabolism at low concentrations. It also plays a role in protecting against reactive oxygen species (ROS) in the form of selenoproteins, as reported by B˘arbieru*et al*. (2019). Therefore, Selenium nanoparticles (SeNPs) could serve as an alternative to Se salts. In terms of SeNPs synthesis, Hu *et al*. (2019) compared a traditional synthesis method (SNP, SeNPs) and a biosynthesis method (TSNP, SeNPs by *Trichoderma*). For the biosynthesis, a 5mM $NaSeO_3$ concentration was applied to a solution of metabolites from eight *Trichoderma* species. The SNP method resulted in SeNPs with spherical and pseudospherical shapes of 50 nm, along with the presence of polysaccharides. The TSNP method, on the other hand, yielded SeNPs of 60 nm with an irregular shape, likely due to the capping effect. The study also found an increased presence of amide materials in TSNP compared to SNP, which act as stabilizing agents (cappings). Three distinct media were used to assess the generation of SeNPs in a different investigation by Nandini *et al*. (2017): culture filtrate (CF), cell lysate (CL), and crude cell wall (CW). Each medium contained six distinct species of *Trichoderma* spp., and a concentration of 25 mM Na_2SeO_3 was utilised. As a result, the range of SeNPs in each medium was 49.5 to 312.5 nm. The outcomes showed that, in comparison to CL and CW, CF was the most efficient medium for producing nanoparticles because it made the procedure simpler. In their analysis of other mycosynthesis-related factors, Diko*et al*. (2020) looked at the impacts of pH, inoculation time, and SeO2 concentration. The ideal circumstances (pH of 8, 2 mM SeO_2 concentration, 24 hours of SeO_2 inoculation, and *Trichoderma* sp.) resulted in the production of 20–220 nm spherical and pseudospherical SeNPs. Alkene, alkane, and alcohol functional groups indicated that they were involved as capping in the SeNPs production pathway.

Biosynthesis of AuNPs

According to do Nascimento *et al*. (2021), gold nanoparticles (AuNPs) have a variety of uses in the biomedical area, such as diagnostics, biomolecule detection, and as nanodrug carriers. They can also be used as catalysts and antibacterial agents. According to several studies (Mishra *et al*., 2014; Abdel-Kareem and Zohri, 2018; Tripathi *et al*., 2018; Elegbede*et al*., 2020), AuNPs have antimicrobial activity against a variety of pathogens, including *Aspergillus niger, Aspergillus flavus, Aspergillus fumigatus, Escherichia coli, Klebsiella granulomatis, Pseudomonas aeruginosa, Aspergillus aureus*, and *Shigella sonnei*. In contrast to the electrochemical treatment of reverse osmosis and ion exchange resins, the biosynthesis of AuNPs is thought to be a more economical and ecologically benign method of recovering gold (do Nascimento *et al*., 2021). *T. harzianum* can biosorb 1,340 mg of gold per g of biomass in 180

minutes, according to a study by do Nascimento *et al*. (2021). This process produces spherical nanoparticles smaller than 30 nm through mycosynthesis. Abdel-Kareem and Zohri (2018) exposed *T. hamatum* SU136 to three distinct concentrations of Au_2C_{l6} (0.25, 0.5, and 1mM) in their investigation of the ideal parameters for mycosynthesis. All settings resulted in AuNPs; however, 0.5 mM Au_2C_{l6} at pH 7 and 38 °C was the ideal combination to make smaller nanoparticles.

Biosynthesis of CuNPs and CuONPs

According to Salvadori *et al*. (2014b), copper nanoparticles (CuNPs) have a wide range of uses, such as high-temperature conductors, gas sensors, catalysts, solar cells, and wood treatment. Furthermore, it has been discovered that they possess antibacterial properties against phytopathogens (Natesan *et al*., 2021). Their high surface-to-volume ratio is thought to be responsible for their easy contact with other particles, which can boost their antibacterial activity (Al-Hakkani, 2020). According to Saravanakumar*et al*. (2019), *T. asperellum* uses the amino and aromatic groups of secondary metabolites as reducing agents or encapsulants in the synthesis of CuONPs. The dead biomass of *T. koningiopsis* was utilised in the mycosynthesis of CuNPs by Salvadori *et al*. (2014b) because it had a greater affinity for copper and a better capacity for metal ion adsorption (21.1 mg/g) than the live biomass and other biosorbents. Ninety percent of the nanoparticles were obtained in 60 minutes, indicating a rapid procedure. 87.5 nm was the average diameter of the spherical CuNPs that were synthesised.

Biosynthesis of ZnONPs

Zinc oxide nanoparticles (ZnONPs) are among the nanoparticles most commonly used in agriculture due to their benefits to plants and soil microbiota, as highlighted by Shobha *et al*. (2020). They have demonstrated antifungal activities against various species such as *Fusarium* spp., *Botrytis cinerea, Penicillium expansum, A. niger,* and *Rhizhopus stolonifera*. In addition, ZnONPs are recognized as effective antibacterial agents against a wide range of species (Consolo*et al*., 2020). In a study by Shobha *et al*. (2020), ZnONPs were synthesized using three different *Trichoderma* isolates and their effectiveness was tested against Xanthomonas oryzaepv. Oryzae. The resulting ZnONPs exhibited unique shapes (hexagons and peaks) and sizes ranging from 12–35 nm. These nanoparticles could be produced sustainably and on a large scale.

CONCLUSION

Microorganisms are thought to be more environment friendly and natural alternative to the chemical treatment methods currently in use for the biological control of plant infections. There have been continuous attempts to use *Trichoderma* species, which have been known for their antifungal qualities since the 1930s, to manage plant diseases. These species have been used as biostimulant and biological control agents; their isolates have been commercially made accessible for use in soil for agriculture. *Trichoderma* species are highly efficient biological control agents due to their diversity and diverse methods of action.

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RESEARCH ARTICLE

Exploring Challenges and Perceptions: Educators Recommendations on Gamified Educational Interventions in an Inclusive Classroom

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ABSTRACT

Examining the benefits and drawbacks of using gamified educational interventions in inclusive classrooms is the goal of this research. The goals of the research are as follows: (1) to determine how gamification affects participation in class, (2) examine the mediating role of implementation issues, and (3) determine the moderating function of educators' opinions. A representative sample of 384 educators took part in the research project and provided their opinions by filling out structured questionnaires. We analyzed the data using structured equation modeling (SEM). Statistical evidence suggests that as the amount of gamification in a course increases, student engagement grows; however, this link is moderated by implementation concerns. To examine the data, structured equation modeling (SEM) was employed. The statistics show that the more gamified a lesson is, the more engaged students are, with implementation challenges mediating the relationship between the two. When it comes to planning and implementing gamified educational interventions in inclusive classrooms, these results highlight how important it is to take into consideration the problems that may arise during implementation as well as the perceived beliefs of educators.

Keywords: gamified educational interventions, inclusive classroom, challenges, perceptions, student engagement

INTRODUCTION

Traditional, passive learning methods are now considered outmoded due to the internet, advancements in information and communication technology, and the ever-changing nature of our modern society. (Ucar & Kumtepe, 2020). On the contrary, active learning strategies push teachers to stimulate students' inventiveness and help them acquire new skills. (Murillo-Zamorano et al., 2021). This is particularly the case with online education, which has grown in popularity as traditional classroom settings have grown increasingly inconvenient due to time and space constraints. All people's social, material, and moral lives were negatively impacted by the coronavirus's emergence and the global crisis it caused. However, many businesses and institutions have already begun to use distance learning as a means to ensure the long-term viability of their educational programs, further proving the significance of these applications. In distance learning environments, when peer support and collaborative learning are scarce and solo work is prioritized, it might be more challenging to encourage students to study and pay attention to the lecture. According to (Chang et al., 2015), The advent of new technological possibilities has greatly improved the viability and effectiveness of distance learning and teaching. Programs with gamification elements might be among the most successful technology strategies because people naturally enjoy and need to play games.

Strong emotional responses to games include wonder, annoyance, and happiness (Richard N. Landers , Gustavo F. Tondello & Andrew B. Collmus , Elisa D. Mekler, 2018). Researchers in the field of education are showing a lot of interest in the new trend of gamification as a means to combat student boredom and boost motivation, active learning, and engagement. (Baptista & Oliveira, 2019). To put it simply, gamification is "incorporating elements of game in a non-game context" (Hanus & Fox, 2015). By providing positive feedback, gamification in education encourages greater engagement, teamwork, and enjoyment from the learning process while also increasing student motivation and interest in the material. Reviews of the relevant literature have demonstrated that gamification significantly improves students' mental and physical health. Increased drive, confidence, happiness, flow, perceived value, and contentment are some of these outcomes. Improved performance on tasks, better overall grades, and higher scores are all examples of the former. Nevertheless, despite a large body of research on various game genres and gamified projects, there is still a dearth of study on challenge-based gamification applications in the literature (Legaki et al., 2020). An innovative and engaging method of gamification in education, challenge-based gamification makes use of resources such as points, badges, levels, and league tables to inspire and satisfy students need for achievements. It is believed to stimulate students curiosity about the material, encourage healthy competition among them, and guarantee their active engagement in class. Applying constructivist theory of learning helps shed light on the benefits of challenge-based gamification. This theory posits that active learning is best fostered via socially built learning chances. In other words, learning happens as a result of how a student interacts with their surroundings, the activities they engage in, and other people who try to assess their knowledge in the learning environment (Kumar Shah, 2019).

LITERATURE REVIEW

The current study intends to make several contributions to the field of educational research. First off, it appears that most gamification research is conceptual in nature, and there is a dearth of study on gamification implementations in higher education notably in the works that are now published in the field of education (Rincon-Flores & Santos-Guevara, 2021). By looking at challenge-based gamification through the prism of constructivist theory of learning, we can better comprehend its benefits. (Sailer & Homner, 2020). This agrees with the findings of the review research carried out by (Dichev et al., 2015), This highlighted the paucity of empirical research that integrate gamification into a real learning environment, even though there has been a boom of studies addressing gamification in education. Most of these studies have adopted a descriptive method. Second, there is conflicting data on gamification's capacity to improve learning, despite research that have examined its effects in the classroom. While some research (Varannai et al., 2017) showed that applying gamification produced positive outcomes like improved performance, increased motivation, and a positive attitude, other research (Toda et al., 2018) found no evidence that gamification improved

students' knowledge or had any negative effect on their performance. According to (Bai et al., 2020) (Oliveira et al., 2021), It is still debatable how gamified learning affects students' motivation, flow, performance, and outcomes, according to this and other recent analytical studies. Additional study in this field is necessary in light of these results.. Thirdly, whereas much research on gamification has concentrated on its effects on students' cognitive learning (such as students' academic achievement), (Huang et al., 2020) Additional research on the affective or behavioral learning consequences of gamification is strongly encouraged by a meta-analysis. Our goal in this study is to close this gap by investigating students' motivation and flow—two crucial affective effects of a gamified learning environment. Last but not least, challenge-based gamification is a fresh, intriguing strategy that hasn't received much attention. Challenge-based gamification is highlighted by (Legaki et al., 2020), who also point out that there is a dearth of empirical research in this field. By providing students with a platform to engage in collaborative learning—sharing their knowledge, experiences, and insights—challenge-based gamification promotes active learning, in line with the constructivist tenets of education. (McPhail, 2016). Researchers expect academics to feel the effects of the present study's empirical results and the unique gamification platform's ability to promote active learning in a challenging setting..

Aim and Objectives

In order to improve educational practices' efficacy and inclusivity, The objective of this research is to delve into the mindsets and challenges surrounding the use of gamified educational interventions in inclusive classrooms. It also asks teachers for their opinions. The main objectives of the study are follows:

- In an inclusive classroom, to directly measure the effect of gamification level on student
- In an inclusive classroom, we want to see how teachers' views on gamified interventions influence the correlation between gamification intensity and student participation.
- Specifically, we want to learn more about how implementation hurdles affect the correlation between gamification intensity and participation in an inclusive classroom.

Hypothesis

H1: Higher levels of gamification in educational interventions will positively influence student engagement in an inclusive classroom.

H2: opinions held by educators moderate the association between gamification level and student engagement. Educators' positive opinions of gamified interventions will lead to a larger impact of gamification on student engagement.

H3: Implementation difficulties will moderate the relationship between gamification level and student engagement, meaning that more gamification means more difficulties, which means less engagement from students.

METHODOLOGY

Conceptual framework

Sample size

The research on "Exploring Challenges and Perceptions: Educators' Recommendations on gamified Educational Interventions in an Inclusive Classroom" features a carefully chosen sample of 384 participants, striking a balance between reliability and manageability. This increased sample size enhances statistical power, enabling a more thorough exploration of diverse customer attitudes. Aligned with structural equation modeling (SEM) principles, this deliberate choice underscores the study's commitment to producing credible and meaningful results

Sampling technique

In our research on "Exploring Challenges and Perceptions: Educators' Recommendations on gamified Educational Interventions in an Inclusive Classroom" we utilized random sampling to ensure a comprehensive and representative participant selection. We divided the population based on key characteristics such as Gender, Age, Education Level, Employment Status, and randomly selected individuals from each group. This approach aimed to

capture diversity, enhancing the accuracy and dependability of our data by examining potential variations in outcomes across different demographic groups within the Educational Revolution.

Data collection

Our study on "Exploring Challenges and Perceptions: Educators' Recommendations on gamified Educational Interventions in an Inclusive Classroom" involved 384 participants surveyed through structured questionnaires. Ethical considerations were prioritized, ensuring informed consent and data security. A stratified random sampling method, considering demographics, was used for inclusivity. Participants chose between in-person interviews or online surveys for flexibility. This approach aimed to gain reliable insights into diverse "Exploring Challenges and Perceptions: Educators' Recommendations on gamified Educational Interventions in an Inclusive Classroom"

Data analysis

In our analysis of "Exploring Challenges and Perceptions: Educators' Recommendations on gamified Educational Interventions in an Inclusive Classroom" we student Structural Equation Modeling (SEM) and moderation analysis and Mediating and Moderating analysis to explore the interconnections between key factors influencing challenges in Implementation and perceptions of gamification. Our data analysis, encompassing descriptive and inferential statistics, rigorously tested hypotheses and provided crucial insights into Exploring Challenges and Perceptions: Educators' Recommendations on gamified Educational Interventions in an Inclusive Classroom.

Analysis of Structural Equation Modelling (SEM)

As part of our research, we used Structural Equation Modelling (SEM) is used to examine intricate interplay between numerous factors all at once. SEM integrates regression and factor analysis, providing a comprehensive understanding of relationships within a theoretical framework. It helps verify and adjust research hypotheses, revealing detailed patterns and insights into the dynamics between MSME performance management, modern marketing strategies, and digital marketing capabilities.

Inclusion and Exclusion Criteria

- Educators actively involved in teaching or supporting students in an inclusive classroom environment.
- Educators who have experience or expertise in utilizing or have been exposed to gamified educational interventions.
- Educators willing to participate in the study and share their perceptions and recommendations regarding gamified educational interventions in an inclusive classroom setting

Exclusion Criteria

- Educators who do not have experience or exposure to gamified educational interventions.
- Educators who are not currently teaching or supporting students in an inclusive classroom environment.
- Educators unwilling or unable to participate in the study and share their perspectives on the topic.
- Educators who do not have sufficient proficiency in the language of the study (if applicable).
- Educators who have conflicts of interest that may bias their responses or recommendations.

RESULTS

SEM (structural equational modelling)

Structural Equation Modeling (SEM), a flexible statistical approach, to describe complex interactions between variables, whether latent or observable. Its ability to analyses intricate causal pathways, integrate latent components, test several hypotheses at once, account for measurement error, evaluate model fit, and combine aspects of factor analysis and regression are just a few of its special features. SEM is an essential tool for research in disciplines like psychology, sociology, economics, and beyond because it can be used to validate theoretical models, examine the

effects of interventions or policies, and simplify complex datasets. This allows for more thorough and accurate data analysis and hypothesis testing.

Measurement model and validity

Measurement models and validity are indispensable in research as they establish a structured framework for ensuring the accuracy and meaningfulness of data. Measurement models clarify the relationships between observed variables and their underlying constructs, enabling researchers to assess complex concepts. Validity, on the other hand, ensures that the measurement instruments precisely capture the intended constructs, safeguarding against misleading or incorrect conclusions. Both measurement models and validity are essential components in research, serving as the foundation for reliable and credible findings, which is paramount for informed decision-making and advancing knowledge across diverse field. In order to do the confirmatory factor analysis, the sample size was adequate and suitable, as indicated in the table above, where the value of KMO was 0.935. We also made sure that the variables used in confirmatory factor analysis were significantly correlated at the 0.00 level of confidence by using Bartlett's Test of Sphericity. We used CFA, or Confirmatory Factor Analysis, to check our instrument's validity thoroughly. The factor loadings for each individual question exceeded the 0.5 threshold, underscoring the instrument's strong capability to accurately measure the intended constructs. This outcome underscores the robustness of our measurement tool. Since the factor loading value is less than 0.6, several items are omitted from the subsequent analysis. The variables "Challenges in Implementation" and "CI4" are eliminated. Table 18 displays the model fit values. To ascertain the internal consistency of the scale, We computed the Composite Reliability (CR) and Average Variance Extracted (AVE). For your perusal, Table 16 displays the results of the post-CFA study. in addition to which are the CR, AVE, and Cronbach's alpha values. When one variable's square root of its AVE is larger than its correction values when compared to other variables, discriminant validity is established. The findings that were collected are shown in Table 17, and they contribute to the determination of the discriminant validity.

Discriminant validity test

Discriminant validity is not a specific test performed in SPSS or any other statistical software but a concept within the context of validating measurement instruments and assessing the relationships between variables. Discriminant validity is crucial to ensure that different constructs or variables in a study are truly distinct and not measuring the same underlying concept. Researchers use various techniques such as confirmatory factor analysis (CFA) or correlation analysis to demonstrate that the measures intended to assess different constructs are, indeed, different and not highly correlated. Discriminant validity helps ensure that the measurement instruments accurately represent the unique concepts they are meant to measure, preventing construct overlap or redundancy and allowing for more robust and accurate data analysis and interpretation. In the discriminant validity test, the relationships between various constructs related to gamification in education are investigated. These constructs include the level of gamification, the level of student engagement, perceptions of gamification, inclusive learning outcomes, recommendations for effective implementation, and challenges in implementation.

Coefficients of correlation are also displayed in the table, and The square roots of each construct's average variance extracted (AVE) are reflected in the diagonal numbers. We can see the interrelationships between the concepts in the non-diagonal numbers. The data indicate that there are significant positive relationships between the amount of gamification and student engagement (.837), perceptions of gamification (.708), and inclusive learning outcomes (.688). Similar to the previous point, there are significant positive relationships between student involvement and views of gamification (.772), inclusive learning outcomes (.747), and suggestions for successful implementation (.692). Furthermore, there is a substantial correlation between views of gamification and inclusive learning results (.822) as well as suggestions for successful implementation (.781). Furthermore, there is a significant positive connection between the results of inclusive learning and the suggestions for successful implementation (.793). On the other hand, the correlations between difficulties in implementation and other kinds of constructs are quite low, which suggests that there is the possibility of discriminant validity. Despite the fact that gamification level, student engagement, perceptions of gamification, inclusive learning outcomes, and recommendations for effective implementation are all closely related to one another, these results suggest that these constructs are distinct from one another, implying that



each contributes in its own unique way to the overall understanding of gamification in educational contexts. With $\chi 2$ = 577.275, the fit quality was satisfactory in representing the sample data. NFI (Normed Fit Index) =0.914; IFI (Incremental fit index) = 0.966, GFI (Goodness of Fit) = 0.908, RFI (Relative Fit Index) = 0.900 and CFI (Comparative Fit Index) =0.965 which is much larger than the 0.90. Similarly, RMR (Root Mean Square Residuals) =0.042 and RMSEA (Root mean square error of approximation) = 0.040 values are lower the 0.080 critical value**.** With an RMSEA of 0.040, RMR of 0.042, GFI of 0.908, and CFI of 0.965, the results showed that the given model was a good fit.

Proposed Hypothesis

H1: Gamification level in educational interventions will positively influence student engagement in an inclusive classroom. In this hypothetical structural equation model, the table shows how two variables—the degree of gamification and student engagement—are dependent on one another. Here, the degree of gamification serves as the independent variable, with student engagement serving as the dependent variable. A favorable and statistically significant correlation between Transparent and Equitable and Faculty Performance was found in the analysis. (β=.786, P<0.05). The standardized coefficient of 0.786, a positive association between Gamification level and Student Engagement, as shown in the route connecting these two variables. The correlation coefficient values (C.R. values) show large magnitudes, suggesting that the observed associations are statistically significant. According to the fit indices shown in Table 20, The data and the model are well-aligned. Thus, seven separate fit indices were used to assess the overall model fit; these indices showed a positive and statistically significant correlation between the degree of gamification and student engagement. With a $\chi 2$ value of 30.262, the fit quality was satisfactory in representing the sample data. NFI (Normed Fit Index) =0.982; IFI (Incremental fit index) = 0.999, GFI (Goodness of Fit) = 0.985, RFI (Relative Fit Index) = 0.972 and CFI (Comparative Fit Index) =0.999 which is much larger than the 0.90. Similarly, RMR (Root Mean Square Residuals) =0.020 and RMSEA (Root mean square error of approximation) = 0.011 values are lower the 0.080 critical value**.** With an RMSEA of 0.011, RMR of 0.020, GFI of 0.985, and CFI of 0.999, the results showed that the displayed model was an excellent fit.

H2: The relationship between gamification level and student engagement will be mediated by challenges in implementation. In the default regression model for Group number 1, the relationships between various factors affecting implementation challenges, gamification level, and student engagement are examined. The unstandardized estimates show the strength and direction of these relationships. Specifically, a higher gamification level is associated with increased challenges in implementation, as indicated by a positive unstandardized estimate of .598. Furthermore, student engagement is positively influenced by both challenges in implementation and gamification level, with unstandardized estimates of .493 and .568, respectively. The p-values and critical ratios (C.R.) for these associations show that they are statistically significant. emphasizing the importance of addressing implementation challenges and leveraging gamification strategies to enhance student engagement. In the default model of Group number 1, standardized indirect effects were analysed between gamification level and challenges in implementation, as well as between student engagement and challenges in implementation. With an RMSEA of 0.011, RMR of 0.020, GFI of 0.985, and CFI of 0.999, the results showed that the displayed model was an excellent fit, suggesting that higher levels of student engagement are associated with increased challenges in implementation. However, there is no significant indirect effect observed between gamification level and challenges in implementation, as the coefficient for this relationship is .000. These findings suggest that while student engagement may contribute to challenges in implementation, the level of gamification does not have a direct impact on implementation challenges in this particular model.

H3: The relationship between gamification level and student engagement will be moderated by educators' perceptions, such that the impact of gamification on student engagement will be stronger when educators have positive perceptions of gamified interventions.

Our model is the Structural Equation Model (SEM), which looks at how Zscore(STUDENT_ENGAGEMENT) and Zscore(Gamification_Level), with moderation by Perceptions_of_Gamification is presented in Table 1. Taking into account measurement errors and feedback directly within the model, this all-encompassing approach permits testing of all important paths.

Path analysis-based hypothesis testing reveals that Zscore(Gamification_Level) is positively and significantly associated with Zscore(STUDENT_ENGAGEMENT) (β=.406, P<0.05). Gender is negatively and significantly associated with Zscore(STUDENT_ENGAGEMENT) (β=-.342, P<0.05).

Moderation Testing

In order to perform the moderation analysis, dealing with Zscore(Gamification_Level) as independent variables, Zscore(STUDENT_ENGAGEMENT) as dependent variable, and Moderation variables (Perceptions_of_Gamification) as moderator variable. To get the numbers, we use SPSS to make interaction terms out of the standardized scores of the variables. We tested the Perceptions_of_Gamification as a moderator. According to the results, the interaction term of Zscore(Gamification_Level) and Zscore (Perceptions_of_Gamification) has a notable and beneficial impact on Zscore(STUDENT_ENGAGEMENT) (β= 0. 180, P<0.05). The findings provide statistical proof that demographic variables influence the relationship, which goes against the expected association's nature. There are significant factors with p>0.05, and the model's fit indices show that it fits the data well. (as shown in Table 2). To determine whether the proposed model was consistent with the data, we used a number of global fit indices and the significance level, or 'r', to measure the model's fit. According to the data in the table above, the relationship between Gamification_Level and STUDENT_ENGAGEMENTis moderated by (Perceptions_of_Gamification).

Recommendations

Educators should tailor gamified interventions to accommodate diverse learning needs and abilities in an inclusive classroom. This can include adjusting difficulty levels, providing multiple pathways to success, and offering various modes of interaction. Integrating Universal Design for Learning principles into gamified educational interventions can enhance accessibility and inclusivity. Collaborative learning opportunities should be encouraged within gamified interventions to foster peer interaction and support. Clear communication and instruction should be provided, using visual aids, verbal explanations, and written instructions to accommodate different learning preferences. Effective feedback mechanisms should be implemented to provide timely and constructive feedback to students. A variety of assessment strategies, including formative assessments, self-assessments, and peer evaluations, should be used to monitor progress and provide opportunities for reflection and improvement. Flexibility and differentiation should be maintained in gamified interventions to accommodate individual learning paces and preferences. Offer options for students to choose activities or challenges based on their interests, strengths, and areas for growth. Professional development and training opportunities should be provided for educators to enhance their knowledge and skills in implementing gamified interventions in inclusive classrooms. Continuous evaluation and reflection should be conducted to identify areas for improvement and refine gamified activities to better meet the needs of all learners.
Community engagement and support should be fostered among educators, parents, and community stakeholders to promote the successful implementation of gamified interventions in inclusive classrooms. Ethical considerations and equity should be ensured, ensuring that gamified interventions uphold ethical standards and promote equity and social justice.

CONCLUSION

Contributing to our understanding of gamified educational interventions that employ inclusive classrooms are the results of this study. This underscores the need of overcoming problems in implementation and taking into consideration the perspectives of educators in order to improve the success of gamification tactics. According to the findings, gamification appears to have a beneficial impact on student engagement, with difficulties in implementation serving as a moderating factor and the perceptions of educators serving as a mediating factor. It is possible for educators and policymakers to build educational solutions that are more successful and inclusive if they acknowledge these aspects. In the long run, this will help students succeed academically and foster a supportive classroom atmosphere. Gamification in education is a complex phenomenon that necessitates ongoing research into its dynamics, taking into account a wide range of contextual elements and investigating its long-term impacts on students' learning and development.

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Table 1: Regression Weights: (Group number 1 - Default model)

Path			Unstandardized Estimate	S.E.	Standardized Estimates	C.R.	P
CI5	<---	Challenges in Implementation	1.000		.673		
CI3	<---	Challenges in Implementation	1.056	.083	.699	12.651	***
CI2	<---	Challenges in Implementation	.803	.071	.629	11.256	***
CI1	<---	Challenges in Implementation	1.017	.084	.708	12.141	***
GL5	<---	Gamification Level	1.000		.639		
GL4	<---	Gamification Level	.991	.086	.632	11.556	***
GL3	<---	Gamification Level	1.117	.088	.674	12.662	***
GL2	<---	Gamification Level	1.215	.109	.749	11.162	***
GL1	<---	Gamification Level	1.329	.109	.816	12.199	***
REI5	<---	Recommendations for Effective Implementation	1.000		.666		
REI4	<---	Recommendations for Effective Implementation	.893	.083	.609	10.699	***
REI3	<---	Recommendations for Effective Implementation	.971	.073	.634	13.293	***
REI2	<---	Recommendations for Effective Implementation	1.147	.088	.763	13.034	***
REI1	<---	Recommendations for Effective Implementation	1.470	.100	.849	14.665	***
PG5	<---	Perceptions of Gamification	1.000		.666		
PG4	<---	Perceptions of Gamification	1.118	.089	.701	12.549	***
PG3	<---	Perceptions of Gamification	1.158	.077	.762	15.000	***
PG2	<---	Perceptions of Gamification	1.127	.089	.790	12.649	***
PG1	<---	Perceptions of Gamification	1.619	.108	.839	15.036	***
SE5	<---	Student Engagement	1.000		.624		
SE4	<---	Student Engagement	1.116	.119	.667	9.353	***
SE3	<---	Student Engagement	1.163	.106	.688	10.989	***
SE2	<---	Student Engagement	1.037	.115	.653	9.048	***
SE1	<---	Student Engagement	1.523	.135	.800	11.291	***
ILO6	<---	Inclusive Learning Outcomes	1.000		.661		
ILO5	<---	Inclusive Learning Outcomes	.995	.099	.672	10.083	***
ILO4	<---	Inclusive Learning Outcomes	1.149	.085	.737	13.573	***
ILO3	<---	Inclusive Learning Outcomes	1.206	.097	.769	12.400	***
ILO2	<---	Inclusive Learning Outcomes	1.438	.109	.858	13.225	***

Path	Unstandardized Estimate	S.E.	Standardized Estimates	C.R.	P
ILO1 <--- Inclusive Learning Outcomes	1.453	.130	.700	11.159	***

Table 2: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.935
Bartlett's Test of Sphericity	Approx. Chi-Square	6544.594
	df	435
	Sig.	.000

Table 3: Post CFA, Cronbach alpha, factor loadings

Factors and items	Cronbach alpha values	Post CFA factor loadings	AVE	CR
Gamification Level	.850		0.702	0.837
GL1		.816		
GL2		.749		
GL3		.674		
GL4		.632		
GL5		.639		
Perceptions of Gamification	.872		0.751	0.855
PG1		.839		
PG2		.790		
PG3		.762		
PG4		.701		
PG5		.666		
Challenges in Implementation	.770		0.677	0.782
CI1		.708		
CI2		.629		
CI3		.699		
CI5		.673		
Recommendations for Effective Implementation	.854		0.704	0.838
REI1		.849		
REI2		.763		
REI3		.634		
REI4		.609		
REI5		.666		
Student Engagement	.836		0.686	0.831
SE1		.800		
SE2		.653		
SE3		.688		
SE4		.667		
SE5		.624		
Inclusive Learning Outcomes	.867		0.732	0.850
ILO1		.700		
ILO2		.858		
ILO3		.769		

ILO4		.737		
ILO5		.672		
ILO6		.661		

Table 4: Discriminant validity Test

	Gamification Level	Student Engagement	Perceptions Of Gamification	Inclusive Learning Outcomes	Recommendations For Effective Implementation	Challenges In Implementation
Gamification Level	0.837854403					
Student Engagement	.772**	0.866602562				
Perceptions Of Gamification	.708**	.781**	0.822800097			
Inclusive Learning Outcomes	.688**	.747**	.839**	0.839047079		
Recommendations For Effective Implementation	.682**	.692**	.793**	.772**	0.82825117	
Challenges In Implementation	.660**	.736**	.841**	.969**	.752**	0.855569985

Table 5: Model fit summary

Variable	**Value**
Chi-square value(χ^2)	577.275
Degrees of freedom (df)	358
CMIN/DF	1.612
P value	0.062
GFI	0.908
RFI	0.900
NFI	0.914
IFI	0.966
CFI	0.965
RMR	0.042
RMSEA	0.040

Table 6: Regression Weights: (Group number 1 - Default model)

Path			**Unstandardized Estimate**	**S.E.**	**Standardized Estimates**	**C.R.**	**P**
Student Engagement	<---	Gamification level	.940	.085	.786	11.104	***
GL5	<---	Gamification level	1.000		.720		

Path			Unstandardized Estimate	S.E.	Standardized Estimates	C.R.	P
GL4	<---	Gamification level	.984	.079	.706	12.526	***
GL3	<---	Gamification level	1.137	.083	.773	13.725	***
GL2	<---	Gamification level	1.000	.081	.694	12.313	***
GL1	<---	Gamification level	1.036	.081	.717	12.822	***
SE1	<---	Student Engagement	1.000		.762		
SE2	<---	Student Engagement	.746	.062	.679	12.039	***
SE3	<---	Student Engagement	.831	.064	.712	12.888	***
SE4	<---	Student Engagement	.789	.065	.685	12.150	***
SE5	<---	Student Engagement	.772	.065	.701	11.796	***

Table 7: Model fit summary

Variable	Value
Chi-square value(χ^2)	30.262
Degrees of freedom (df)	29
CMIN/DF	1.044
P value	0.401
GFI	0.985
RFI	0.972
NFI	0.982
IFI	0.999
CFI	0.999
RMR	0.020
RMSEA	0.011

Table 8: Regression Weights: (Group number 1 - Default model)

Path			Unstandardized Estimate	S.E.	Standardized Estimates	C.R.	P
Challenges in Implementation	<---	Gamification Level	.598	.035	.660	17.174	***
Student Engagement	<---	Challenges in Implementation	.493	.047	.400	10.523	***
Student Engagement	<---	Gamification Level	.568	.042	.509	13.376	***

Table 9: Standardized Indirect Effects (Group number 1 - Default model)

	Gamification Level	Challenges in Implementation
Challenges in Implementation	.000	.000
Student Engagement	.264	.000

Table 10: Regression Weights: (Group number 1 - Default model)

Path			Unstandardized Estimate	S.E.	Standardized Estimates	C.R.	P
ZSTUDENT_ENGAGEMENT	<--	ZGamification_Level	.406	.040	.406	10.211	***
ZSTUDENT_ENGAGEMENT	<--	ZPerceptions_of_Gamification	.342	.053	.342	6.442	***
ZSTUDENT_ENGAGEMENT	<--	ZGamification_Level*ZPerceptions_of_Gamification	.180	.052	.180	3.496	***

Table 11: Regression Weights: (Group number 1 - Default model)

Path			Unstandardized Estimate	S.E.	Standardized Estimates	C.R.	P
ZSTUDENT_ENGAGEMENT	<--	ZGamification_Level*ZPerceptions_of_Gamification	.180	.052	.180	3.496	***

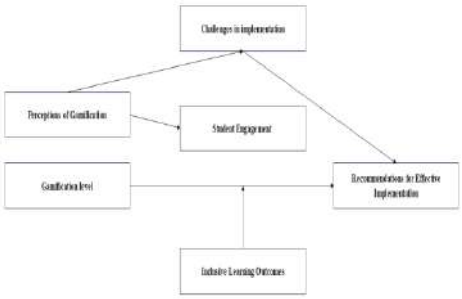


Figure 2: Conceptual Framework

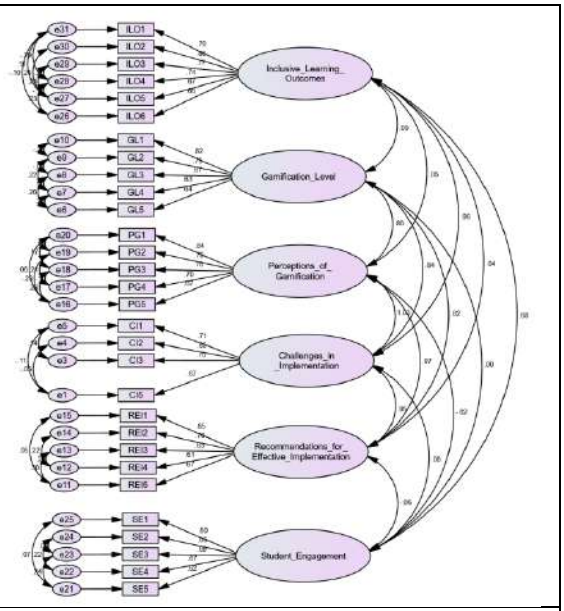


Figure 2: Measurement model and validity

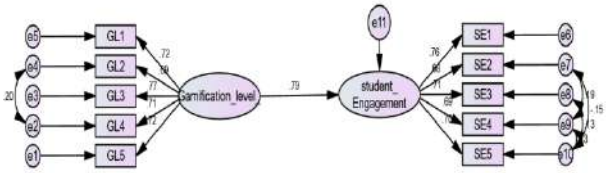


Figure 3: Proposed Hypothesis

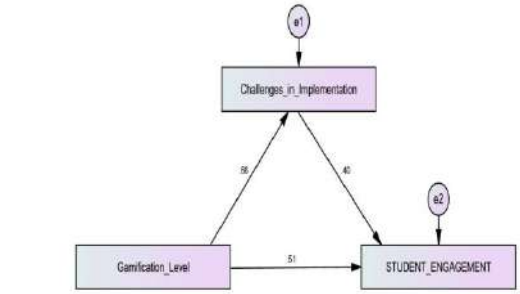


Figure 4:Implementation

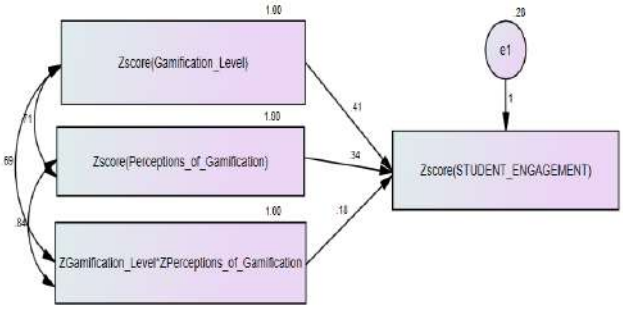


Figure 5:Relationship

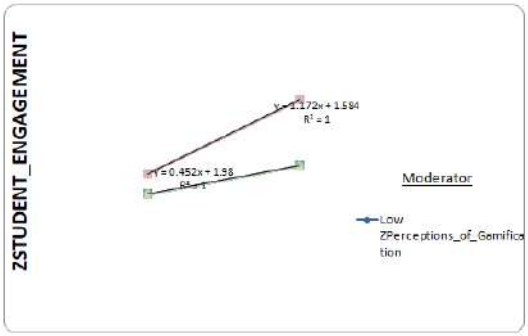


Figure 6:Moderator

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RESEARCH ARTICLE

Knowledge, Attitude and Practice of Infection, Prevention and Control Precautions among Undergraduate Pharmacist Students in South India

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ABSTRACT

This review examines the knowledge, attitude, and practice (KAP) of infection prevention and control (IPC) among undergraduate pharmacy students in South India, highlighting the significance of IPC in healthcare and the pivotal role of pharmacy students in this domain. The review delves into the current educational frameworks within pharmacy curricula in South India, assessing the integration of IPC training and its practical application. It identifies challenges such as resource limitations, curriculum constraints, and cultural aspects that affect IPC learning and implementation. Through a comparative analysis, the study provides insights into how IPC KAP among pharmacy students in South India stands in relation to their global counterparts, underscoring the influence of diverse educational and healthcare contexts. The review emphasizes the critical impact of effective IPC training on patient care and infection control, advocating for enhanced educational strategies and policy support to improve IPC practices. Recommendations for future research and educational innovations are presented, including the integration of emerging technologies and interactive teaching methods to enrich IPC education. This comprehensive analysis aims to contribute to the advancement of IPC competencies among future pharmacists, ultimately fostering improved healthcare outcomes and public health.

Keywords: Infection Prevention and Control, Pharmacy Education, South India, Knowledge, Attitude, and Practice, Healthcare Outcomes.

INTRODUCTION

Infection prevention and control (IPC) is a critical aspect of healthcare that aims to prevent or reduce the incidence of healthcare-associated infections (HAIs) among patients and healthcare workers. The significance of IPC in healthcare settings is underscored by its direct impact on patient safety, treatment outcomes, and overall healthcare costs(1,2). Effective IPC measures, such as hand hygiene, the use of personal protective equipment (PPE), sterilization of medical equipment, and isolation protocols, are essential to prevent the transmission of infectious pathogens within healthcare facilities(3,4). The implications of inadequate IPC practices are profound, ranging from increased morbidity and mortality to extended hospital stays and heightened financial burdens on healthcare systems(5). For instance, HAIs can lead to severe complications, including bloodstream infections, surgical site infections, and pneumonia, which can be life-threatening if not addressed promptly and effectively. Moreover, the emergence of antibiotic-resistant bacteria has made the implementation of robust IPC strategies more crucial than ever(6-8). IPC is not only about preventing infection but also about fostering a culture of safety that permeates all levels of healthcare delivery. It involves a comprehensive approach that includes surveillance, reporting, and analysis of infection data, education and training of healthcare personnel, and adherence to evidence-based practices. Through these concerted efforts, healthcare settings can create a safer environment for both patients and healthcare professionals, ultimately enhancing the quality of care and patient outcomes(9). The objectives of a review focusing on the knowledge, attitude, and practice (KAP) of infection prevention and control (IPC) among undergraduate pharmacy students in South India are multifaceted and aim to comprehensively understand the current landscape, identify gaps, and suggest improvements in education and practice.

Assess the Current Level of Knowledge

One primary objective is to assess the current level of knowledge that undergraduate pharmacy students in South India possess regarding IPC. This involves understanding what students know about various IPC protocols, guidelines, and the rationale behind them. The review would aim to identify specific areas where knowledge is strong and areas where there may be significant gaps or misconceptions.

Evaluate Attitudes Towards IPC

Another critical objective is to evaluate the attitudes of pharmacy students toward IPC practices. This includes understanding how students perceive the importance of IPC in their future professional roles, their willingness to comply with IPC guidelines, and their perception of the impact of IPC on patient safety and healthcare outcomes. Attitudes can significantly influence the implementation of knowledge into practice, making this a crucial area of investigation.

Analyze Practice Behaviours

The review also aims to analyze the actual practice behaviors of pharmacy students regarding IPC. This involves investigating how well students apply their knowledge of IPC in clinical settings or simulations, their adherence to IPC guidelines during their training, and any barriers they face in implementing best practices.

Identify Educational Gaps and Needs

By synthesizing information on knowledge, attitudes, and practices, the review intends to identify educational gaps and needs within the pharmacy curriculum. It aims to pinpoint areas where additional training or emphasis could enhance IPC understanding and implementation among students.

Inform Policy and Curriculum Development

An essential objective of the review is to provide evidence-based recommendations that can inform policy and curriculum development. By identifying the strengths and weaknesses in current IPC education for pharmacy students, the review can suggest targeted interventions to improve IPC knowledge, attitudes, and practices. This

could involve recommendations for curriculum enhancement, teaching methodologies, and student assessment strategies.

Contribute to Improved Healthcare Outcomes

Ultimately, the review aims to contribute to improved healthcare outcomes by enhancing the IPC competence of future pharmacists. By ensuring that pharmacy students in South India are well-equipped with the necessary IPC knowledge, attitudes, and skills, they can play a pivotal role in preventing infections, improving patient safety, and reducing the burden of healthcare-associated infections(10).

Pharmacy Students' Role in IPC and the Significance

Pharmacy students are integral to the healthcare team, and their role in IPC extends beyond the pharmacy's confines to the broader healthcare setting. As future pharmacists, they are positioned to influence IPC practices through various avenues, including medication management, patient education, and participation in multidisciplinary teams. Their education in IPC is crucial, as it lays the foundation for their understanding of how infectious diseases are transmitted and controlled, the importance of antimicrobial stewardship, and the impact of their actions on the health and safety of patients and colleagues. Pharmacy students learn to apply IPC principles in diverse settings, from community pharmacies to hospital wards, where they can advocate for and adhere to best practices in infection control. They are trained to provide advice on the proper use of antibiotics, educate patients on hygiene practices, and ensure the aseptic handling of medications. Their role in promoting vaccination, managing isolation precautions, and contributing to the development and implementation of IPC policies further underscores their importance in this field. The education of pharmacy students in IPC is significant not only for their professional development but also for the broader goal of enhancing healthcare quality and patient safety. By embedding IPC principles in pharmacy education, students are equipped with the knowledge and skills necessary to become champions of infection control, whether through direct patient care, participation in infection control committees, or through research and advocacy(11).

Rationale for Focusing on South India

Focusing on South India for a study on IPC among pharmacy students is justified by several region-specific factors. South India, with its dense population, diverse healthcare settings, and varying levels of healthcare access and quality, presents a unique environment for examining IPC practices. The region's healthcare system is a mix of urban and rural settings, with differences in healthcare infrastructure, which can influence IPC practices and outcomes. Moreover, South India has a significant number of pharmacy colleges and a large population of pharmacy students, making it an ideal setting for studying educational practices and their impacts on IPC. The region's diverse socio-cultural context also plays a role in shaping attitudes and practices related to health and hygiene, which are crucial components of effective IPC. Investigating IPC practices in South India can provide insights into the challenges and opportunities in pharmacy education and healthcare delivery in the region. It can also contribute to developing tailored IPC strategies that address the specific needs and constraints of South India. By focusing on this region, researchers can generate evidence that informs policy and practice, ultimately improving infection control measures and healthcare outcomes in South India and potentially serving as a model for other regions with similar contexts.

METHODOLOGY

The search strategy for the review aims to comprehensively capture literature related to the knowledge, attitude, and practice (KAP) of infection prevention and control (IPC) among undergraduate pharmacy students in South India. To achieve this, a meticulous approach involving various databases and specific keywords, alongside defined inclusion and exclusion criteria, is employed.

Databases

The search will encompass several databases to ensure a broad and diverse collection of relevant literature. These may include PubMed, Scopus, Web of Science, and Google Scholar, among others. Each database offers a unique range of journals and publications, enhancing the comprehensiveness of the search.

Keywords

A combination of keywords will be used to capture all relevant literature. These might include "infection prevention and control," "knowledge," "attitude," "practice," "pharmacy students," "South India," and "undergraduate education." Boolean operators (AND, OR) will be utilized to refine the search, e.g., "infection prevention and control AND pharmacy students AND South India."

Inclusion and Exclusion Criteria

The inclusion criteria might consist of studies focusing on undergraduate pharmacy students, studies conducted in South India, and publications within the last decade to ensure relevance. Exclusion criteria could include non-English publications, studies not specifically addressing IPC, or research focusing on postgraduates or professionals outside the pharmacy discipline.

Approach to Selecting and Analysing the Relevant Literature

Selection Process

Initially, titles and abstracts will be screened based on the inclusion and exclusion criteria. Subsequently, full-text articles will be reviewed for detailed analysis. This two-step process ensures that only pertinent studies are considered for review.

Analysing Literature

Each selected study will be critically analyzed to extract data on the knowledge, attitudes, and practices regarding IPC among pharmacy students. This analysis will consider the study design, sample size, methodology, key findings, and limitations. The critical appraisal will help in understanding the robustness and applicability of the findings.

Organization

The literature will be organized thematically or methodologically, depending on the nature and diversity of the findings. This organization aids in identifying patterns, trends, and gaps in the existing research(12).

Method for Synthesizing the Findings

Synthesis Approach

The synthesis of findings will be approached through a narrative synthesis or a thematic analysis, depending on the nature of the collected data. This involves summarizing and explaining the findings across the selected studies, identifying common themes, and noting any significant variances or contradictions.

Thematic Analysis

If a thematic analysis is chosen, the data will be categorized into themes such as knowledge gaps, attitudes towards IPC, and observed practices. This approach allows for a nuanced understanding of the various dimensions of the KAP related to IPC.

Integration of Quantitative and Qualitative Data

In cases where the review includes both quantitative and qualitative studies, a mixed-methods synthesis will be employed. This will involve integrating quantitative data on prevalence and statistical correlations with qualitative insights into student perceptions and experiences.

Drawing Conclusions

The synthesis will aim to draw evidence-based conclusions regarding the current state of IPC KAP among pharmacy students in South India. It will identify patterns, assess the quality of the evidence, and consider the implications of the findings for education, practice, and policy.

Recommendations for Future Research

Based on the synthesis, the review will highlight areas where further research is needed, pointing out any significant gaps or inconsistencies in the existing literature(13).

Current Knowledge, Attitudes, and Practices

Knowledge Levels of Pharmacy Students in South India Regarding IPC

Research on the knowledge levels of pharmacy students in South India often reveals a spectrum of understanding regarding IPC. Studies typically evaluate students' familiarity with IPC guidelines, their understanding of the modes of transmission of infectious diseases, and their knowledge of the measures necessary to prevent these infections. Results might show that while students have a foundational understanding of basic IPC principles, there can be significant gaps in their knowledge about specific protocols, such as the correct use of personal protective equipment (PPE), hand hygiene techniques, and the latest guidelines on infection control. Moreover, the depth of IPC knowledge could vary based on the year of study, with senior students demonstrating a higher level of understanding compared to their junior counterparts. This gradient in knowledge suggests an ongoing learning process but also highlights the need for early and consistent integration of IPC topics throughout the pharmacy curriculum. The research might also indicate a disparity in knowledge between students from different institutions, pointing towards variability in the emphasis on IPC in pharmacy education across South India. Such studies underscore the importance of a standardized IPC curriculum to ensure that all pharmacy students acquire the necessary knowledge to safeguard patient health and prevent the spread of infections in healthcare settings(14).

Attitudes Towards IPC Among Pharmacy Students

Studies assessing attitudes towards IPC among pharmacy students in South India would likely explore students' perceptions of the importance of IPC, their willingness to adhere to IPC guidelines, and their sense of responsibility in preventing infections. The findings might reveal a generally positive attitude toward IPC, with students recognizing its critical role in healthcare and patient safety. However, research might also uncover challenges such as complacency, perceived barriers to IPC adherence (such as time constraints or resource limitations), and a possible underestimation of the role of pharmacists in infection control. Some studies could highlight the influence of cultural factors and educational background on students' attitudes, indicating that while students value IPC, they may not always perceive it as a direct component of their future professional practice. Enhancing positive attitudes toward IPC would involve not only education but also role modelling by faculty and exposure to real-world scenarios where IPC is crucial. This would help bridge the gap between theoretical knowledge and practical implementation, fostering a culture of infection prevention that aligns with global healthcare standards(15).

IPC Practices Adopted by Pharmacy Students

Reviewing the actual IPC practices adopted by pharmacy students in South India would involve examining how students apply their knowledge in practical settings, such as during clinical rotations or in simulation labs. Findings might show a discrepancy between theoretical knowledge and practice, with students sometimes failing to adhere to IPC measures due to lack of confidence, oversight, or understanding of the real-world implications of these practices. Observations might include inconsistent hand hygiene, improper use or disposal of PPE, and inadequate sterilization techniques. Such studies could also assess the impact of educational interventions, like workshops or hands-on training, in improving IPC practices among students. The research could emphasize the need for more experiential learning opportunities where students can apply IPC knowledge in controlled, supervised environments. This hands-

on experience is crucial for students to understand the practical importance of IPC measures, ultimately leading to better adherence in their professional lives.

By exploring these three areas, research provides a holistic view of the IPC preparedness of pharmacy students in South India, offering insights into how education can be enhanced to promote better infection control practices in future healthcare professionals(16,17).

Educational Framework and Curriculum Analysis:

Examination of IPC-related Content within Pharmacy Curricula in South Indian Institutions

A thorough examination of the IPC-related content within pharmacy curricula in South Indian institutions would involve a detailed analysis of course syllabi, teaching methods, and educational materials to identify the extent and depth of IPC coverage. This evaluation aims to understand how well the curricula prepare pharmacy students for the critical role of infection prevention and control in healthcare settings. Typically, this analysis would reveal the presence of dedicated IPC modules or the integration of IPC topics across various subjects. Key areas of focus might include the principles of microbiology, modes of infection transmission, standard precautions, use of personal protective equipment, and antimicrobial stewardship. However, the depth of coverage could vary, with some institutions offering comprehensive, in-depth discussions on IPC, while others may only touch on these topics superficially. The evaluation might also consider the pedagogical approaches used to teach IPC, such as lectures, seminars, workshops, and hands-on training. The presence of interdisciplinary learning experiences, which expose students to IPC practices in real-world healthcare settings, could also be a focal point. Additionally, the assessment would look at how current and evidence-based the IPC content is, ensuring that students are being taught the most up-to-date practices(18).

Assessment of How IPC Training is Integrated into Pharmacy Education and Practical Training

Assessing the integration of IPC training into pharmacy education and practical training involves looking beyond the curriculum to understand how theoretical knowledge is applied in practical settings. This includes evaluating clinical rotations, laboratory work, and other experiential learning opportunities where students can engage in IPC practices.

In ideal scenarios, IPC training should not be confined to the classroom but extensively incorporated into practical training sessions. This might involve simulated exercises, role-playing scenarios, or clinical placements where students can observe and participate in IPC measures firsthand. The assessment would explore whether students receive consistent feedback and reinforcement of IPC practices during these activities and if they have opportunities to reflect on and improve their IPC skills. Another critical aspect is the collaboration with other healthcare disciplines in IPC training, promoting a multidisciplinary approach that reflects real-world healthcare settings. Assessing how pharmacy students interact with nursing, medical, and other health science students in joint IPC exercises can provide insights into their readiness for collaborative practice in infection control(19).

Challenges and Barriers

Challenges and Barriers in Acquiring and Applying IPC Knowledge

Pharmacy students often face a myriad of challenges and barriers in acquiring and applying IPC knowledge effectively. One primary challenge is the complexity and breadth of IPC itself, which requires a deep understanding of microbiology, epidemiology, clinical practices, and behavioural sciences. Students may find it challenging to integrate this multidisciplinary knowledge into a cohesive framework for practical application. Moreover, the translation of theoretical knowledge into practice is a significant hurdle. Many students have limited opportunities to engage in hands-on IPC activities or to observe these practices in clinical settings before they enter the workforce. This lack of practical exposure can lead to a gap between what students know and how they apply this knowledge in real-world settings. There's also the challenge of keeping abreast with the rapidly evolving field of IPC, especially with the emergence of new pathogens and resistance mechanisms. Students may find it challenging to stay updated with the latest guidelines and research, particularly if the curriculum is not regularly updated(20).

Resource Limitations, Curriculum Constraints, and Cultural Aspects

Resource Limitations

Many educational institutions in South India may face resource constraints that affect IPC training. This can include limited access to modern laboratory facilities, insufficient teaching materials, or a shortage of faculty with expertise in IPC. Such limitations can hinder the provision of comprehensive and hands-on IPC education, impacting students' learning experiences and outcomes.

Curriculum Constraints

The pharmacy curriculum is often packed with a wide range of subjects, and IPC might not receive the emphasis it requires. There may be a lack of dedicated IPC courses, or the topic may be scattered across various subjects without a coordinated approach. This fragmentation can lead to students not fully appreciating the centrality of IPC in their future professional roles.

Cultural Aspects

Cultural factors can also influence how IPC is perceived and practiced by pharmacy students. For example, attitudes toward hygiene, infection risk, and compliance with IPC measures can vary widely and be influenced by societal norms and beliefs. Furthermore, the hierarchical nature of healthcare settings in South India may deter students from voicing concerns or taking initiative in IPC-related matters, especially when it contradicts the practices of more senior healthcare providers(21).

Comparative Analysis

Comparison of IPC KAP Among Pharmacy Students in South India with Other Regions or Countries:

A comparative analysis of IPC knowledge, attitudes, and practices (KAP) among pharmacy students in South India versus their counterparts in other regions or countries can reveal significant insights. This comparison often involves evaluating the curriculum, the depth of knowledge, the prevailing attitudes towards IPC, and the practical application of IPC principles in various settings. For instance, pharmacy students in South India may have a different level of IPC knowledge compared to students in Western countries, where IPC protocols might be more rigorously integrated into healthcare systems. The comparison could show that students in more developed healthcare settings possess a more advanced understanding of IPC due to greater access to resources, advanced training simulations, and exposure to diverse clinical environments. On the other hand, pharmacy students in South India might exhibit certain strengths, such as adaptability and innovation in IPC practices, driven by resource constraints and unique healthcare challenges. These comparative analyses can shed light on how different educational, healthcare, and socio-economic contexts influence IPC KAP among pharmacy students.

Highlighting Differences and Discussing Potential Reasons

The differences in IPC KAP among pharmacy students across different regions can be attributed to several factors: Curriculum and Education: The structure and content of pharmacy education can vary widely, influencing how well students are prepared in IPC. Regions where the curriculum emphasizes practical IPC training might produce students with a more profound practical understanding of infection control. Resource Availability: Access to modern educational resources, including simulation labs and clinical training sites, can enhance IPC learning experiences, leading to better KAP outcomes among students.

Cultural Influences

Cultural attitudes towards hygiene, disease prevention, and healthcare practices can impact students' attitudes and practices related to IPC. In some cultures, there may be greater emphasis on collective responsibility and community health, which can influence how IPC principles are adopted and practiced.

Healthcare System

The structure and standards of the healthcare system, including policy enforcement around IPC, can affect how students learn and apply IPC principles. In regions with stringent IPC regulations and practices, students are likely to gain more rigorous training and adhere more strictly to IPC guidelines.

Exposure to Diverse Clinical Settings

Students in regions with diverse clinical training opportunities, including exposure to various healthcare settings and patient populations, might develop a more nuanced understanding of IPC's importance across different contexts(22).

Impact of Effective IPC Training

Impact on Patient Care and Infection Control in Healthcare Settings

Effective IPC training has a profound impact on patient care and infection control in healthcare settings. When pharmacy students are equipped with comprehensive IPC knowledge and skills, they transition into healthcare professionals who can significantly contribute to reducing the incidence of healthcare-associated infections (HAIs). This contribution is crucial, as HAIs are a major concern globally, affecting patient outcomes, increasing hospital stay durations, and elevating healthcare costs. With a solid foundation in IPC, pharmacists can implement and advocate for stringent infection control measures, such as proper hand hygiene, appropriate use of personal protective equipment, and effective sterilization practices. Their role extends beyond personal adherence to IPC protocols; they become influencers and educators within their healthcare teams, promoting a culture of safety and compliance. Moreover, pharmacists with robust IPC training are better positioned to engage in antimicrobial stewardship, a critical aspect of infection control. They can guide the appropriate selection, dosing, and duration of antimicrobial therapy, which is pivotal in combating antimicrobial resistance. The ripple effect of effective IPC training is vast, leading to improved patient outcomes, reduced transmission of infections, and enhanced overall healthcare quality. This underscores the importance of integrating comprehensive IPC education within pharmacy curricula, ensuring that future pharmacists are well-prepared to contribute effectively to infection control efforts.

Long-term Benefits of Equipping Future Pharmacists with Robust IPC Knowledge and Practices

The long-term benefits of providing pharmacy students with robust IPC training are substantial. Firstly, it contributes to the creation of a healthcare workforce that is proficient in implementing best practices for infection prevention, thereby enhancing the overall safety and quality of healthcare delivery. In the long run, pharmacists with strong IPC knowledge can lead and participate in multidisciplinary teams to develop, implement, and evaluate infection control policies and interventions, adapting to emerging challenges such as new pathogens or resistance patterns. Educating future pharmacists in IPC also has a broader public health impact. It equips them to educate patients and the community about infection prevention, extending the benefits beyond healthcare settings into the wider community, thereby contributing to public health promotion and disease prevention. Furthermore, as healthcare continues to evolve, pharmacists with a solid foundation in IPC are better equipped to adapt to new technologies, practices, and guidelines, ensuring that their practices remain at the forefront of patient care and safety. Ultimately, investing in IPC education for pharmacy students is an investment in the future of healthcare. It ensures the sustainability of infection control efforts, contributes to the resilience of healthcare systems, and promotes a safer healthcare environment for patients and healthcare workers alike(23,24).

Recommendations for Improvement

Enhancing IPC Education in Pharmacy Schools

To enhance IPC education in pharmacy schools, curricula should be designed to incorporate IPC topics comprehensively and pragmatically. This includes embedding IPC principles across various subjects, ensuring that students understand IPC's relevance in all aspects of pharmacy. Introducing dedicated IPC modules can provide depth, while case-based learning can illustrate IPC's application in real-world scenarios. Interactive teaching methods like simulations and role-playing can engage students actively, helping them develop practical skills in IPC.

Incorporating digital tools and e-learning platforms can also facilitate a more flexible and accessible learning environment. Assessment strategies should evolve beyond traditional exams to include practical assessments that evaluate students' ability to apply IPC knowledge in clinical settings. This could involve simulated patient interactions or situational analysis where students propose IPC strategies for specific scenarios(25).

Policies and Initiatives to Support Improved IPC Practices

Policies should mandate the inclusion of comprehensive IPC training within pharmacy curricula, ensuring that accreditation standards reflect the importance of IPC education. Initiatives could include partnerships with healthcare institutions to provide students with hands-on IPC experience in diverse clinical settings. Encouraging inter professional education can foster a collaborative approach to IPC, reflecting the multidisciplinary nature of infection control in healthcare settings. Additionally, continuous professional development programs can ensure that students and practicing pharmacists stay updated on the latest IPC guidelines and research. Supporting research and innovation in IPC education can also drive improvements, encouraging the development of new teaching methods, materials, and assessment tools. This would not only enhance IPC practices among students but also contribute to the broader goal of improving infection control standards in healthcare(26).

Future Directions in Research and Education

Areas for Further Research in IPC KAP among Pharmacy Students

Future research should focus on longitudinal studies to track changes in IPC KAP among pharmacy students from entry to graduation, providing insights into how education impacts long-term competencies. Investigating the correlation between IPC education and actual practice in clinical settings can highlight the effectiveness of current training methods. There's also a need for comparative studies examining IPC KAP across different pharmacy schools, identifying best practices and areas needing improvement. Research into the psychological and social factors influencing IPC adherence can offer a deeper understanding of how attitudes and behaviours are formed and changed. Additionally, exploring the impact of interprofessional education on IPC KAP can provide valuable information on how collaborative learning influences IPC outcomes(27).

Incorporating Emerging Technologies and Innovative Teaching Methods

The potential for enhancing IPC education through emerging technologies and innovative teaching methods is vast. Virtual reality (VR) and augmented reality (AR) can simulate complex clinical environments for students to practice IPC procedures in a risk-free setting. Gamification of IPC education can increase engagement and motivation, turning learning into an interactive and enjoyable experience. Artificial intelligence (AI) can offer personalized learning experiences, adapting educational content to meet individual student needs and pace. Online platforms and mobile applications can facilitate continuous learning and provide accessible resources for reinforcing IPC knowledge. Innovative teaching methods, such as flipped classrooms, can encourage active learning and critical thinking, essential for effective IPC practices. These approaches, combined with traditional education methods, can provide a more holistic and engaging learning experience, better preparing students for the IPC challenges in the healthcare environment(28).

CONCLUSION

It provides an in-depth exploration of IPC knowledge, attitudes, and practices among pharmacy students in South India, revealing critical insights into the current state of IPC education and its implications for healthcare. The review identifies significant gaps in IPC knowledge and practice, emphasizing the need for a robust and integrated approach to IPC education within pharmacy curricula. It highlights the essential role of pharmacists in infection control and patient safety, advocating for enhanced training and interdisciplinary learning to equip future pharmacists with the necessary IPC skills. The comparative analysis offers valuable perspectives on the global context of IPC education, suggesting that tailored strategies and continuous innovation are crucial for addressing regional challenges and

aligning with international standards. The recommendations provided in the manuscript underscore the importance of policy interventions, educational reforms, and research initiatives to advance IPC practices among pharmacy students, ultimately contributing to better health outcomes and strengthening the healthcare system's response to infectious threats.

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RESEARCH ARTICLE

Significant Pharmacological Role of Herbs in the Regulation of Sexual Dysfunctions

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ABSTRACT

Sexual dysfunction, which includes a variety of problems with sexual functioning, is a common problem that affects people all over the world. This research explores the potential of different natural and synthetic chemicals in addressing sexual dysfunctions and gives an overview of the interaction between them. The paper investigates the physiological bases of sexual function, emphasizing the intricate interplay during sexual arousal and response between hormones, vascular factors, and neurotransmitters. It highlights how disruptions in these networks can lead to disorders such as erectile dysfunction, female sexual arousal disorder, and hypoactive sexual desire disorder. The study also looks at how bioactive substances, such as synthetic medications, vitamins, minerals, and phytochemicals, affect sexual function. It talks about the pharmacological characteristics of these substances, clarifying their modes of action and possible medical advantages in treating sexual dysfunctions. The review evaluates the safety and efficacy profiles of different bioactive substances in the treatment of sexual dysfunctions by taking into account the evidence from preclinical and clinical trials. It highlights encouraging results and suggests directions for further study to broaden our comprehension of the therapeutic potential of bioactive substances in this situation.

Keywords: Sexual dysfunction, erectile disfunction, phytochemicals, bioactive compounds

INTRODUCTION

Erectile dysfunction (ED) is the inability to achieve and maintain sufficient penile erection for sexual intercourse. Globally, over 152 million men suffer from ED, with projections indicating an increase to around 322 million by 2025. Treatment options include pharmacological interventions like phosphodiesterase (PDE) inhibitors, alprostadil, penile prosthesis surgery, and hormonal replacement therapy. However, these treatments can have adverse effects, prompting interest in natural remedies. Medicinal plants offer a promising avenue due to their natural, abundant, and cost-effective nature, with fewer side effects reported. This review discusses the causes, risk factors, and treatment options for ED, focusing on medicinal plants proven effective both in vivo and in vitro. Traditional herbal treatments for ED have been utilized across various cultures, leveraging the therapeutic properties of plant materials. Plant-derived polyphenols affect key enzymes associated with ED, such as PDE-5, ACE, ADA, arginase, phenolic acids, flavonoids, terpenoids, carotenoids, and polyunsaturated fatty acids. These bioactive compounds interact synergistically or cumulatively, offering significant protection against male erectile dysfunction. This knowledge may inform future drug discovery efforts, potentially leading to the development of natural remedies with minimal side effects (1). *Spirulina platensis*, a filamentous cyanobacterium rich in proteins, vitamins, minerals, and antioxidants, is renowned for its health benefits including anti-inflammatory, antioxidant, and anti-obesity effects. This study aimed to explore *Spirulina platensis*' role in reversing damage caused by a hypercaloric diet on rat erectile function. Rats were divided into groups: standard diet (SD), hypercaloric diet (HCD), HCD supplemented with *Spirulina platensis* at doses of 25, 50, and 100 mg/kg (HCD+SP25, HCD+SP50, HCD+SP100), and HCD followed by a standard diet (HCD+SD). Results showed that *Spirulina platensis* supplementation increased erections, decreased latency to initiate penile erection, enhanced NO bioavailability, reduced inflammation, improved relaxation effect, restored contractile reactivity damage, decreased oxidative stress, and increased total antioxidant capacity. This suggests *Spirulina platensis* as a promising therapeutic option for obesity-induced erectile dysfunction (2).

Diets supplemented with raw and roasted pumpkin (*Cucurbita pepo* L) seeds

This research explored the impact of incorporating raw and roasted pumpkin seeds into diets on key biochemical factors relevant to erectile function in male rats' corpus cavernosal tissues. Rats were divided into groups fed basal diets (NC) or diets supplemented with raw (5% and 10%) and roasted (5% and 10%) pumpkin seeds. Parameters assessed included adenosine deaminase (ADA), phosphodiesterase-5 (PDE-5), arginase, acetylcholinesterase (AChE) activities, as well as nitric oxide (NO) level and malondialdehyde (MDA) content. Results indicated that diets supplemented with roasted pumpkin seeds exhibited improved PDE-5, ADA, and arginase activities, as well as increased NO and decreased MDA levels. AChE activities showed no significant difference between raw and roasted pumpkin seed groups. These findings suggest that both raw and roasted pumpkin seeds modulate enzymes associated with erectile dysfunction, indicating their potential therapeutic role. However, roasted pumpkin seeds (10% of diet) demonstrated more favorable effects compared to raw seeds. Practical implications include the acknowledgment of pumpkin's nutritional benefits and its traditional use in treating various ailments. Processing, such as roasting, was found to enhance the seeds' antioxidant activity and improve key enzymes related to erectile function, making consumption of roasted pumpkin seeds potentially more advantageous than raw ones (3).

HERBAL SOURCES USED IN TREATMENT SEXUAL DYSFUNCTIONS

Mimosa pudica Linn

Traditional use of plant-derived molecules includes managing various health issues like erectile dysfunction (ED). Mimosa pudica Linn., known as the touch-me-not plant, and its extract offer promising leads in drug discovery. This study aimed to identify effective molecules from M. pudica for penile erection using molecular docking and dynamics simulations. Twenty-eight bioactive molecules were sourced from public repositories and assessed for drug likeness. Docking against phosphodiesterase type 5 (PDE5) enzymes revealed four potent molecules (Bufadienolide, Stigmasterol, Isovitexin, Apigetrin) with superior binding affinities compared to sildenafil, the

standard PDE5 inhibitor. Molecular dynamics simulations confirmed their stable binding and low toxicity profiles, suggesting their potential as safe and potent PDE5 inhibitors for ED treatment (4).

Grapefruit peel extract

The side effect of erectile dysfunction induced by paroxetine can be burdensome despite its antidepressant effectiveness. Grapefruit peel extract (GFP) is rich in antioxidants and phenolic compounds, offering various therapeutic benefits. This research investigates GFP's potential in treating paroxetine-induced ED using a rat model. Rats were divided into five groups and treated for 28 days. Sexual behavior was evaluated, and penile tissue enzyme activities were measured. HPLC-DAD analysis revealed several bioactive compounds in GFP extract. Paroxetine reduced erectile response and elevated enzyme activities and oxidative stress markers. However, GFP extract reversed these effects, suggesting its erectogenic and protective properties against paroxetine-induced ED. This study highlights the potential of utilizing grapefruit peels, rich in bioactive compounds, for managing erectile dysfunction, thereby transforming waste into therapeutic products (5).

***Ocimum gratissimum* Linn.**

Ocimum gratissimum L., a medicinal plant common in tropical and subtropical areas, is traditionally utilized to improve male erectile function. This study explored its potential inhibitory effects on key enzymes linked with erectile dysfunction in rat penile and testicular tissues. The aqueous extract (1:10 w/v) of *O. gratissimum* leaves was evaluated for its impact on phosphodiesterase-5 (PDE-5), arginase, angiotensin I-converting enzyme (ACE), and acetylcholinesterase (AChE) activities. Additionally, its antioxidant properties were assessed using ferric reducing antioxidant power (FRAP) and 1,1-diphenyl-2-picryl-hydrazil (DPPH) radical scavenging assays. The results demonstrated that the extract significantly inhibited PDE-5, ACE, AChE, and arginase activities in both penile and testicular tissues, with stronger inhibitory effects observed in penile tissue. Moreover, the extract exhibited antioxidant activity by scavenging free radicals in a dose-dependent manner. These findings suggest that the bioactive compounds present in *O. gratissimum* may contribute to its traditional use in managing erectile dysfunction (ED) (6).

Garcinia kola seeds

Erectile dysfunction (ED) is a prevalent issue among men globally, characterized by difficulty achieving or maintaining an erection during sexual activity. While drugs like sildenafil are commonly used to address ED, they often come with adverse effects. This study aimed to explore the molecular interactions between compounds from *Garcinia kola* and the receptor associated with ED. Using molecular docking analysis; we assessed the binding of catechin, garcinal, garcinoic acid, and d-tocotrienol to the PDE-5 receptor. Results showed that all compounds acted as protein inhibitors, with garcinoic acid exhibiting the strongest binding affinity (-10.0 kcal/mol) to the PDE-5 receptor relevant to ED. These findings suggest the potential development of garcinoic acid as a promising alternative for ED management, warranting further investigation (7).

BIOACTIVE COMPOUNDS USED IN TREATMENT SEXUAL DYSFUNCTIONS

In the flaccid state, the penis maintains contraction through adrenergic control. Erection occurs via corporal smooth muscle relaxation, aided by various mechanisms. Compounds inhibiting adrenergic transmission or promoting muscle relaxation aid in erection. Macrocycle 1, a new agent, inhibits receptor-stimulated contraction without altering field-stimulated contraction. Testing on rabbit corpus cavernosum showed it reduced phenylephrine-induced contraction and enhanced relaxation induced by stimulation and certain drugs. This suggests potential for treating erectile dysfunction, though its exact mechanism is unclear (8).

Catechin from *Anonna senegalensis* is a Potential Inhibitor of Erectile Dysfunction

Erectile dysfunction (ED) presents a significant hurdle for men, often accompanied by side effects from conventional treatments. Phytomedicinal exploration has spotlighted *Annona senegalensis* (*A. senegalensis*) for its rich phytochemical composition and diverse pharmacological properties, yet a definitive sex-enhancing compound remains elusive. This study aimed to elucidate the molecular interactions of *A. senegalensis'* potent molecule for male sexual enhancement.

Docking simulations were performed with a library of 69 compounds from *A. senegalensis* against ED-targeted proteins, benchmarked against sildenafil citrate. Catechin emerged as the lead compound, exhibiting robust binding affinity across ED-related proteins. Moreover, catechin demonstrated favorable drug-like properties according to Lipinski's Rule of 5, promising pharmacokinetic profiles, and notable bioactivity scores. These findings underscore catechin, a flavonoid from *A. senegalensis*, as a potential candidate for male sexual enhancement, warranting further *in vivo* toxicity and therapeutic assessments (9).

Effect of icarisid II on diabetic rats with erectile dysfunction

Erectile dysfunction (ED) is a significant complication of diabetes mellitus. Icarisid II, derived from icariin, has demonstrated potential in enhancing erectile function. This study examines its effects on diabetic rats with ED and explores its mechanism through assessing advanced glycosylation end products (AGEs), autophagy, mTOR, and the NO-cGMP pathway. Icarisid II was extracted enzymatically from icariin. Rats were divided into control, diabetic ED, and icarisid II groups. Erectile function was evaluated by intracavernosal pressure/mean arterial pressure (ICP/MAP). Enzyme immunoassay was used to measure AGE concentrations, nitric oxide synthase (NOS) activity, and cGMP concentration. Cell proliferation was analyzed through methyl thiazolyl tetrazolium assay and flow cytometry. Autophagosomes were observed via transmission electron microscopy and staining. Western blot was utilized to examine the expression of NOS isoforms and key autophagy proteins. Results indicated that Icarisid II increased ICP/MAP values, smooth muscle cell (SMC) growth curve, S phase, and SMC/collagen fibril (SMC/CF) proportions while decreasing Beclin 1. It also enhanced proliferative index and p-p70S6K (Thr389) levels, while reducing autophagosomes and LC3-II levels. Additionally, Icarisid II decreased AGE concentrations and increased cGMP concentration, NOS activity, and cNOS levels in the diabetic ED group. These findings suggest that Icarisid II holds promise for diabetic ED treatment, potentially by upregulating SMC proliferation and the NO-cGMP pathway, and downregulating AGEs, autophagy, and the mTOR pathway (10).

Cordyceps militaris, while less popular than *Cordyceps sinensis*, offers similar bioactive compounds and medicinal properties. It contains adenosine, cordycepin, D-mannitol, and exopolysaccharides, showing potential benefits like anti-inflammatory, anti-fatigue, and anti-bacterial effects, along with improving organ functions and addressing certain health conditions, including cancer and sexual dysfunctions. Due to its increasing recognition, cultivation of C. militaris is expanding. This study aimed to optimize cultivation parameters for consistent quality. Adenosine was found to be highest when cultivated with millet substrate in the dark for 7 days and harvested on day 40. Cordycepin levels peaked when soybean substrate was used, cultivated in darkness for 14 days, and harvested on day 50. D-mannitol content was highest with millet substrate, in darkness for 7 days, and harvested on day 50. Over the cultivation period, adenosine levels decreased while cordycepin increased (11). The study focused on *Securidaca longepedunculata's* effectiveness in treating erectile dysfunction in South Africa. Through bioassay-guided isolation and structural elucidation using spectroscopic techniques, researchers identified two new xanthones. One of these xanthones demonstrated significant activity in relaxing corpus cavernosal smooth muscle, showing a 97% effectiveness compared to sildenafil (Viagra) at a concentration of 1.8 x 10(-5) mg/ml. This supports the traditional use of S. longepedunculata root bark for erectile dysfunction treatment (12).

FUTURE PROSPECTS

Prospects for the future in the subject of bioactive chemicals and sexual dysfunctions appear bright, as continuing research keeps revealing fresh perspectives and possible treatments. With developments in personalized healthcare and precision medicine, it is possible that tailored medicines for sexual dysfunctions will be developed in the future. These are some possible avenues for further research and conclusions based on the available data. Customized genetic, hormonal, and physiological profiles could enable these medicines to maximize effectiveness while minimizing negative effects. Significant promise exists for the investigation of bioactive substances derived from natural sources, including plants and marine life. New remedies for sexual dysfunctions may be developed as a result of ongoing study into the mechanisms of action and therapeutic potential of these substances. The connection between nutrition and diet and sexual health is gaining popularity. Subsequent research endeavors could concentrate on pinpointing certain nutrients and dietary regimens that enhance sexual function, as well as investigating the

possibilities of nutraceuticals as complementary or substitute therapies for sexual dysfunctions. Sexual function is significantly influenced by psychosocial and mental health variables. To address the psychological components of sexual dysfunctions, future interventions may include marital counseling, mindfulness training, and psychiatric therapy. Future treatments for sexual dysfunctions may incorporate combination medicines that address several elements of sexual function at once, given their complex nature. This can entail combining pharmaceuticals with psychotherapy, lifestyle modifications, or complementary and alternative medical techniques. There are new options for the diagnosis and treatment of sexual dysfunctions thanks to telemedicine and digital health platforms. Future advancements in telemedicine technology may facilitate remote monitoring, increase patient involvement in the treatment of sexual health disorders, and improve access to care.

CONCLUSION

In conclusion, a multidisciplinary approach integrating advancements in pharmacology, nutraceuticals, psychology, and digital health is what will define the future of sexual dysfunctions and bioactive chemicals. By utilizing these developments, medical professionals and researchers can create more individualized and successful therapies for people with sexual dysfunctions, so enhancing their general well-being and quality of life.

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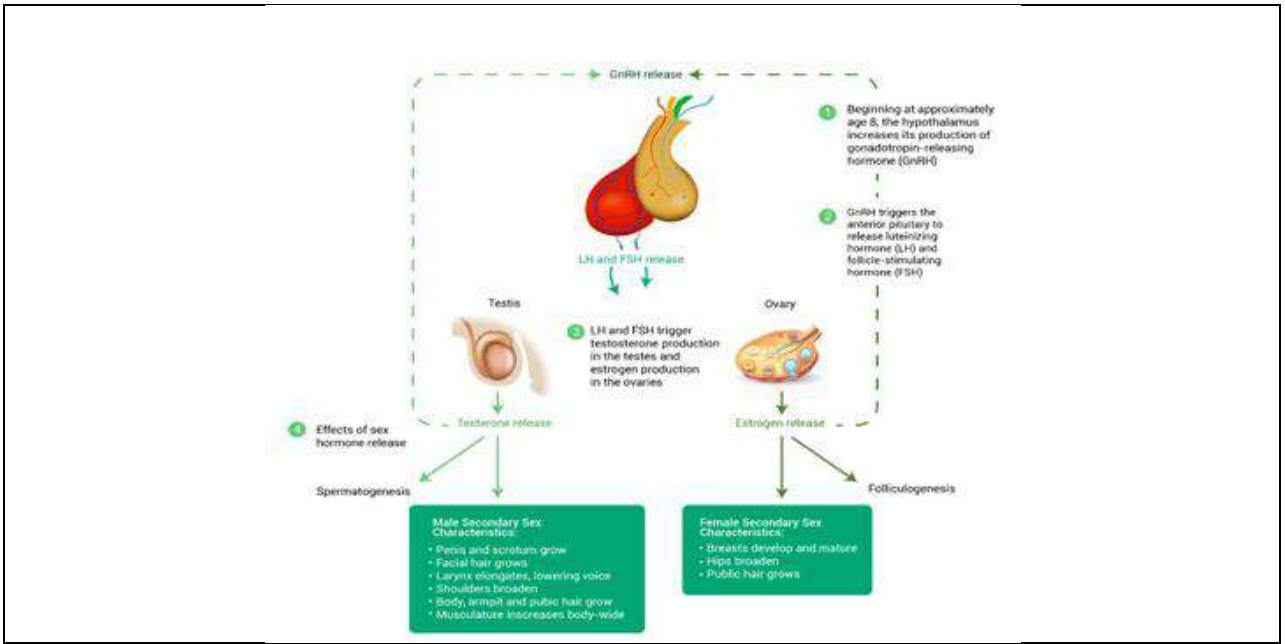


Figure 1: Bioactive compounds and their mechanism in erectile dysfunction

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RESEARCH ARTICLE

An Assessment of the Dependencies of Coastal Communities on Ecosystem Goods and Services: A Case Study of Mangroves in Karnataka, India

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ABSTRACT

The Blue Economy refers to an economic system focused on the sustainable exploitation, preservation, and regeneration of marine ecosystems. It emphasizes the responsible use of marine resources to drive economic growth and enhance livelihoods. In India, the Blue Economy holds significant growth potential, with projections estimating it could reach USD 2.5 to 3 trillion by 2030. For a developing country like India, coastal ecosystems are crucial as they provide employment and resources vital for the livelihoods of people who depend on them directly or indirectly.The purpose of this study is to establish dependencies of coastal communities on coastal ecosystem products and services, with a special focus on mangroves in Karnataka, India. A mixed-methods approach was employed to assess the extent to which local inhabitants depend on mangroves for their livelihoods and well-being. This was achieved by integrating field surveys with participatory evaluations. The findings indicate that these ecosystems provide a wide range of products and services, such as fishing supplies, fuelwood, and medicinal plants, all of which significantly contribute to the livelihoods of local populations. Furthermore, the study discusses the policy implications of these findings and provides solutions for sustainable coastal ecosystem management. This research is significant because it demonstrates the critical role that mangroves play in supporting the livelihoods and well-being of local populations in Karnataka, India. The research emphasizes the importance of successful conservation strategies in improving community welfare and environmental resilience by giving useful insights into the socioeconomic advantages of these coastal habitats. This is critical for making sound decisions and managing coastal ecosystems for the long term.

Keywords: Coastal ecosystem, Mangroves, livelihood, socio-economic dependence, sustainability.
JEL Classification Codes: EOI, Q56, Q57.

INTRODUCTION

Mangroves, as important coastal ecosystems, contribute greatly to coastal populations' ecological and socioeconomic well-being. Despite accounting for just 0.15 percent of the country's overall land area, these unique ecosystems encompass 4,975 square kilometers in India, accounting for 3 percent of the world's mangrove forest area and 8 percent of Asia's mangrove forestry (Anonymous, 2019). Karnataka has 0.205 percent of India's mangroves, with an area of 10 square kilometers, predominantly in the district of Uttara Kannada (Mesta et al., 2017). India's coastal regions are rich in biodiversity and serve as essential habitats for a variety of flora and animals, including coral reefs, tidal mudflats, estuaries, lagoons, and marshes. These vulnerable coastal habitats, known as Coastal Eco-sensitive Areas (ESAs), are critical to preserving the ecological integrity of the shoreline and sustaining coastal biodiversity. They offer several ecological services that sustain the lives of millions of coastal populations, both directly and indirectly. Several studies (NCSCM, 2013; Census of India, 2011; UNDP, 2014) have investigated the socioeconomic features of coastal communities that rely on commodities and services obtained from these ecosystems. Along Karnataka's coastline, the Uttara Kannada district offers a varied environment of gently sloping hills, plateaus, and coastal strips facing the Arabian Sea. However, the area has seen major changes in land use, including a decrease in the amount of evergreen forests and an increase in built-up areas and monoculture, which might disturb the natural flow of rivers (Ramachandra, 2016). As a result of climate change effects, severe weather events have been documented, which have a negative influence on traditional crops like the saline-resistant Kagga growers and have a negative impact on farmers' livelihoods (Hashmi and Varma, 2018). The Aghanashini estuary stands out as a significant source of bivalve production, feeding more than 60,000 people via a variety of ventures including fishing, aquaculture, and bivalve shell mining. Comparing the river to other rivers in the area, the importance of the river's overall economic services has been underlined (Ramachandra et al., 2013). Despite the value of coastal ecosystems and the benefits they provide, maintaining their sustainability is difficult. As a practical policy tool to create markets for the economic benefits derived from natural ecosystems, the idea of "payment for ecosystem services" (PES) has emerged. According to Le Quesne and McNally (2005), PES may encourage conservation and restoration efforts among coastal communities and transfer property rights for better ecosystem preservation. The potential of mangrove forests to absorb carbon has led to its recognition as a cost-effective climate solution (UNEP-WCMC, 2006). This study aims to clarify the complex interrelationships between coastal populations, mangrove ecosystems, and sustainable development while taking into account the potential contribution of PES to improving environmental conservation and livelihood resilience. The research takes a comprehensive approach, using a variety of indicators to evaluate different elements of community dependence on commodities and services provided by coastal ecosystems. Employment prospects, income levels, accessibility to necessary resources, risk mitigation techniques, community attitudes, and willingness to participate in coastal resource protection are important indicators. The study concentrated on eight coastal villages in the Kumta and Honnavar taluks of the Uttara Kannada district, as illustrated in Figure 1, to guarantee thorough data gathering. The locations of the settlements were carefully picked because they were close to important coastal resources, including mangroves, estuaries, and wetlands. A stratified random selection method was used to choose 200 families from the villages for the sampling phase. These homes were evenly split up into a variety of groups, including farming communities, families with wage workers, and households with people who ran businesses or provided services.

Objectives of the Study

1. To assess the Socio-Economic Impact of Mangrove Restoration on Coastal Communities
2. To critically analyze and evaluate the perceived benefits and challenges associated with dependency on coastal ecosystems

Hypotheses:

H 1: Mangrove restoration in degraded areas would improve the socioeconomic circumstances of coastal communities (resulting in increased income, livelihood options, and general well-being)

H 2: Coastal communities rely heavily on a range of goods and services provided by coastal ecosystems (direct and indirect advantages of these resources)

METHODOLOGY

A pretested questionnaire with five separate parts was created to collect primary data. These sections discussed how households' socioeconomic and resource characteristics were assessed, how much of their livelihoods depended on coastal ecosystems, how likely they were to participate in ecosystem governance, and how effective the current conservation measures were. After a comprehensive training procedure, the field enumerators collected data in July 2021. It is crucial to remember that this research is a component of a larger program that includes collaborative restoration and preservation activities aimed at mangroves. The main goals of the initiative are to encourage sustainable lifestyles based on mangrove ecosystems and earn carbon income for restored lands held by farmers.

Study Area

The study area comprises the bustling coastal villages found in the Kumta and Honnavar taluks of Uttara Kannada district. These places were carefully picked to represent varied distances from critical coastal resources including mangroves, estuaries, and wetlands. The district's distinctive geography, highlighted by its coastal beauty, provides a perfect site for exploring the connections between populations and coastal ecosystems.

RESULTS

This research gives vital insights into the complicated interactions between coastal populations and coastal ecosystems. It evaluates factors including job patterns, income levels, and access to resources, indicating community reliance and measures for limiting hazards. The research also analyses the opinions of coastal populations about environmental governance and their desire to engage in conservation activities. The study is part of a comprehensive approach aiming at repairing and protecting mangroves in a participatory way, concentrating on carbon income and sustainable livelihood options. The results have significance for policymakers, environmentalists, and development practitioners, underlining the necessity of supporting sustainable livelihoods while maintaining and restoring natural resources.

Demographic Profile of the Respondents

The information in Table 1 sheds important light on the socio-demographic traits of the respondents, including information on their age, gender, education, occupation, ownership of property, and income levels. The research area includes coastal communities in the Indian state of Karnataka's Kumta and Honnavar taluks.

Note: Figures are Brackets indiacate the percentage to total respondents

The bulk of respondents (61 percent) belong to the 55 and over age group, showing that there are more senior people in general. The younger generation may be engaging in more non-farming activities in rural regions or looking for jobs in cities, according to this trend. It is also noteworthy that almost one-third of respondents in the senior age category are female, which is likely a result of male migration for employment, leaving women in charge of providing for the family. Additionally, almost 90 percent of these women get widow or old-age pensions, demonstrating their precarious financial situation as they live below the poverty level.

Note: Figures are Brackets indicating percentage to total respondents

The respondents consist of 67 percent male and 33 percent female. Amongst them, 66 percent are married, 7 percent are single, and 27 percent are widowed. The existence of a substantial number of widows further underscores the ramifications of male migration, leaving women as heads of families and facing economic hardships.

Note: Figures are Brackets indicate the percentage to total respondents

According to the respondents' literacy levels, 34.5 percent are illiterate, and the majority have not completed secondary school. Literacy rates in coastal taluks are higher than the state's general literacy rate, indicating an increase in literacy levels in the area. However, the survey also finds a gender discrepancy in literacy rates, highlighting the need of ensuring equal access to education for women.

Note: Figures are Brackets indicating the percentage to total respondents

Farming is the principal occupation of 42 percent of respondents, followed by farm labor (28 percent), and small-scale fishing (20 percent). The majority of farmers (68 percent) rely primarily on farming, rendering them subject to economic hazards. According to land ownership data, the vast majority (86 percent) are marginal farmers with landholdings of less than one hectare. Cropping intensity is modest, with rice and certain vegetables mostly for home use and the odd distress sale.

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The respondents' yearly income varies, falling between Rs. 10,000 and Rs. 33,000. The main sources of this revenue include the growing of crops and vegetables, agricultural work, and fishing. Comparing homes that are 500 meters away from coastal resources with those that are further away finds that those farther away from the resources have higher socioeconomic positions and are less vulnerable. Overall, the information from the respondents' livelihoods rely on the goods and services provided by coastal ecosystems. The data acquired in this research offers a solid basis to comprehend the economic and social circumstances of coastal populations and crucial inputs for creating targeted interventions meant to improve their well-being and encourage sustainable livelihoods. The data also emphasize how critical it is to reduce gender inequalities and improve possibilities for education for women in the area in order to promote inclusive growth for all members of the community. The table shows the proportion of ecological resources that coastal towns are dependent on. The research shows that certain resources are crucial for the lives and welfare of the people. The most important resources are Mangroves, Mud Flats, Rivers/Estuaries, Beaches, and Wildlife Habitats, with reliance percentages exceeding 90 percent. These resources probably provide a variety of ecosystem services, such as fisheries, habitat preservation, and tourist attractions. With percentages ranging from 76 percent to 85.50 percent, terrestrial forests, ponds, lakes, seagrasses, and dunes likewise exhibit high degrees of reliance. The conservation of sand dunes, carbon sequestration, and water resources are only a few examples of the many livelihood opportunities and environmental services that these resources may provide. The moderate reliance on coral reefs, seaweed, tidal pools/rock cliffs, fishing grounds, and fish breeding grounds ranges from 36.50 percent to 68.50 percent. These resources most likely help coastal protection, marine biodiversity preservation, and fishing. With reliance rates of 54 percent and 61.50 percent, respectively, salt marshes and others exhibit lower levels of dependency. These resources could still be very important for maintaining the natural balance and certain communities' way of life. Overall, the results highlight the significance of conserving and sustainably managing coastal ecosystem resources to maintain the well-being of coastal populations and their means of subsistence. To guarantee the resiliency and prosperity of the communities that depend on these resources, conservation efforts should concentrate on preserving their health and functioning.

Note: Figures are Brackets indicating the percentage to total respondents

The table shows how long it takes coastal towns to reach the resource. The information shows how soon and how close to the community the resources are:

Less than 5 minutes

According to the majority of survey participants (51.50 percent), they can access the resource in under 5 minutes. This implies that a sizeable section of the coastal populations has quick access to the resource, which might have a good influence on their everyday lives and means of subsistence.

5–15 minutes

About 26 percent of respondents said that accessing the resource takes them between 5 and 15 minutes. Communities in this category may be a little farther away from the resource, but they still have easy access to it.

16–30 minutes

Nearly 22.50 percent of respondents said that it takes them 16–30 minutes to access the resource. This category most likely consists of towns that are reasonably accessible yet comparatively further away from the resource. According to the data, most coastal towns have rather straightforward access to the resources, with more than half of them being able to do so in less than five minutes. Being so near to the resources may have a big impact on their way of life since it makes it easy for them to participate in ecosystem-based livelihoods like fishing and harvesting natural resources. It also highlights how crucial it is to protect coastal habitats in order to maintain communities' sustainability and access to these resources. Additionally, knowing the period of access may assist in organizing and putting into practice conservation and management policies that give the demands of various people priority according to their proximity to the resources. The table shows how long (in years) coastal towns have been dependent on the resources. It sheds light on how historically connected the communities are to the environmental resources they depend on.

Less than a year

A tiny proportion of respondents (3.50 percent) said that their reliance on resources began less than a year ago. New residents in the coastal region or those who have just begun taking part in activities that depend on the resources may fall into this group.

Two generations

Approximately 13.50 percent of respondents said that they rely on the resources for both of their two generations. This implies that some coastal communities have depended on these resources for a long time—possibly even going back to the preceding generation in excess of two generations: The majority of respondents (44.00 percent) said that they had been dependent on the resources for more than two generations. This suggests that a sizeable number of coastal communities have long-standing, traditional connections to these resources. The results emphasize how the coastal communities' reliance on the resources has persisted through time and across generations. This dependence on the past is an indication of the cultural, economic, and social importance of coastal ecosystems in influencing these people's identities and means of subsistence across time. The significant proportion of respondents who identified as belonging to the "**More than two generations**" group highlights the traditional knowledge and ways of life that have been handed down through the generations, further highlighting how crucial it is to protect ecosystems in order to ensure the survival of these communities. Understanding how long a community has been dependent on a resource may help conservationists and legislators recognize the importance of that resource to the community and create interventions that take into account their historical links and basic needs. In order to maintain the resources of the coastal environment and their good health for the benefit of both the present and coming generations of coastal communities, it is also important to stress the need for sustainable management and conservation techniques.

Note: Figures are Brackets indicating the percentage to total respondents

The table shows how coastal communities see the significance of both direct and indirect resource advantages. The comments provide light on the varied weights given to various advantages resulting from the resources of the coastal environment. Direct advantages are more significant: 17.50 percent of respondents said they place more value on the immediate advantages of using resources than anything else. These immediate advantages might be material ones like food, revenue from the sale of gathered resources, or the direct application of resources to livelihood activities. About 12.50 percent of respondents believe that direct advantages from harvested resources have a somewhat higher value for them than indirect benefits. This group argues that while direct advantages are crucial, they could also place equal weight on other aspect Benefits, both direct and indirect, are equally significant: The majority of respondents (49.00 percent) ranked both in-direct (non-gathered) and direct benefits (from resources harvested) as equally essential. This perspective is in line with the knowledge that, in addition to direct resource extraction, coastal ecosystems provide a broad variety of advantages, including ecosystem services like coastal protection, support for biodiversity, and climate control Direct advantages are rather more significant: Indirect benefits, such as ecological services and non-harvested resources, are somewhat more significant to respondents (18.00 percent) than direct benefits. This frame of view emphasizes how important ecosystem health and resilience are to coastal populations' general well-being. Resources' indirect advantages are rather significant: Only 0.50 percent of respondents think that indirect advantages of resources are only somewhat significant. Respondents who fall into this group usually understand the worth of non-harvested resources but believe that direct benefits are more essential to their lives.

We don't harvest

A tiny percentage of respondents (3.50 percent) said that their household doesn't participate in resource harvesting. This population may depend on other sources of income or get indirect advantages from coastal resources in other ways. The results show how different coastal communities see the significance of various resource advantages from various angles. While many people place a high value on the direct advantages from harvested resources, a significant portion of respondents also acknowledged the significance of indirect benefits, highlighting the multifaceted worth of coastal ecosystems. This understanding of the larger ecosystem services emphasizes the need of sustainable management and conservation activities to maintain the delivery of these fundamental advantages for coastal communities.

Note: Figures are Brackets indicating the percentage to total respondents

The chart shows how coastal towns see the environmental difficulties they confront. The comments clarified the numerous problems that present dangers and have an effect on the communities' welfare and way of life.

Flood

he most often mentioned concern, with 38.00 percent of respondents citing floods as a major problem. Flooding may cause property damage, crop loss, and relocation in coastal regions, particularly during periods of heavy rainfall and high tides.

Drought

Around 17.50 percent of respondents voiced drought-related worries. Even though coastal regions are recognized for being close to water sources, they sometimes face droughts that may have a significant impact on agriculture and water supply.

Sea-level rise

According to 22.00 percent of respondents, this issue is very concerning. Climate change-related sea level rise poses a hazard to populations and ecosystems by causing coastal erosion, saltwater intrusion, and the submergence of low-lying regions.19.00 percent of respondents identified cyclones, hurricanes, or tsunamis as a significant issue. Coastal regions are vulnerable to these severe weather conditions, which may seriously harm infrastructure and way of life. About 14.000 percent of respondents named erosion as one of the major environmental problems. Coastal erosion may result in the loss of land, ecosystems, and coastal protection, which can have an impact on local residents'

livelihoods and safety. Seawater intrusion, which affects agriculture, drinking water, and biodiversity, is a major worry for 70.00 percent of respondents. It happens when seawater seeps into freshwater sources.

Pollution

Almost 50 percent of respondents (49.50 percent) identified pollution as a common problem. Coastal habitats may suffer from pollution from a variety of sources, including home, industrial, and agricultural pollution.

Water scarcity

About 54.0 percent of survey participants said that the issue was urgent. Coastal settlements may experience water shortages while being close to water bodies because of things like over-extraction and pollution. The results illustrate the variety of environmental issues that coastal towns deal with, many of which are often made worse by human activity and climate change. These difficulties may have a serious negative effect on the communities' livelihoods, food security, and general well-being. To solve these issues and safeguard the lives of coastal populations while assuring the preservation of coastal ecosystems, sustainable coastal management and climate resilience methods are crucial.

Policy Suggestions and Implications

PES for Long-Term Survival

The study underlines the potential for PES to enhance the socio-economic status of coastal communities, particularly via carbon revenue generated through mangrove restoration. Carbon credits enable these communities to participate in carbon markets, therefore encouraging mangrove conservation and regeneration.

Involvement of Multiple Stakeholders

The study advocates for multistakeholder cooperation with an emphasis on socioeconomic concerns to address the challenges of mangrove degradation and ensure sustainable conservation. This kind of collaboration has the potential to promote fair and sustainable development that benefits both local people and the global environment.

CONCLUSION

The maritime ecosystems of India's Uttara Kannada district are essential for supporting local residents' livelihoods and providing essential ecosystem services. This research examined the community's reliance on the products and services provided by coastal ecosystems, how important they think resources are, and the environmental issues they deal with. The results highlight the need of maintaining these ecosystems and putting into place sustainable management techniques to protect the well-being of coastal populations. According to the communities' socio-demographic profile, a significant share of the population is elderly, showing a tendency for younger people to move to metropolitan regions or engage in non-farm activities. The majority of families, the majority of whom were marginal farmers, depended on farming as their main source of income. Their ability to sustain their way of life faces serious obstacles as a result of their reliance on agriculture, diminishing forest cover, and unpredictable weather patterns. The communities showed a strong knowledge of and reliance on the products and services provided by coastal ecosystems. Among the most important resources were mangroves, coral reefs, mud flats, and estuaries. The availability of resources nearby made it simple for people to obtain them, thus increasing their dependence. Coastal societies understood the multifaceted importance of coastal ecosystems, valuing equally significant both the direct advantages of harvested resources and the indirect benefits of ecosystem services. This viewpoint emphasizes the relevance of ecosystem health and the wide range of advantages they provide, from food and revenue to coastal protection and support for biodiversity. However, the research also identified a number of environmental difficulties that coastal towns confront. Among the main issues were frequent floods, sea level rise, storms, saltwater intrusion, pollution, and water shortages. The livelihoods of the people, the agricultural industry, and their general well-being are all seriously threatened by these issues. The results highlight the need for thorough conservation and sustainable management policies that emphasize ecosystem health and the many advantages they provide. To solve

environmental concerns and safeguard priceless coastal resources, policymakers, environmentalists, and local people must collaborate to create climate-resilient and adaptable methods. Maintaining these ecosystems would not only guarantee future livelihoods but also maintain the coastal region's distinctive biodiversity and ecological integrity. The findings of this research may act as a starting point for the design of policies and decisions that will enhance the resilience and well-being of coastal communities in the face of shifting environmental circumstances.

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Table-1: Age Distribution of Respondents

Age Group	Within 500 meters	Outside 500 meters	Total
Young (<35)	5 (2.50)	5 (2.50)	10 (5.00)
Middle (35-50)	35 (17.50)	33 (16.50)	68 (34.00)
Old (>50)	60 (30.00)	62 (31.00)	122 (61.00)
Total	100 (50.00)	100 (50.00)	200 (100.00)
Mean	54.93	56.13	55.68
Standard Deviation	13.1	14.28	13.66

Source: Field Survey

Table-2: Gender and Marital Status of Respondents

Category	Within 500 meters	Outside 500 meters	Total
Male	71 (35.50)	63 (31.50)	134 (67.00)
Female	29 (14.50)	37 (18.50)	66 (33.00)
Married	65 (32.50)	67 (33.50)	132 (66.00)
Unmarried	7 (3.50)	7 (3.50)	14 (7.00)
Widow	28 (14.00)	26 (13.00)	54 (27.00)

Source: Field Survey

Table-3: Education Level of Respondents

Education Level	Within 500 meters	Outside500 meters	Total
Illiterate	37 (18.50)	32 (16.00)	69 (34.50)
Primary	20 (10.00)	23 (11.50)	43 (21.50)
Higher Primary	16 (8.00)	20 (10.00)	36 (18.00)
High School	12 (6.00)	24 (12.00)	36 (18.00)
Higher Secondary	3 (1.50)	6 (3.00)	9 (4.50)
Graduation	1 (0.50)	3 (1.50)	4 (2.00)
Post-Graduation	0	3 (1.50)	3 (1.50)

Source: Field Survey

Table-4: Occupational Profile of Respondents

Occupation	Within 500 meters	Outside 500 meters	Total
Agriculture	43 (21.50)	41 (20.50)	84 (42.00)
Fisheries	24 (12.00)	15 (7.50)	39 (19.50)
Wage Earner	31 (15.50)	25 (12.50)	56 (28.00)
Government Servants	0	5 (2.50)	5 (2.50)
Housewife	1 (0.50)	6 (3.00)	7 (3.50)
Business	1 (0.50)	6 (3.00)	7 (3.50)
Others	0	2 (1.00)	2 (1.00)

Source: Field Survey

Table-5: Land Ownership and Income of Respondents

Land Holding	Within 500 meters	Outside 500 meters	Total
No Land	35 (17.50)	34 (17.00)	69 (34.50)
Marginal (up to 1 ha)	43 (21.50)	48 (24.00)	91 (45.50)
Small (1-4 ha)	22 (11.00)	16 (8.00)	38 (19.00)
Large (more than 4 ha)	2 (1.00)	2 (1.00)	4 (2.00)

Source: Field Survey

Table-6: Income Levels of Respondents

Income Range (Rs.)	Within 500 meters	Outside 500 meters	Total
Below 10,000	1 (0.50)	0	1 (0.50)
10,000 - 33,000	96 (48.00)	84 (42.00)	180 (90.00)
33,000 - 50,000	0	2 (1.00)	2 (1.00)
50,000 - 1,00,000	0	2 (1.00)	2 (1.00)
Above 1,00,000	3 (1.50)	8 (4.00)	15 (7.50)
Mean	16,890	43,720	30,305
Standard Deviation	21,862	1,18,861	86,706.06

Source: Field Survey

Table 7: Coastal Resources Dependency

Sl. No.	Resources	N	Percentage
1	Mangroves	187	92.57
2	Coral reef	73	36.50
3	Dunes	152	76.00
4	Mud Flats	192	96.00
5	Rivers/Estuaries	195	97.50
6	Salt marshes	108	54.00
7	Seaweeds	80	40.00
8	Seagrasses	102	51.00
9	Beaches	180	90.00
10	Tidal pools/Rock cliffs	137	68.50
11	Wildlife Habitats (turtles, Horseshoe crabs)	199	99.50
12	Terrestrial forest	159	79.50
13	Ponds/Lake	171	85.50
14	Fishing ground	116	58.00
15	Fish breeding ground	116	58.00
16	Others	123	61.50

Source: Field Survey

Table-8: Duration of Time to Access the Resource

Sl. No.	Categories	Frequency (percent)
1	Less than 5 minutes	103 (51.50)
2	5-15 minutes	52 (26.00)
3	16-30 minutes	45 (22.50)

Source: Field Survey

Table-9: Duration (years) of dependency on the resources

Sl. No.	Categories	Frequency (percent)
1	Less than one year	7 (3.50)
2	Two generations	27 (13.50)
3	More than two generations	88 (44.00)

Table-10: Perception of the benefits of coastal resources

Sl. No.	Categories	Frequency (percent)
1	Direct benefits (from harvested resources) are more important	33 (17.50)
2	Direct benefits (from harvested resources) are a little more important	25 (12.50)
3	Direct benefits and in-direct (non-harvested) benefits are equally important	98 (49.00)
4	In-direct (non-harvested) benefits are a little more important	36 (18.00)
5	In-direct benefits of resources are a little important	01 (0.50)
6	Our household does not harvest	07 (3.50)

Source: Field Survey

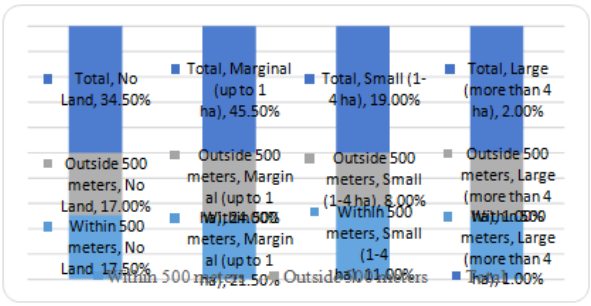


Fig-1 Land ownership and the Source of income

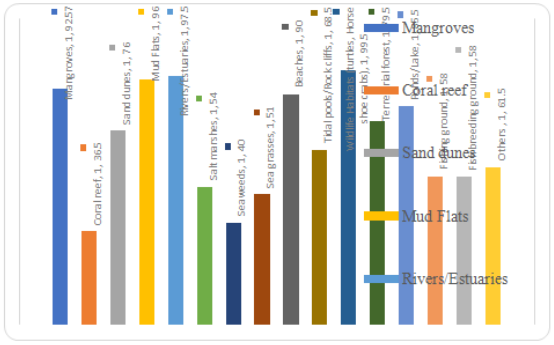


Fig-2: Knowledge and accessibility of coastal resource

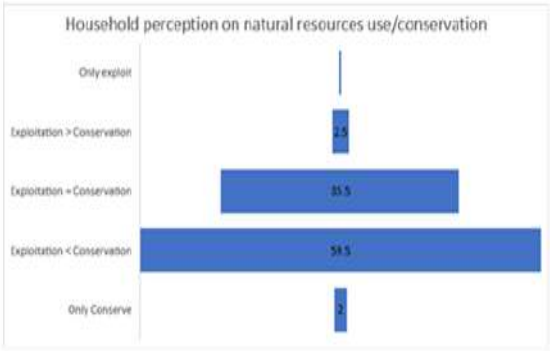


Fig-3: Perception of natural resource usage and conservation by respondents.

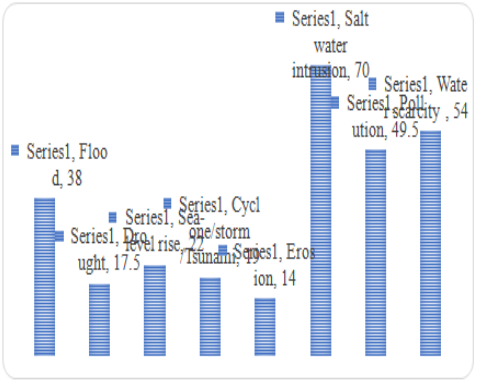


Fig-4: Perceived Environmental Hazards

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RESEARCH ARTICLE

Effect of Respiratory Muscle Stretch Gymnastic (RMSG) on Chest Expansion in Middle Age Obese Population of Ahmedabad City : An Experimental Study

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ABSTRACT

The aim of the present study is to determine the effectiveness of respiratory muscle stretch gymnastic on chest expansion in middle age population of Ahmedabad city. Total 30 subjects accordance with the Asian criteria of BMI, middle age population (< 27) was selected in the study. Subjects with the history of pulmonary conditions, insignificant cardiac disease or neurological conditions were excluded from the study. The protocol of respiratory muscle stretch gymnastic pattern was given for 15 days, 5 days/week, 10 times/session with 2 session/day. Before and after completion of session chest expansion at axillary, nipple level and xiphisternal level was measured. As the data was not normally distributed, non parametric Wilcoxon test was used for comparing within data. Statistical analysis shows that there was significant improvement on chest expansion at all the three levels. Study concluded that respiratory muscle stretch gymnastic patterns are useful in improving chest expansion thereby improves the lung capacity of middle age obese population.

Keywords: respiratory muscle stretch gymnastic, chest expansion, obese population

INTRODUCTION

The world wild prevalence of overweight and obesity has doubled since 1980 to an extent nearly a third of the world population is now classified an overweight or obese. Obesity adversely affects nearly all physiological functions of the body and compromises a significant public health threat. It increases the risk for developing multiple diseases conditions, such as diabetes mellitus, cardiovascular disease, several types of cancers, an array of musculoskeletal

disorders, and poor mental health[1]. Obesity as one of the major health concerns it has reached a worldwide epidemic dimension. Obesity is frequently associated with, include breathing at lower lung volumes, decreased thoracic and lung compliance, increased respiratory resistance secondary from the reduction in lung volumes, reduction in respiratory muscle strength, heterogeneity of ventilation distribution, increased pulmonary diffusion and hypercapnic respiratory failure[2].However aging is associated with decrease in lung complication and thoracic mobility. Kyphotic curvature of spine occurs due to aging, which increases AP diameter of the thoracic area. Which cause the reduction of chest expansion because of different causes like obesity and weak accessory muscle. Obesity has significant effect upon the pulmonary mechanics. BMI has a direct relationship with the degree of airways resistance and work of breathing, and is inversely correlated with the thoracic lung volumes[3]. RMSG is a group of stretching exercises sequentially performed to stretch specific muscles involved in respiration. It stretches the external intercostals muscles during inspiration and the internal intercostals muscles during expiration, which aims to reduce chest wall stiffness. Respiratory muscle stretch gymnastic (RSMG) is a combination of stretching and breathing used simultaneously, which is proven to be beneficial in improving the function of respiratory muscles in the elderly[4]. In obesity the mechanical properties of the lungs and chest wall are altered significantly, it might be due to deposition of fat in the mediastinum and the abdominal cavities. These alterations reduce the lung compliance, chest wall and entire respiratory system, and likely contribute to the respiratory symptoms of obesity such as dyspnoea and wheeze breathing pattern is also alter by reduction in respiratory system compliance (increased stiffness)[5]. So the aim of the present study is to determine the effect of respiratory muscle stretch gymnastic on chest expansion among middle age obese population of Ahmedabad city.

MATERIALS AND METHODS

An experimental study was conducted among 30 obese middle age (40 to 60 years) population of Ahmedabad city. Criteria of obesity were selected from Asian criteria of body mass index. Both male and female and the subjects who understands the procedure and follows the command was included in the study. Participants with the history of any neurological condition, cardio respiratory conditions, or musculoskeletal disorders related to the spine was excluded from the present study. Informed consent was taken from all the participants. Participant was made to perform RSMG pattern 5days/week under the guidance of author for 2 weeks with 10 repetition/session and 2 sessions/day.

Following Respiratory muscle stretch gymnastic pattern was performed

- **Pattern 1: Elevating the shoulders**
  As you slowly breathe in through your nose, gradually elevate both the shoulders. After taking a deep breath, slowly breath out through your mouth, relax and lower your shoulders.
- **Pattern 2: Stretching the upper chest slowly**
  Place both the hands on your upper chest. Pull back your elbows and pull down your chest while lifting your chin and inhaling a deep breath through your nose. Expire through your mouth and relax.
- **Pattern 3: Stretching the back muscle**
  Hold your hands in front of your chest. As you slowly breath in through your nose, Move tour hands frontward and down and stretch your back. After deep inspiration, slowly breath out and resume the original position.
- **Pattern 4: Stretching the Lower chest**
  Hold the end of the towel with both hands outstretched at shoulder height. After taking a deep breath, move your arms up while breathing out slowly. After deep expiration, lower your hands and breathe normally.
- **Pattern 5: Elevating the Elbow**
  Hold one hand behind your head. Take a deep breath through your nose. While slowly exhaling through your mouth, Stretch your trunk by raising your elbow as high as is easily possible. Return to the original position while breathing normally. Repeat the process using the alternate hand behind the head. (While doing this

exercise one hand is used to protect the surgical wound to prevent exacerbating post CABG pain - therapist can also support the wound by himself).[6]

Outcome measure

Chest circumference was measured at three different levels, axillary, nipple and xiphisternal level using a flexible measuring tape. Placement of measuring tape

a) **At axilla level**: Anteriorly 3rd intercostal space at mid clavicular line. Posteriorly 5th thoracic spinous process.
b) **At nipple level**: anteriorly 5th intercostals space at mid clavicular line. Posteriorly 7th thoracic spinous process.
c) **At xiphisternal level**: Anteriorly tip of the xiphoid process. Posteriorly 10th thoracic spinous process[7]. As an outcome measure Chest expansion with measure tape method at axillary level, nipple level and xiphisternal level was taken before and after 15 days of completion of RMSG pattern.

RESULT

A study was conducted amongst 30 obese middle age population who met the inclusion and exclusion criteria. Pre and post 15 days of RMSG protocol, chest expansion with measure tape method at all the three levels axillary, nipple and xiphisternal was taken as an outcome measure. Analysis was done using SPSS version 20.0. As the data was not normally distributed, non parametric Wilcoxon test was used for within comparison. Statically analysis shows significant changes at axillary level $z= -6.714$, $p< 0.00$, nipple level $z= -6.613$, $p <0.00$ and xiphisternal level $z= -6.673$, $p<0.00$.

DISCUSSION

In the present study we observed the effect of 15 days protocol of RMSG pattern among obese male population of Ahmedabad city, Gujarat, India. Result concluded that there was significant changes noted on chest expansion after completion of 15 days of RMSG protocol at all the levels. RMSG is based on theory of Lapascle's law, Ventilation of Lung depends upon the Length of Respiratory muscle. When the respiratory muscles are in optimal length maximum force is generated. During RMSG muscle spindle stimulates & sends signals to alpha motor neuron, as a result of which extrafusal fibers of muscle spindle contracts so, according to the frank starling law more the muscle contracts, the more it will relax. Hence by Giving RMSG, Optimal Length of the respiratory Muscle can be reached. So it might be the reason that the present study find the improvement on chest expansion by RMSG in obese population [8]. Study done by Ganesh BR, Anantlaxmi Goud, in 2017 further supported the present study which shows improvement on chest expansion and pulmonary function by applying 5 days of RMSG protocol and hold relax PNF technique amongst 40 subjects with age group above 60 years. Also, Hagbarth et al. reported RMSG, designed to stretch the respiratory muscles which affected chest wall compliance and decreased chest wall stiffness hence improved the pulmonary function and chest expansion[9]. Marek, 2005, Taylor et al., 1990, have reported the acute effects of stretching study concluded that single session of muscle stretching could increase the extensibility of soft tissues by affecting the contractile properties of muscle fibers and the viscoelastic changes promoted in the muscle-tendon unit[10]. Limitation of the present study was comparison was not done with the conventional group, uneven ratio was there between male and female, follow up was not taken after completion of protocol. Future recommendation is functional capacity and quality of life should be taken in consideration, comparison of all age group, comparison of all BMI range according to asian as well as WHO criteria should be done.

CONCLUSION

Respiratory muscle stretch gymnastic patterns are useful in improving chest expansion thereby improves the lung capacity of middle age obese population of Ahmedabad city.

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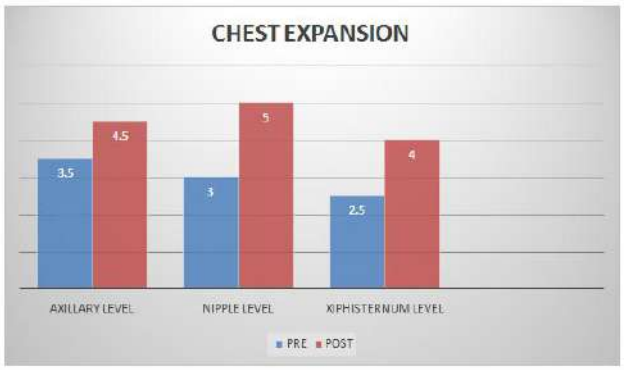
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Table number: 1 Mean and SD of Chest Expansion

LEVELS	Pre Mean±SD	Post Mean±SD
Axillary	3.5±0.707	4.5±0.70
Nipple	3±1.414	5±0.0
Xiphisternal	2.5±0.707	4±0.0



Graph: 1 Pre and Post Intervention

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RESEARCH ARTICLE

Lehmer – 3 mean Labeling of Theta Related Graphs

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ABSTRACT

A graph G with p vertices and q edges is calledLehmer - 3mean graph if it is possible to label the vertices $x \epsilon V$ with distinct lables$g(x)$from $1,2,\dots,q+1$ in such a way that when each edge $e=uv$ is labeled with $g(e=uv)=\left\lceil\frac{g(u)^3+g(v)^3}{g(u)^2+g(v)^2}\right\rceil$ or $\left\lfloor\frac{g(u)^3+g(v)^3}{g(u)^2+g(v)^2}\right\rfloor$, then the resulting edge labels are distinct. In this case g is called a Lehmer – 3 mean labeling of G. In this paper we prove that theta related graphs such as $\theta_\gamma, \theta_\gamma \odot \overline{K}_1, \theta_\gamma \odot \overline{K}_2, \theta_\gamma \odot \overline{K}_3$, $\theta_\gamma \odot K_2, S(\theta_\gamma), \left(S(\theta_\gamma)\right) \odot \overline{K}_1, \left(S(\theta_\gamma)\right) \odot \overline{K}_2, \left(S(\theta_\gamma)\right) \odot \overline{K}_3, \left(S(\theta_\gamma)\right) \odot K_2$ are all Lehmer – 3 mean graphs.

Keywords: Graph, Lehmer – 3 Mean Labeling, Corona Product of G, Subdivision of G, Theta Graph.

INTRODUCTION

Graph Theory is a branch of mathematics concerned with networks of points connected by lines. The subject of graph theory had its beginning in recreational with problems but it has grown into a significant area of mathematical research , application in chemistry, operations research, social science, application in biology and computer science. Graph labeling is one of the fascinating areas of graph theory with wide range of applications. A graph labeling is an assignment of integers to the vertices or the edges or both, subject to certain conditions. If the domain is the set of vertices we speak about the vertex labeling. If the domain is the set of edges, then the labeling is called edge labeling. Most graph labeling methods trace their origin to the one introduced by Rosa in 1967. Over the past three decades more than 600 papers have been published in graph labeling**.** For all other standard terminology and notations we follow Harary [3]. Graph labeling is used in many areas of sciences and technology. A lot of graph labeling

techniques are discussed in [2]. The concept and notation of mean labeling was first introduced by S. Somasundaram and R. Ponraj [9].S. Somasundaram, S.S.Sandya and T. Pavithra[10] introduced the concept of Lehmer -3 mean labeling of graphsand studied their behavior in [11], [12], [13] and [14]. Meena. S and Mani. R [6] investigated this labeling for some cycle related graphs. Meena. S and R. Mani [7] proved root square mean labeling of theta related graphs. Paramaguru. N and Manirathnam. D [8] investigated Lehmer – 3 mean labeling of cycle related graphs. Prime cordial labeling for theta graph has been proved by Sugumaran. A and Vishnu Prakash. P [15] and they also find some new lehmer -3 mean graphs in [4,5]. In this paper, we examine about the lehmer – 3 mean labeling of theta related graphs and some new examples are presented and verified. We now give the definitions which are necessary for the present investigation.

Definition: 1.1
The Corona of two graphs G_1 and G_2 is the graph $G = G_1 \odot G_2$ formed by taking one copy of G_1 and $|V(G_1)|$ copies of G_2 where the ith vertex of G_1 is adjacent to every vertex in the ith copy of G_2.

Definition: 1.2
A subdivision graph $S(G)$ of a graph G is a graph obtained from G by subdividing all edges of G exactly once.

Definition: 1.3
A theta graph is a block with two non-adjacent vertices of degree 3 and all other vertices of degree 2 is called a theta graph and it is denoted by θ_γ.

Notation
Here $\lceil h \rceil$ is the least integer greater than or equal to h and $\lfloor h \rfloor$ is the greatest integer less than or equal to h.

MAIN RESULTS

In this paper, we investigate the lehmer – 3 mean labeling of theta related graphs.

Theorem: 2.1
Theta θ_γ is a lehmer – 3 mean graph.

Proof
Let $G = \theta_\gamma$
Let $r_1 r_2 \dots r_\gamma$ be the vertices of theta in G.
Let $V(G) = \{r_1 r_2 \dots r_\gamma\}$
$E(G) = \{r_j r_{j+1} \,/\, 1 \le j \le \gamma - 1\} \cup \{r_2 r_\gamma, r_1 r_{\gamma-2}\}$.
Define a mapping $g: V(G) \to \{1,2, \dots, \gamma + 1\}$ by
$g(r_j) = j$ for $1 \le j \le \gamma - 1$
$g(r_\gamma) = \gamma + 1$
Then the edge lables are
$g(r_j r_{j+1}) = j$ for $1 \le j \le \gamma - 4$
$g(r_j r_{j+1}) = j + 1$ for $\gamma - 3 \le j \le \gamma - 1$
$g(r_{\gamma-1} r_\gamma) = \gamma + 1$
$g(r_1 r_{\gamma-2}) = \gamma - 3$
$g(r_2 r_\gamma) = \gamma$
Hence g is a lehmer – 3 mean labeling of G.

Theorem: 2.2
$\theta_\gamma \odot \overline{K}_1$ is a lehmer – 3 mean graph.

Proof:
Let $G = \theta_\gamma \odot \overline{K}_1$
Let $r_1 r_2 \dots r_\gamma$ be the vertices of theta in G.
Let $s_1 s_2 \dots s_\gamma$ be the pendant vertices attached at $r_1 r_2 \dots r_\gamma$ respectively.
Let $V(G) = \{r_1 r_2 \dots r_\gamma, s_1 s_2 \dots s_\gamma\}$
$E(G) = \{r_j r_{j+1} / 1 \le j \le \gamma - 1\} \cup \{r_j s_j / 1 \le j \le \gamma\} \cup \{r_2 r_\gamma, r_1 r_{\gamma-2}\}$.
Define a mapping $g: V(G) \to \{1,2, \dots, 2\gamma + 1\}$ by
$g(r_j) = 2j - 1$ for $1 \le j \le \gamma - 1$
$g(r_\gamma) = 2\gamma$
$g(s_j) = 2j$ for $1 \le j \le \gamma - 1$
$g(s_\gamma) = 2\gamma + 1$
Then the edge lables are
$g(r_j r_{j+1}) = 2j$ for $1 \le j \le \gamma - 4$
$g(r_j r_{j+1}) = 2j + 1$ for $\gamma - 3 \le j \le \gamma - 1$
$g(r_1 r_{\gamma-2}) = \gamma + 1$
$g(r_2 r_\gamma) = 2\gamma$
$g(r_j s_j) = 2j - 1$for $1 \le j \le \gamma - 3$
$g(r_j s_j) = 2j$for $\gamma - 2 \le j \le \gamma - 1$
$g(r_\gamma s_\gamma) = 2\gamma +$
Hence g is a lehmer – 3 mean labeling of G.

Theorem: 2.3
$\theta_\gamma \odot \overline{K}_2$ is a lehmer – 3 mean graph.

Proof
Let $G = \theta_\gamma \odot \overline{K}_2$
Let $r_1 r_2 \dots r_\gamma$ be the vertices of theta in G.
Let $s_1 s_2 \dots s_\gamma$ and $t_1 t_2 \dots t_\gamma$be the pendant vertices attached at $r_1 r_2 \dots r_\gamma$ respectively.
Let $V(G) = \{r_1 r_2 \dots r_\gamma, s_1 s_2 \dots s_\gamma, t_1 t_2 \dots t_\gamma\}$
$E(G) = \{r_j r_{j+1} / 1 \le j \le \gamma - 1\} \cup \{r_j s_j / 1 \le j \le \gamma\} \cup \{r_j t_j / 1 \le j \le \gamma\} \cup \{r_2 r_\gamma, r_1 r_{\gamma-2}\}$.
Define a mapping $g: V(G) \to \{1,2, \dots, 3\gamma + 1\}$ by
$g(r_j) = 3j - 2$ for $1 \le j \le \gamma - 2$
$g(r_j) = 3j - 1$ for $\gamma - 1 \le j \le \gamma$
$g(s_j) = 3j - 1$ for $1 \le j \le \gamma - 2$
$g(s_j) = 3j$for $\gamma - 1 \le j \le \gamma$
$g(t_j) = 3j$ for $1 \le j \le \gamma - 2$
$g(t_j) = 3j + 1$ for $\gamma - 1 \le j \le \gamma$
Then the edge lables are
$g(r_j r_{j+1}) = 3j$ for $1 \le j \le \gamma - 3$
$g(r_j r_{j+1}) = 3j + 1$ for $\gamma - 2 \le j \le \gamma - 1$
$g(r_1 r_{\gamma-2}) = 2\gamma - 1$
$g(r_2 r_\gamma) = 3\gamma - 1$
$g(r_j s_j) = 3j - 2$ for $1 \le j \le \gamma - 3$
$g(r_j s_j) = 3j - 1$for $\gamma - 2 \le j \le \gamma - 1$
$g(r_\gamma s_\gamma) = 3\gamma$
$g(r_j t_j) = 3j - 1$for $1 \le j \le \gamma - 3$
$g(r_j t_j) = 3j$for $\gamma - 2 \le j \le \gamma - 1$
$g(r_\gamma t_\gamma) = 3\gamma + 1$

Hence g is a lehmer – 3 mean labeling of G.

Theorem: 2.4

$\theta_\gamma \odot \overline{K}_3$ is a lehmer – 3 mean graph.

Proof

Let $G = \theta_\gamma \odot \overline{K}_3$

Let $r_1 r_2 \dots r_\gamma$ be the vertices of theta in G.

Let $s_1 s_2 \dots s_\gamma, t_1 t_2 \dots t_\gamma$ and $w_1 w_2 \dots w_\gamma$ be the pendant vertices attached at $r_1 r_2 \dots r_\gamma$ respectively.

Let $V(G) = \{r_1 r_2 \dots r_\gamma, s_1 s_2 \dots s_\gamma, t_1 t_2 \dots t_\gamma, w_1 w_2 \dots w_\gamma\}$

$E(G) = \{r_j r_{j+1} \ / \ 1 \le j \le \gamma - 1\} \cup \{r_j s_j \ / \ 1 \le j \le \gamma\} \cup \{r_j t_j \ / \ 1 \le j \le \gamma\} \cup \{r_j t_j \ / \ 1 \le j \le \gamma\} \cup \{r_2 r_\gamma, r_1 r_{\gamma-2}\}$.

Define a mapping $g: V(G) \to \{1,2, \dots, 4\gamma + 2\}$ by

$g(r_j) = 4j - 3$ for $1 \le j \le \gamma - 3$

$g(r_j) = 4j - 2$ for $\gamma - 2 \le j \le \gamma - 1$

$g(r_\gamma) = 4\gamma - 1$

$g(s_j) = 4j - 2$ for $1 \le j \le \gamma - 3$

$g(s_j) = 4j - 1$ for $\gamma - 2 \le j \le \gamma - 1$

$g(s_\gamma) = 4\gamma$

$g(t_j) = 4j - 1$ for $1 \le j \le \gamma - 3$

$g(t_j) = 4j$ for $\gamma - 2 \le j \le \gamma - 1$

$g(t_\gamma) = 4\gamma + 1$

$g(w_j) = 4j$ for $1 \le j \le \gamma - 3$

$g(w_j) = 4j + 1$ for $\gamma - 2 \le j \le \gamma - 1$

$g(w_\gamma) = 4\gamma + 2$

Then the edge lables are

$g(r_j r_{j+1}) = 4j$ for $1 \le j \le \gamma - 4$

$g(r_j r_{j+1}) = 4j + 1$ for $\gamma - 3 \le j \le \gamma - 1$

$g(r_1 r_{\gamma-2}) = 3\gamma - 5$

$g(r_2 r_\gamma) = 4\gamma - 2$

$g(r_j s_j) = 4j - 3$ for $1 \le j \le \gamma - 3$

$g(r_j s_j) = 4j - 2$ for $\gamma - 2 \le j \le \gamma - 1$

$g(r_\gamma s_\gamma) = 4\gamma - 1$

$g(r_j t_j) = 4j - 2$for $1 \le j \le \gamma - 3$

$g(r_j t_j) = 4j - 1$ for $\gamma - 2 \le j \le \gamma - 1$

$g(r_\gamma t_\gamma) = 4\gamma$

$g(r_j w_j) = 4j - 1$for $1 \le j \le \gamma - 3$

$g(r_j w_j) = 4j$for $\gamma - 2 \le j \le \gamma - 1$

$g(r_\gamma w_\gamma) = 4\gamma + 1$

Hence g is a lehmer – 3 mean labeling of G.

Theorem: 2.5

$\theta_\gamma \odot K_2$ is a lehmer – 3 mean graph.

Proof:

Let $G = \theta_\gamma \odot K_2$

Let $r_1 r_2 \dots r_\gamma$ be the vertices of theta in G.

Let $s_1 s_2 \dots s_\gamma$ and $t_1 t_2 \dots t_\gamma$ be the pendant vertices attached at $r_1 r_2 \dots r_\gamma$ respectively.

Let $V(G) = \{r_1 r_2 \dots r_\gamma, s_1 s_2 \dots s_\gamma, t_1 t_2 \dots t_\gamma\}$

$E(G) = \{r_j r_{j+1} / 1 \le j \le \gamma - 1\} \cup \{r_j s_j / 1 \le j \le \gamma\} \cup \{r_j t_j / 1 \le j \le \gamma\} \cup \{s_j t_j / 1 \le j \le \gamma\} \cup \{r_2 r_\gamma, r_1 r_{\gamma-2}\}$.
Define a mapping $g: V(G) \to \{1,2, \dots, 4\gamma + 1\}$ by
$g(r_j) = 4j - 3$for $1 \le j \le \gamma - 3$
$g(r_j) = 4j - 2$for $\gamma - 2 \le j \le \gamma - 1$
$g(r_\gamma) = 4\gamma - 1$
$g(s_j) = 4j - 2$ for $1 \le j \le \gamma - 3$
$g(s_j) = 4j - 1$for $\gamma - 2 \le j \le \gamma - 1$
$g(s_\gamma) = 4\gamma$
$g(t_j) = 4j - 1$ for $1 \le j \le \gamma - 3$
$g(t_j) = 4j$ for $\gamma - 2 \le j \le \gamma - 1$
$g(t_\gamma) = 4\gamma + 1$
Then the edge lables are

$g(r_j r_{j+1}) = 4j$ for $1 \le j \le \gamma - 3$
$g(r_j r_{j+1}) = 4j + 1$ for $\gamma - 2 \le j \le \gamma - 1$
$g(r_1 r_{\gamma-2}) = 3\gamma - 1$
$g(r_2 r_\gamma) = 4\gamma - 2$
$g(r_j s_j) = 4j - 3$ for $1 \le j \le \gamma - 3$
$g(r_j s_j) = 4j - 2$ for $\gamma - 2 \le j \le \gamma - 1$
$g(r_\gamma s_\gamma) = 4\gamma - 1$
$g(r_j t_j) = 4j - 2$ for $1 \le j \le \gamma - 3$
$g(r_j t_j) = 4j - 1$ for $\gamma - 2 \le j \le \gamma - 1$
$g(r_\gamma t_\gamma) = 4\gamma$
$g(s_j t_j) = 4j - 1$ for $1 \le j \le \gamma - 3$
$g(s_j t_j) = 4j$ for $\gamma - 2 \le j \le \gamma - 1$
$g(s_\gamma t_\gamma) = 4\gamma + 1$

Hence g is a lehmer – 3 mean labeling of G.

heorem: 2.6
$S(\theta_\gamma)$ is a lehmer – 3 mean graph.

Proof:
Let $G = S(\theta_\gamma)$
Let $r_1 r_2 \dots r_\gamma$ be the vertices of theta in G.
Let $s_1 s_2, .., s_\gamma$ be the vertices of subdivision theta graph $S(G)$.
Let $V(G) = \{r_1 r_2 \dots r_\gamma, s_1 s_2, .., s_\gamma\}$
$E(G) = \{r_j s_{j+1} / 1 \le j \le \gamma - 1\} \cup \{s_j r_j / 1 \le j \le \gamma\} \cup \{s_2 r_{\gamma-2}, r_2 s_{\gamma+1}\}$.
Define a mapping $g: V(G) \to \{1,2, \dots, 2\gamma + 2\}$ by

$g(r_j) = 2j$ for $1 \le j \le \gamma$
$g(s_j) = 2j - 1$ for $1 \le j \le \gamma$
$g(s_\gamma) = 2\gamma + 2$

Then the edge lables are

$g(r_j s_{j+1}) = 2j$ for $1 \le j \le \gamma - 3$
$g(r_j s_{j+1}) = 2j + 1$ for $\gamma - 2 \le j \le \gamma - 1$
$g(r_\gamma s_{\gamma+1}) = 2\gamma + 2$
$g(r_2 s_{\gamma+1}) = 2\gamma + 1$
$g(s_1 r_{\gamma-2}) = 2\gamma - 5$
$g(s_j r_j) = 2j - 1$ for $1 \le j \le \gamma - 3$
$g(s_j r_j) = 2j$ for $\gamma - 2 \le j \le \gamma$

Hence g is a lehmer – 3 mean labeling of G.

Theorem: 2.7

$\left(S(\theta_\gamma)\right) \odot \bar{K}_1$ is a lehmer – 3 mean graph.

Proof:

Let $G = \left(S(\theta_\gamma)\right) \odot \bar{K}_1$

Let $r_1 r_2 \dots r_{2\gamma+1}$ be the vertices of subdivision theta graph $S(G)$.

Let $s_1 s_2, .., s_{2\gamma+1}$ be the pendant vertices attached at $r_1 r_2 \dots r_{2\gamma+1}$ respectively.

Let $V(G) = \{r_1 r_2 \dots r_{2\gamma+1}, s_1 s_2, .., s_{2\gamma+1}\}$

$E(G) = \{r_j r_{j+1} \,/\, 1 \le j \le 2\gamma\} \cup \{s_j r_j \,/\, 1 \le j \le 2\gamma+1\} \cup \{r_1 r_{2\gamma-4}, r_4 r_{2\gamma+1}\}$.

Define a mapping $g: V(G) \to \{1,2, \dots, 4\gamma+4\}$ by

$g(r_j) = 2j-1$ for $1 \le j \le 2\gamma-4$

$g(r_j) = 2j$ for $2\gamma-3 \le j \le 2\gamma$

$g(r_{2\gamma+1}) = 4\gamma+3$

$g(s_j) = 2j$ for $1 \le j \le 2\gamma-4$

$g(s_j) = 2j+1$ for $2\gamma-3 \le j \le 2\gamma$

$g(s_{2\gamma+1}) = 4\gamma+4$

Then the edge lables are

$g(r_j r_1) = 2j$ for $1 \le j \le \gamma+1$

$g(r_j r_1) = 2j+1$ for $\gamma+2 \le j \le \gamma-1$

$g(r_{2\gamma+1} r_{2\gamma}) = 4\gamma+2$

$g(r_{2\gamma+1} r_1) = 4\gamma+1$

$g(r_{2\gamma+1} r_4) = 3\gamma-3$

$g(r_j r_{j+1}) = 2j-1$ for $1 \le j \le \gamma+2$

$g(r_j r_{j+1}) = 2j$ for $\gamma+3 \le j \le 2\gamma$

$g(r_{2\gamma+1} s_{2\gamma+1}) = 4\gamma+3$

Hence g is a lehmer – 3 mean labeling of G

Theorem: 2.8

$(S(\theta_\gamma) \odot \bar{K}_2$ is a lehmer – 3 mean graph.

Proof:

Let $G = (S(\theta_\gamma) \odot \bar{K}_2$

Let $r_1 r_2 \dots r_{2\gamma+1}$ be the vertices of subdivision theta graph $S(G)$.

Let $s_1 s_2, .., s_{2\gamma+1}$ and $t_1 t_2, .., t_{2\gamma+1}$ be the pendant vertices attached at $r_1 r_2 \dots r_{2\gamma+1}$ respectively.

Let $V(G) = \{r_1 r_2 \dots r_{2\gamma+1}, s_1 s_2, .., s_{2\gamma+1}, t_1 t_2, .., t_{2\gamma+1}\}$

$E(G) = \{r_j r_{j+1} \,/\, 1 \le j \le 2\gamma\} \cup \{r_j s_j \,/\, 1 \le j \le 2\gamma+1\} \cup \{r_j t_j \,/\, 1 \le j \le 2\gamma+1\} \cup \{r_1 r_{2\gamma-4}, r_4 r_{2\gamma+1}\}$

Define a mapping $g: V(G) \to \{1,2, \dots, 6\gamma+4\}$ by

$g(r_j) = 3j-2$ for $1 \le j \le \gamma+3$

$g(r_j) = 3j-1$ for $\gamma+4 \le j \le 2\gamma$

$g(r_{2\gamma+1}) = 6\gamma+3$

$g(s_j) = 3j-1$ for $1 \le j \le \gamma+3$

$g(s_j) = 3j$ for $\gamma+4 \le j \le 2\gamma$

$g(s_{2\gamma+1}) = 6\gamma+4$

$g(t_j) = 3j$ for $1 \le j \le \gamma+3$

$g(t_j) = 3j+1$ for $\gamma+4 \le j \le 2\gamma$

$g(t_{2\gamma+1}) = 6\gamma+5$

Then the edge lables are

$g(r_j r_{j+1}) = 3j$ for $1 \le j \le \gamma+2$

$g(r_j r_{j+1}) = 3j+1$ for $\gamma+3 \le j \le 2\gamma$
$g(r_4 r_{2\gamma+1}) = 6\gamma+2$
$g(r_1 r_{2\gamma-4}) = 4\gamma$
$g(r_j s_j) = 3j-2$ for $1 \le j \le \gamma+2$
$g(r_j s_j) = 3j-1$ for $\gamma+3 \le j \le 2\gamma$
$g(r_{2\gamma+1} s_{2\gamma+1}) = 6\gamma+3$
$g(r_j t_j) = 3j-1$ for $1 \le j \le \gamma+2$
$g(r_j t_j) = 3j$ for $\gamma+3 \le j \le 2\gamma$
$g(r_{2\gamma+1} t_{2\gamma+1}) = 6\gamma+4$

Hence g is a lehmer – 3 mean labeling of G.

Theorem: 2.9

$\left(S(\theta_\gamma)\right) \odot \overline{K}_3$ is a lehmer – 3 mean graph.

Proof

Let $G = \left(S(\theta_\gamma)\right) \odot \overline{K}_3$

Let $r_1 r_2 \dots r_{2\gamma+1}$ be the vertices of subdivision theta graph $S(G)$.

Let $s_1 s_2, .., s_{2\gamma+1}, t_1 t_2, .., t_{2\gamma+1}$ and $w_1 w_2, .., w_{2\gamma+1}$ be the pendant vertices attached at $r_1 r_2 \dots r_{2\gamma+1}$ respectively.

Let $V(G) = \{r_1 r_2 \dots r_{2\gamma+1}, s_1 s_2, .., s_{2\gamma+1}, t_1 t_2, .., t_{2\gamma+1}, w_1 w_2, .., w_{2\gamma+1}\}$

$E(G) = \{r_j r_{j+1} / 1 \le j \le 2\gamma\} \cup \{r_j s_j / 1 \le j \le 2\gamma+1\} \cup \{r_j t_j / 1 \le j \le 2\gamma+1\} \cup \{r_j w_j / 1 \le j \le 2\gamma+1\}$
$\cup \{r_1 r_{2\gamma-4}, r_4 r_{2\gamma+1}\}$

Define a mapping $g: V(G) \to \{1,2, \dots, 8\gamma+6\}$ by

$g(r_j) = 4j-3$ for $1 \le j \le \gamma+2$
$g(r_j) = 4j-2$ for $\gamma+3 \le j \le 2\gamma$
$g(r_{2\gamma+1}) = 8\gamma+4$
$g(s_j) = 4j-2$ for $1 \le j \le \gamma+2$
$g(s_j) = 4j-1$ for $\gamma+3 \le j \le 2\gamma+1$
$g(t_j) = 4j-1$ for $1 \le j \le \gamma+2$
$g(t_j) = 4j$ for $\gamma+3 \le j \le 2\gamma$
$g(t_{2\gamma+1}) = 8\gamma+5$
$g(w_j) = 4j$ for $1 \le j \le \gamma+2$
$g(w_j) = 4j+1$ for $\gamma+3 \le j \le 2\gamma$
$g(w_{2\gamma+1}) = 8\gamma+6$

Then the edge lables are

$g(r_j r_{j+1}) = 4j$ for $1 \le j \le \gamma+2$
$g(r_j r_{j+1}) = 4j+1$ for $\gamma+3 \le j \le 2\gamma$
$g(r_4 r_{2\gamma+1}) = 8\gamma+2$
$g(r_1 r_{2\gamma-4}) = 6\gamma-5$
$g(r_j s_j) = 4j-3$ for $1 \le j \le \gamma+2$
$g(r_j s_j) = 4j-2$ for $\gamma+3 \le j \le 2\gamma$
$g(r_{2\gamma+1} s_{2\gamma+1}) = 8\gamma+4$
$g(r_j t_j) = 4j-2$ for $1 \le j \le \gamma+2$
$g(r_j t_j) = 4j-1$ for $\gamma+3 \le j \le 2\gamma$
$g(r_{2\gamma+1} t_{2\gamma+1}) = 8\gamma+5$
$g(r_j w_j) = 4j-1$ for $1 \le j \le \gamma+2$
$g(r_j w_j) = 4j$ for $\gamma+3 \le j \le 2\gamma$
$g(r_{2\gamma+1} w_{2\gamma+1}) = 8\gamma+6$

Hence g is a lehmer – 3 mean labeling of G.

Theorem: 2.10

$\left(S(\theta_\gamma)\right) \odot K_2$ is a lehmer – 3 mean graph.

Proof:

Let $G = \left(S(\theta_\gamma)\right) \odot K_2$

Let $r_1 r_2 \ldots r_{2\gamma+1}$ be the vertices of subdivision theta graph $S(G)$.

Let $s_1 s_2, .., s_{2\gamma+1}$ and $t_1 t_2, .., t_{2\gamma+1}$ be the pendant vertices attached at $r_1 r_2 \ldots r_{2\gamma+1}$ respectively.

Let $V(G) = \{r_1 r_2 \ldots r_{2\gamma+1}, s_1 s_2, .., s_{2\gamma+1}, t_1 t_2, .., t_{2\gamma+1}\}$

$E(G) = \{r_j r_{j+1} \,/\, 1 \le j \le 2\gamma\} \cup \{r_j s_j \,/\, 1 \le j \le 2\gamma+1\}$

$\cup \{r_j t_j \,/\, 1 \le j \le 2\gamma+1\} \cup \{s_j t_j \,/\, 1 \le j \le 2\gamma+1\} \cup \{r_1 r_{2\gamma-4}, r_4 r_{2\gamma+1}\}$

Define a mapping $g: V(G) \to \{1,2, \ldots, 9\gamma-2\}$ by

$g(r_j) = 4j-3$ for $1 \le j \le \gamma+2$

$g(r_j) = 4j-2$ for $\gamma+3 \le j \le 2\gamma$

$g(r_{2\gamma+1}) = 9\gamma-2$

$g(s_j) = 4j-2$ for $1 \le j \le \gamma+2$

$g(s_j) = 4j-1$ for $\gamma+3 \le j \le 2\gamma$

$g(s_{2\gamma+1}) = 9\gamma-4$

$g(t_j) = 4j-1$ for $1 \le j \le \gamma+2$

$g(t_j) = 4j$ for $\gamma+3 \le j \le 2\gamma$

$g(t_{2\gamma+1}) = 9\gamma-3$

Then the edge lables are

$g(r_j r_{j+1}) = 4j$ for $1 \le j \le \gamma+2$

$g(r_j r_{j+1}) = 4j+1$ for $\gamma+3 \le j \le 2\gamma$

$g(r_4 r_{2\gamma+1}) = 9\gamma-5$

$g(r_1 r_{2\gamma-4}) = 6\gamma-5$

$g(r_j s_j) = 4j-3$ for $1 \le j \le \gamma+2$

$g(r_j s_j) = 4j-2$ for $\gamma+3 \le j \le 2\gamma$

$g(r_{2\gamma+1} s_{2\gamma+1}) = 9\gamma-3$

$g(r_j t_j) = 4j-2$ for $1 \le j \le \gamma+2$

$g(r_j t_j) = 4j-1$ for $\gamma+3 \le j \le 2\gamma$

$g(r_{2\gamma+1} t_{2\gamma+1}) = 9\gamma-2$

$g(s_j t_j) = 4j-2$ for $1 \le j \le \gamma+2$

$g(s_j t_j) = 4j-1$ for $\gamma+3 \le j \le 2\gamma$

$g(s_{2\gamma+1} t_{2\gamma+1}) = 9\gamma-2$

Hence g is a lehmer – 3 mean labeling of G.

CONCLUSION

It is very interesting to find whether a graph admits lehmer -3 mean labeling or not. We present tennew results on lehmer – 3 mean labeling of thetarelated graphs. The investigation about similar results for various graphs families is an open area of research .

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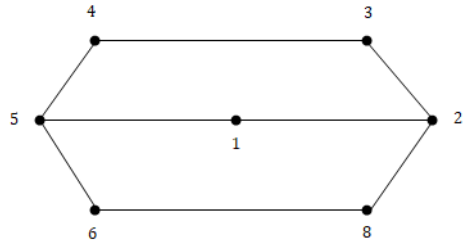


Figure 1: Lehmer -3 mean labeling of θ_7

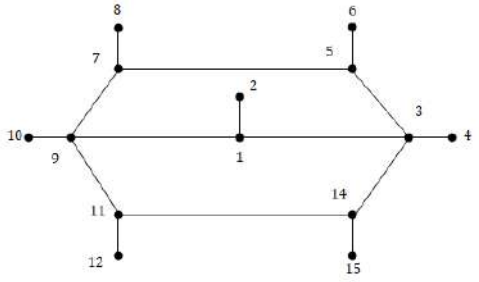


Figure 2: Lehmer – 3 mean labeling of$\theta_7 \odot \bar{K}_1$

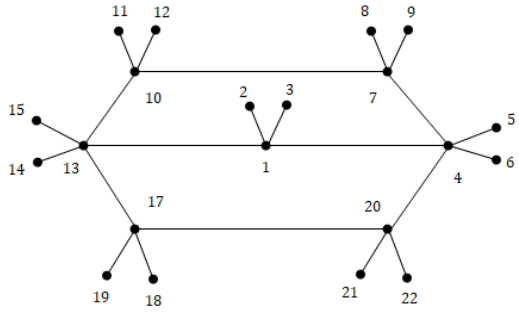


Figure 3: lehmer – 3 mean labeling of $\theta_7 \odot$

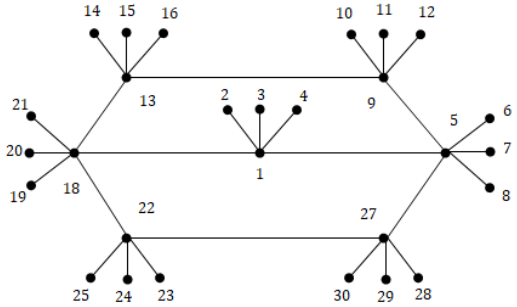


Figure 4: lehmer -3 mean labeling of $\theta_7 \odot \bar{K}_3$

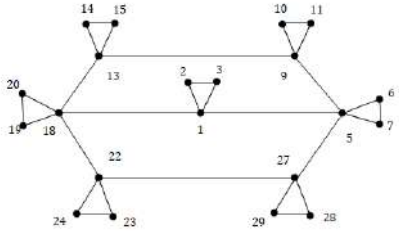


Figure 5: lehmer -3 mean labeling of $\theta_7 \odot K_2$

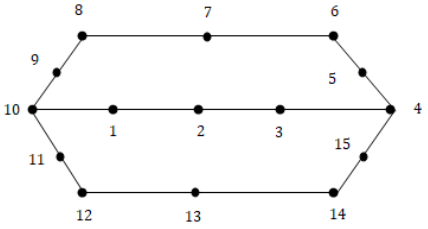


Figure 6: lehmer -3 mean labeling of $(S(\theta_7))$

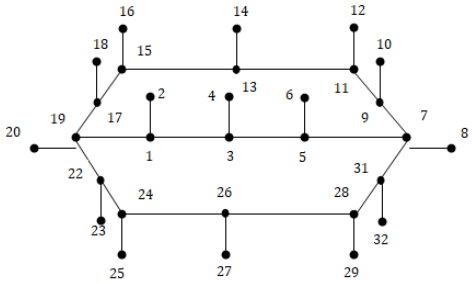


Figure 7: lehmer -3 mean labeling of $(S(\theta_7)) \odot \bar{K}_1$

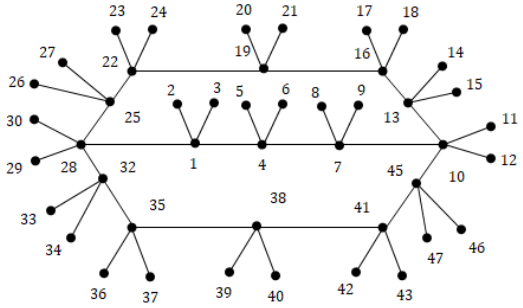


Figure 8:lehmer – 3 mean labeling of $(S(\theta_7)) \odot \bar{K}_2$

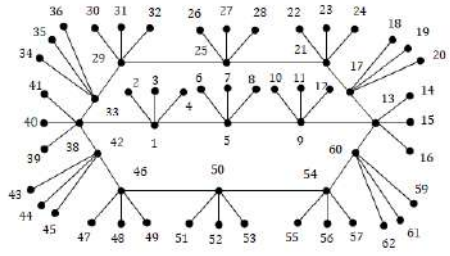


Figure 9:lehmer – 3 mean labeling of $(S(\theta_7)) \odot \bar{K}_3$

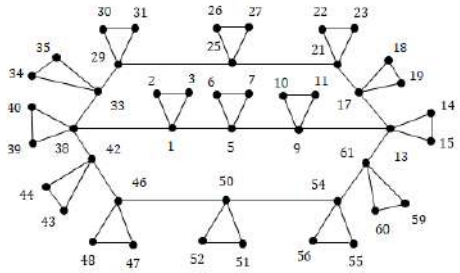


Figure 10:lehmer – 3 mean labeling of $(S(\theta_7)) \odot K_2$

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REVIEW ARTICLE

Potential Health Benefits of *Rauwolfia serpentina*: A Review

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ABSTRACT

Rauwolfia serpentina commonly known as "Indian Snakeroot" is a medicinal plant native to Indian subcontinent. It has been traditionally used in ayurvedic and other traditional medicine systems for its diverse therapeutic properties. In India, it has been used for a long time in the treatment of hypertension. Reserpine is the main alkaloid that is well researched and documented for its anti-hypertensive mechanism. Reserpine binds to vesicular monoamine transporters (VMATs) and prevents binding of catecholamine which eventually results in vasodilation and helps in lowering blood pressure. *Rauwolfia Serpentina* also contain other alkaloids which possess many potential health benefits including stress reduction, anti-venom properties, treatment of fever, insomnia and hysteria. The present review focuses general features of *Rauwolfia serpentina*, cultivation, chemical composition, mechanism of action, ayurvedic perspective, pharmacological activities and toxic effects of components of *Rauwolfia Serpentina.*

Keywords: *Rauwolfia serpentina,* sarpagandha, hypertension, mechanism, pharmacological activity.

INTRODUCTION

The genus name "*Rauwolfia*" is derived from the surname of German doctor, botanist and traveler Leonhard Rauwolf, who documented his observations of various plants he encountered during his journey in the year1582 [1]. The specific epithet "serpentine" is derived from the Latin word "serpens" means snake, which refers to the plant's historical use as an antidote for snake bites in traditional medicine. The Sanskrit name of *Rauwolfia serpentina* is sarpagandha, universally popular as Indian snakeroot or serpentine wood [2]. The plant is commonly known by many vernacular identity such as Chandrabagha, Chandrika, ChotaChand, Harkaya, Sarpgandha, and Snake root plant etc [3]. *Rauwolfia serpentina* is a species of flowering plant belonging to Apocynaceae family. This plant is native to the Indian subcontinent and Southeast Asia [4].

Taxonomic classification

Kingdom	Plantae
Phylum	Tracheophytes
Sub-phylum	Angiospermae
Class	Magnoliopsida
Order	Gentianales
Family	Apocynaceae
Genus	*Rauwolfia*
Species	*R. serpentina*

Rauwolfia serpentina belongs to the plant kingdom and is classified under the division Magnoliophyta, which includes flowering plants. It falls under the class Magnoliopsida, which refers to dicotyledonous plants. In the order gentianales, *Rauwolfia serpentina* is classified under the family Apocynaceae, which is commonly known as the dogbane family. The *Rauwolfia serpentina* belongs to the genus *Rauwolfia and serpentina* is the specific epithet that distinguishes this particular species within the genus [4].

Distribution

In terms of distribution, *Rauwolfia serpentina* is primarily found in India, Nepal, and Sri Lanka, where it grows naturally in the forests and hilly regions. It is also cultivated in other parts of the world with suitable climates, such as Southeast Asia, Africa, and South America. It is also grown in Pakistan, China, Burma and Thailand. The family includes immense number of species which are distributed worldwide [5] . In India, Sarpagandha is an important medicinal plant scattered in the foot-hills of Himalayan range, up to an elevation of 1300-1400 m. and almost all over the country. It is specifically cultivated in Utter Pradesh, Bihar, Odisha, Tamil Nadu, West Bengal, Karnataka, Maharashtra, Gujarat, Assam, Pegu, Java, Tenasserim, Deccan Peninsula, Malay Peninsula [1], Punjab, Nepal, Sikkim and Bhutan [1,5,6]. In addition to these primary distribution areas, *Rauwolfia serpentina* has been introduced and cultivated in other parts of the world, including tropical and subtropical regions, for its medicinal properties [4].

Cultivation

Rauwolfia serpentina can be propagated through numerous suitable methods, including seed germination, stem cutting and root cuttings.

- **Seed Propagation:** *Rauwolfia serpentina* can be easily propagated from mature, healthy and heavy seeds for sowing purpose. Prior to sowing, given pre-treatment to seeds such as scarification or soaking to improve germination rates, as per the needs. The seeds are sown in the month of april, 2-3 cm apart in a row in a well-drained nursery bed to maintain appropriate moisture levels and provide partial shade. The seeds will probably germinate after 15-20 days and can continue upto 30-40 days. Once the seedlings reach a suitable size, they can be easily transplanted to the main field.

- **Stem Cutting Propagation:** Stem cuttings are another preferred method of choice for propagating *Rauwolfia serpentina*. Stem cuttings from healthy, mature plants are taken around 15-22cm long in maintained moisture and provided partial shade. The cuttings will develop roots within a few weeks, and once well-established, they can be carefully transplanted to the main field.
- **Root Cutting Propagation:** *Rauwolfia serpentina* can also be propagated from root cuttings from established plants during the spring season. Cut the roots into sections, each around 5cm long and plant horizontally in a well-draining medium. Keep the soil moist and wait for the cuttings to develop new shoots and roots. Once they grow sufficiently, they can be transplanted to the desired location during rainy season [7,.8].

Uses

Rauwolfia serpentina is commonly used in the treatment of asthma and respiratory disorders, AIIDS, breast cancer, diarrhea, dizziness, eye disorders, fever, headache, hypertension, hysteria, insanity, malaria, mental agitation, neurological symptomatic disorders like anxiety, psychosis, schizophrenia, epilepsyand insomnia, pneumonia, psychotic disorder, skin diseases and scabies, spleen disorders and traumas [5,9,10].

REVIEW OF LITERATURE

usage dates back at least 3000 years. Indian manuscripts dating back to 1000 B.C. had the complete mention of *Rauwolfia* as Sarpagandha and Chandra. In 1931, Sen and Bose reported that *Rauwolfia serpentina* was quite valuable and safe in treating high blood pressure [4,12]. In 1940, Hamet reported the hypotensive effects of numerous alkaloids present in *Rauwolfia serpentina*. In 1944, Bhatia and Kapur reported that isoajmaline and neoajmaline constituents dropped blood pressure [13]. In 1949, Vakil reported a study of 50 patients with essential hypertension who were treated with Rauwolfia. In that study, 85% of patients experienced a drop in systolic blood pressure, whereas drop in diastolic blood pressure was experienced by 81% patients. In a survey conducted by Vakil, 46 out of 50 physicians across India voted for *Rauwolfia serpentina* as the best antihypertensive agent based on their personal experience [4,14]. More than 100 scientific articles are published after Vakil's study. In 1952, Vida in Germany and Australia reported decrease in blood pressure in 25 patients with hypertension [14]. Arnold and Bach demonstrated a positive reaction in 37 and 50 patients whose systolic pressure and diastolic pressure decreased by an average of 30mm Hg and 15mm Hg respectively [14,15]. Meissner stated in 1953 that 90% of study participants found *Rauwolfia* to be effective, resulting in a reduction in systolic blood pressure between 15 and 40 mm Hg. Loffler in Switzerland noted a decrease in blood pressure in 51 hypertensive Swiss workers in 1953. In 1954, Goto in Japan reported that 12 of 15 patients with hypertension had reduced blood pressure. Doyle and smirk in Zealand in 1954, reported that after within 4 to 8 hours of administration, reserpine induce a dramatic drop in blood pressure. Furthermore, it has been demonstrated that *Rauwolfia* was the more effective and majorly used hypertensive remedy utilized in India throughout the 1950s. More than 60,000 doctors nationwide or 90% of all doctors, used it as their preferred medication. One manufacturer claimed to have exported dry root tablets to more than 17 countries and sold 94 million tablets of dried root in 1954 [5,14].

VARIETIES OF RAUWOLFIA

It has been reported that *Rauwolfia* has many different varieties & species including *Rauwolfia amsoniifolia, Rauwolfia andina, Rauwolfia anomala, Rauwolfia aphlebia, Rauwolfia bahiensis, Rauwolfia balansae, Rauwolfia biauriculata, Rauwolfia caffra, Rauwolfia capixabae, Rauwolfia capuronii, Rauwolfia chaudocensis, Rauwolfia cubana, Rauwolfia decurva, Rauwolfiadichotoma, Rauwolfia gracilis, Rauwolfia grandiflora, Rauwolfia hookeri, Rauwolfia indosinensis, Rauwolfia insularis, Rauwolfia × ivanovii, Rauwolfia javanica, Rauwolfia kamarora, Rauwolfia leptophylla, Rauwolfia letouzeyi, Rauwolfia ligustrina, Rauwolfia linearifolia, Rauwolfia littoralis, Rauwolfia macrantha, Rauwolfia mannii, Rauwolfia mattfeldiana, Rauwolfia maxima, Rauwolfia media, Rauwolfia micrantha, Rauwolfia microcarpa, Rauwolfia moluccana, Rauwolfia mombasiana, Rauwolfia moricandii, Rauwolfia nana, Rauwolfia nitida, Rauwolfia nukuhivensis, Rauwolfia obtusiflora, Rauwolfia oligantha, Rauwolfia pachyphylla, Rauwolfia paraensis, Rauwolfia paucifolia, Rauwolfia peguana, Rauwolfia pentaphylla, Rauwolfia polyphylla, Rauwolfia praecox, Rauwolfia pruinosifolia, Rauwolfia purpurascens, Rauwolfia rhonhofiae,*

Rauwolfia rivularis, Rauwolfia rostrata, Rauwolfia sachetiae, Rauwolfia salicifolia, Rauwolfia sanctorum, Rauwolfia sandwicensis, Rauwolfia schuelii, Rauwolfia sellowii, Rauwolfia semperflorens, Rauwolfia serpentina Rauwolfia sevenetii, Rauwolfia spathulata, Rauwolfia sprucei, Rauwolfia steyermarkii, Rauwolfia sumatrana, Rauwolfia tetraphylla (also known as Rauwolfia carescens), Rauwolfia tiaolushanensis, Rauwolfia verticillata, Rauwolfia vietnamensis, Rauwolfia viridis, Rauwolfia volkensii, Rauwolfia vomitoria, Rauwolfia weddeliana and *Rauwolfia woodsoniana* [11,16].

MORPHOLOGY

Rauwolfia serpentina is a perennial shrub belonging to the Apocynaceae family. It is straight, evergreen perennial bush with a long, uneven, nodular, yellowish rootstock, growing to a length of 60-90cm [16]. It is important to note that the morphology of plants can vary to some extent depending on environmental conditions, cultivation practices and individual plant characteristics.

Height: The height of the plant ranges from 0.5 feet to two feet. The maximum height of the plant is up to 60 cm i.e 2 feet[2].

Stem: *Rauwolfia serpentina* possess cylindrical stems, covered with pale [4] and thick bark [2] . Its latex is viscous and light in color with 1-3 cm diameter [4].

Leaves: The thin leaves of *Rauwolfia serpentina* are arranged in whorls of three. Their shapes range from elliptic to lanceolate or obovate. Color of leaf is bright & vivid with green colour at top and pale green underneath [8].

Roots: The root system of *Rauwolfia serpentina* is well-developed and consists of a tap root with pale brown cork. The color of root varies from reddish-yellow to light brown on outer surface outside and pale yellowish white inside. The roots are the most valuable part of the plant, as they contain valuable bioactive compounds used in medicine [17].

Flower: The flowering time ranges from March to May and august to september in Indian conditions. Flowers of *Rauwolfia serpentina* are generally white in color, often tinged with violet or pink hues. Flowers are arranged in irregular corymbose cymes. Chymes consist of multiple flowers clustered together at the end of the branches [7].

Temperature: The temperature range between 10 to 38 degrees is ideal for the growth of this plant [4].

Fruit: *Rauwolfia serpentina* produce drupe like fruits, 0.5cm in measurement. They may be single or didymous. Fruits are fleshy and small and are typically shiny black in color when ripe [2].

Medicinal Uses: *Rauwolfia serpentina* has a long history of use in traditional medicine, particularly in Ayurveda and other indigenous medicinal systems. The plant is primarily valued for its roots, which are utilized in preparing various herbal formulations for treating hypertension, anxiety, insomnia, and other ailments [11]. Because of presence of alkaloids, it is also popularly known to cure various circulatory disorders [18].

CHEMICAL COMPOSITION

Rauwolfia contains a lot of useful phytochemicals [1,17]. Based on chemical structure and properties, phytochemicals have been classified into six broad categories. These categories include majorly carbohydrates, lipids, phenolics, terpenoids and alkaloids, and other nitrogen containing compounds [1]. Alcohols, oleoresins, sugar, glycosides, steroids, fatty acids, tannins, flavonoids and phytosterols are few examples of the phytochemicals present in Rauwolfia Approximately 10 % of plant species are believed to synthesize alkaloids as secondary metabolites, to protect themselves from attack of herbivores, predators and pathogens. Alkaloids are large group of organic

molecules which contain a heterocyclic nitrogen ring [19]. About 50 types of alkaloids are isolated from this plant, which can be broadly classified into the following types:

1) Indole alkaloids
2) Indolenine alkaloids
3) Oxindole alkaloids
4) Pseudo indoxyl alkaloids
5) Indole alkaloids[4].

These can also be classified into 3 categories:

1. Weakly Basic Indole Alkaloids: The principal alkaloids are reserpine, Rescinnamine and despiridine which are also categorized under tertiary Indole Alkaloids.
2. Indoline Alkaloids with intermediate basicity: Tertiary indoline alkaloids with intermediate basicity includes rauwolfinine, reserpiline, Ajmaline and Iso- Ajmaline.

3. Strong Anhydronium Bases: Strongly basic anhydronium alkaloids include serpentine, serpentinine and alsotonine. While Ajmalinine, Ajmalicine, Chandrine, renoxidine, reserpinine, Sarpagine, Tetraphyllicine, Yohimbine, 3-epi-ayohimbine are the other alkaloids present in *Rauwolfia serpentina*. prolongation and calcium channel blockade[8]. Phenolic compounds present in *Rauwolfia* possess useful antimicrobial activities, flavonoids acts as antioxidants and also have anti-cancer properties, tannins hasten the healing of wounds and inflamed mucous membrane, pure isolated alkaloids and their synthetic derivatives are used as basic medicinal agents for their analgesic, antispasmodic and bactericidal effects. The alkaloids extracted from the root extract acts directly on central nervous system and reduces blood pressure effectively as compared to other blood-pressure lowering agents [19]. *Rauwolfia* is also known to contain a large number of macro and micro nutrients. The most abundant macro nutrient in calcium, sodium is present in least amount. The lower sodium content of *Rauwolfia* serpentine may be considered as a benefit because of direct relationship between sodium intake and hypertension in human [20]. The presence of zinc plays important role in management of diabetes, which result from insulin malfunction. *Rauwolfia serpentina* is also an excellent source of ascorbic acid which is vital for wound healing and normal body performance [20,21].

Mechanism of Action of Reserpine In Hypertension

Rauwolfia is considered as the best remedy for hypertension as of now till date[1]. *Rauwolfia serpentina* acts as an antihypertensive drug mainly owing to the presence of alkaloid called reserpine. Reserpine is effective orally as well as parentally for the treatment of hypertension. Parentally, the onset of antihypertensive action of Reserpine usually begins within 1 hour of introduction, whereas in case of intramuscular injection, the maximum effect occurs within approximately 4 hours and can lasts for about 10 hours. When reserpine is administered orally, the maximum effect occurs approximately within 2 weeks and may persist up to 4 weeks after the final dose. In conjugation with other hypotensive drugs in the treatment of severe hypertension, the daily dose can vary from 100 to 250 micrograms [4]. Half a teaspoon of its powder taken thrice a day is effective in relieving hypertension [9]

Mechanism

Reserpine has been extensively studied for its hypertensive effects. Reserpine is an antihypertensive medication that has been used for many years in the treatment of hypertension. It works by inhibiting the storage and release of certain neurotransmitters, particularly norepinephrine, from the synaptic vesicles in nerve terminals. Catecholamines are a class of neurotransmitters and hormones derived from the amino acids tyrosine. The three primary catecholamines are norepinephrine, epinephrine and dopamine. By inhibiting the vesicular monoamine transporter [VMAT] in organelle membrane of secretory cells of presynaptic neurons, reserpine interferes with the packaging of catecholamines into synaptic vesicles, leading to a decrease in their storage. As the result, there is a reduced availability of catecholamines for release upon neuronal stimulation. This depletion of catecholamine stores ultimately leads to a decrease in sympathetic activity, resulting in lower blood pressure [4].Norepinephrine is a key neurotransmitter involved in the regulation of blood pressure, and its reduction results in a decrease in vasocontaction and heart rate. The decreased sympathetic outflow and subsequent reduction in vasoconstriction result in vasodilation of blood vessels helps to lower blood pressure by reducing peripheral resistance [4,5,17].

Because of lipid-soluble property of reserpine, it can pass through the blood-brain barrier and slowdowns the activity of the nervous system, which results in decreased heart rate, decreased cardiac output and peripheral resistance as well as decreased blood pressure [14]. VMAT1 and VMAT2 are two isoforms of VMAT. VMAT1 is primarily found in neuroendocrine cells of the peripheral nervous system, including chromaffin granules in adrenal medulla, sympathetic neurons and platelets. VMAT2, on the other hand, is mainly found in the brain and sympathetic nervous system. Reserpine has three times greater affinity for VMAT1 as compared to VMAT2 [8].

Ayurvedic Perspective

Rauwolfia serpentina holds a significant place in Ayurveda. In Ayurvedic perspective it is primarily classified as a medicinal plant with antihypertensive properties. As the primary focus of Ayurvedic treatment is to restore and maintain the balance of the three fundamental energies or doshas i.e vatta (air and space), pitta (fire) and kapha (earth and water), *Rauwolfia serpentina* is believed to have a balancing effect on the doshas, particularly on Pitta and Vatta dosha [22]. Cooling and calming properties: *Rauwolfia serpentina* is considered to have cooling and calming properties, which help pacify excess heat and balance Pitta dosha. According to Ayurveda, imbalances in Pitta dosha can contribute to hypertension and other related conditions, and the cooling properties of *Rauwolfia serpentina* are thought to help alleviate these imbalances.

Blood pressure regulation: Ayurvedic practitioners have traditionally used *Rauwolfia serpentina* for its antihypertensive effects. It is believed to have a calming effect on the nervous system and support healthy blood pressure levels. In Ayurvedic terminology, it is considered a "hypotensive" herb, meaning it helps lower high blood pressure. *Rauwolfia serpentina* is believed to have a positive effect on heart health in Ayurveda. It is traditionally used to support a healthy cardiovascular system and maintain normal heart function [11].

Traditional Ayurvedic herbal formulations of *Rauwolfia serpentina* are utilized as a solution for restoring hypertension, sleep deprivation, nervousness, CNS disorders, fever, gastrointestinal issues, antidote, epilepsy, injuries, schizophrenia, narcotic sleep deprivation, insanity, manages regular menstural flow, improve appetite and aids in digestion[16].

Stress-reducing effects: *Rauwolfia serpentina* is also valued in Ayurveda for its sedative and stress-reducing properties. It is believed to have a calming effect on the mind and help alleviate stress and anxiety, which can contribute to high blood pressure. Ayurvedic practitioners may recommend it for individuals experiencing sleep disturbances or insomnia caused by an overactive mind or anxiety [23].

Mental clarity and focus: Ayurvedic texts describe *Rauwolfia serpentina* as a "medhya" herb, meaning it supports cognitive function, memory, and mental clarity. It is believed to enhance mental focus and concentration, making it beneficial for individuals experiencing mental fatigue or difficulty concentrating. Appetite and digestive fire: *Rauwolfia serpentina* is known to stimulate the digestive fire in Ayurveda. It may help improve appetite and enhance the body's ability to digest and strong assimilate nutrients from food. A balanced and strong digestive fire is essential for overall digestive health

Properties of Sarpagandha

- Paachansansthan: It enhances the process of digestion.
- Rakatvehsansthan: It lowers the high blood pressure.
- Prajannansansthan: It maintains the overall reproductive health of males and females.
- Taapkram: It is effective in the treatment of fever.
- Saatmikaran: It is used as an anti-venom in snake bite.
- Naadisansthan: It is mainly used in epilepsy and insomnia. It is administered with ghee during night in insomnia. It can also be used in the treatment of anxiety and insanity.

Sarpagandha Churna, Sarpagandha Ghanvati, Sarpagandha Yoga and Mahesvari Vati are some examples of Ayurvedic formulations of *Rauwolfia serpentine* [16,24].

Pharmacological Activity of *Rauwolfia serpentina*

Various alkaloids found in *R. serpentina* give it a significant position in the pharmaceutical industry. Alkaloids of this plant have a great medicinal importance to treat cardiovascular diseases, high blood pressure, hypertension, arrhythmia, mental disorders, breast cancer, leukemia, and many more [20].

Anti-hypertensive property

Rauwolfia serpentina is also known as universal medicine for lowering blood pressure. Aqueous extract of leaves contains Deserpidine, Reserpine, Rescinnamine which acts as antihypertensive chemicals. In 1942, Paranjpe made an overcast allusion to the use of an alcoholic tincture or extract of the root of *R. Serpentina* in situations of high blood pressure. The hypotensive activity was stated to be particularly satisfying in senior people, and in the case of the diastolic pressure, the tincture was said to be an excellent cough-sedative and diuretic. He claimed relief, without any statistical support, in the majority of instances of hypertension. On occasional dosages of the tincture, there had been a lasting drop in blood pressure in two cases recorded by Paranjpe for well over a year [15].

Bhatia and Kapur in 1942, reported it as a useful and well tolerated hypotensive remedy after using *R. serpentina* in the treatment of high blood pressure [13]. Ranjini et al. investigated the antihypertensive effect of aqueous extract of *Rauwolfia serpentina* leaves along with the Allium sativum cloves using animal models as sheep kidney and lung ACE [25]. Shah et al., in their study concluded that *Rauwolfia serpentina* extract has shown a significant improvement in the blood

Gastrointestinal health

Ezeigbo et al. proved that the extract of *R. serpentina* leaves has a significant antidiarrhoeal activity [26].
Rajasree et al. proved that roots and leaves of the species can also used to cure intestinal disorders especially dysentery, cholera and fever due to digestive problems [27].

Antibleeding activity

Rauwolfia serpentina's high saponin concentration supports its usage as an anti-bleeding agent and as a wound treatment [19].

Antipsychotic activity

Rauwolfia serpentina have antipsychotic (neuroleptic) properties. Root powder of *Rauwolfia serpentina* contains Reserpine, Ajmaline and Serpentine which acts as pressure, lipid profile, and tissues histopathology [25]. Antipsychotic agents. Reserpine is used for treatment of schizophrenia and tardive dyskinesia [4]. As proved by Sen and Bose, Ray, Gupta et al, Chakravarty et al, Chopra et al and Deb, reserpine can also be used as a sedative and a tranquilizer, even with patients of mental disorders [12-14,28].

Anti-venom property:

It is also used for the treatment of snake (cobra), scorpion or reptile bite and stings of any poisonous insects in various part of the world. The Ethanolic extract of whole plant acts as antivenom agent [27]. Sivaraman et al. Showed the presence of anti snake venom compounds in the aqueous extract of Rauwolfia serpentine [29].

Antibacterial activity

Using an ethanolic extract of the *R. serpetina* root, Rathi et al. investigated the antibacterial properties [11].

Antioxidant activity

Rauwolfia serpentina contains several bioactive compounds which are known to reduce oxidative stress and protect cells from damage caused by free radicles. Methanolic extract of leaves and Ethanolic extract of roots acts as

Antioxidants[7]. Nair et al. investigated the antioxidant effect of *R. serpentina*. They used methanolic extract of leaves of five species of Rauwolfia (*R. beddomei, R. micrantha, R. serpentina, R. tetraphylla, and R. densiflora*) for evaluation of total antioxidant capacity, 1,1-diphenyl-2-picryl hydrazyl (DPPH) radical scavenging activity, reducing power and superoxide anion scavenging activity, and determination of ascorbic acid, carotenoids, flavonoids, phenolics, tocopherols and pigment composition. He found that *R. serpentina* contain highest total phenolic content, DPPH radical scavenging activity and highest pigment composition of Vitamin E content among the five species. Whereas, R. Tetraphylla had highest flavonoid content along with β carotene, lycopene, and other nutrient composition, and the least amount was found in R. beddomei Using the ferric reducing capacity of plasma or plants, Rathi et al. used an ethanolic root extract of R. serpentine to counteract oxidative stress and free radicals. The extract had a considerable impact on the activities, it was discovered [11].

Antifungal property

Rauwolfia serpentina has shown promising antifungal activity. It has been found to inhibit the growth and activity of certain fungal species. Methanolic and acetonic extracts of leaves show antibacterial as well as antifungal activity [11].

Hepatoprotective activity:

Ethanolic extract of rhizomes and methanolic extract of rhizomes of *R. serpentina* show hepatoprotective activity [19]. It is also due to antioxidant and anti-inflammatory of *Rauwolfia serpentina.* Some studies also demonstrated that *Rauwolfia serpentina* can help in regulating liver enzymes, such as alanine aminotransferase (ALT) and aspartate aminotransferase (AST), which are markers of liver function. Modulating theses enzymes can indicate a protective effect on liver [11]. Ashok et al. concluded in their study that 70% ethanolic leaf extract of *Rauwolfia serpentina* has hepatoprotective properties using disk diffusion method and hepatoprotective activity by liver function tests (LFT) and histological examination [31].

Hysteria

Powdered root when administered thrice with milk can be used to treat hysteria. Consumption is suggested to continue till the full results obtain.

Insomnia

Biradar et al. mentioned the consumption of 1 g root powder of *R. serpentina* with 250 ml of sweetened goat milk after/before meal for treating insomnia [4]. Gupta et al., from their study on patients suffering from various mental disorders, state the potential of standardized *R. serpentina* root alcoholic extract to pro-long the sleep duration, saying, "*Rauwolfia serpentina* never failed to induce sedation and sleep" [28].

Breast Cancer

In 3 case-controlled investigations conducted between 1960 and 1970 A.D., there was a claimed connection between rauwolfia and breast cancer, which led to a decrease in the usage of rauwolfia and reserpine products. However, research and analyses that account for exclusion bias reveal that Rauwolfia plays no part in the prevalence of breast cancer among patients. It has anticancer activity rather than cancer-causing potential [3].

Anxiolytic action

Some clinical study concluded that alseroxylon, reserpine and crude root part of the plant exhibited anxiolytic action in ambulatory patients [16].

Other uses

The juice of the leaves is used as a remedy for opacity of the cornea[9]. It is also useful for in the treatment of schizophrenia, cures plague and fever, anxiety, psychosis and epilepsy, treats colic and cholera, ease childbirth by stimulating uterine contractions in difficult cases, cures toxic goiter and dizziness. Sarpagandha is also used for rheumatism, edema and intestinal diseases [7].

Based on experimental and clinical studies, it is concluded that the root of *R. Serpentina* has following pharmacological attributes:

- It leads to generalized vasodilatation and lowers the blood pressure, by acting on the vaso-motor centre [21].
- It soothes the general nervous system, by depressant action on the cerebral centres.
- It exerts a sedative action on the gastric mucosa and stimulating action on the plain musculature of the intestinal tract[15].
- It improves the bronchial musculature function [9,15,17].

CLINICAL STUDIES

Antihypertensive Activity: On 41 patients suffering from essential hypertension without any comorbid illness, Alka et al. investigated the antihypertensive potential of the polyherbal compound M - sarpagandha mishran. The patients were administered M - marpagandha mishran for 8 weeks and blood pressure was monitored at 2nd, 4th, 6th, and 8th week. Changes in diastolic, systolic, and mean arterial blood pressure were analyzed. A significant fall in blood pressure was observed in all the patients [1]. Murray B. Sheldon et al. conducted a 2-year double-blind study of 18 ambulatory patients suffering from essential hypertension treated with *Rauwolfia serpentina* and reserpine and evaluated significantly reducing effect of *R. serpentina* and its derivatives on the systolic pressure in 7 of 18 patients and on the diastolic pressure in 10 of 18 patients, in comparison with placebo [32].

Vakil reported a study of 50 patients with essential hypertension who were treated with Rauwolfia. In that study, 85% of patients experienced a drop in systolic blood pressure, whereas drop in diastolic blood pressure was experienced by 81% patients [15]. Coronary Artery Disease: Lewis et al. reported the therapeutic spectrum of *R. serpentina* in angina syndrome in accordance with double blind technique. Fifteen patients of coronary artery disease and angina pectoris were administered alternatively with alseroxylon fraction of *R. serpentina* and placebo. Use of alseroxylon revealed the prolonged therapeutic effect against coronary heart disease [11].

TOXIC EFFECTS

The most common side effect noted in majority of patients was nasal congestion. Mental depression may also develop with continuous usage of the drug for several months. Lethargy, sedation, psychiatric depression, hypotension, nausea, vomiting, abdominal cramping, gastric ulceration, nightmares, bradycardia, angina-like symptoms, bronchospasm, skin rash, itching, galactorrhea, breast enlargement, sexual dysfunction, and withdrawal psychosis were some of the undesirable complications which appeared after the intake of reserpine

CONCLUSION

Rauwolfia serpentina, commonly known as Indian snakeroot or sarpagandha, is a remarkable medicinal plant with a long history of traditional use and therapeutic properties. This review paper highlighted the various bioactive components present in *Rauwolfia serpentina* plant along with their pharmacological properties and potential health benefits. The major alkaloid traced in the plant is Reserpine which is quite acknowledged for its hypotensive activity with minimal side effects when used in lower or prescribed dose. The careful administration and monitoring of dosage are important to ensure the optimal use of *Rauwolfia serpentina* in clinical sittings. This plant is also known to exhibit a wide range of pharmacological activities, including anti-inflammatory, anti-psychotic, anti-oxidative, hepatoprotective and anti-cancer properties. The use of *Rauwolfia serpentina* and its alkaloids can be further studied to explore their full potential and to develop new treatments for various

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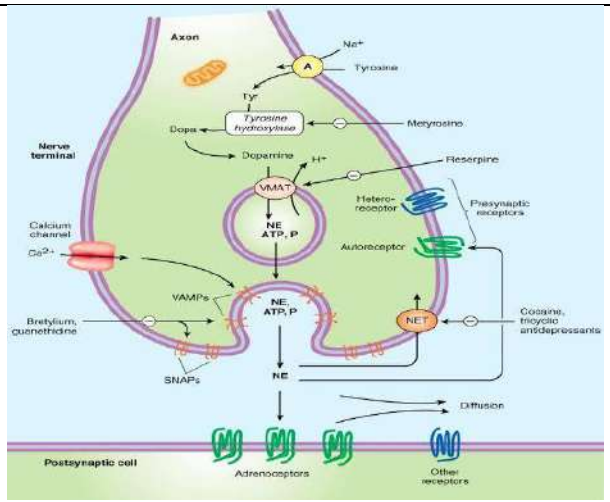
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Source: Self

Fig. 1. *Rauwolfia Serpentina* plant with flowers



Source: https://images.app.goo.gl/PBpqpHbp1TRBAr9f8

Fig. 2. Mechanism

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RESEARCH ARTICLE

A Content Analysis of Indian News Articles on Violence against Medical Professionals

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ABSTRACT

The escalating global trend of violence against medical professionals is a significant concern, leading to heightened levels of burnout, PTSD, diminished quality of life, compromised work performance, and a myriad of other mental and physical health challenges. This qualitative study aimed to analyse reported cases of violence against Indian medical professionals, focusing on causative factors, types of abuse, and the impact on mental health. It is a content analysis based on 20 news articles about violence against medical professionals using QDA Miner Lite for analysis. The study findings have 9 sub-themes and 3 themes, which are violence against medical professionals, consequences of violence against medical professionals and coping ways respectively. The findings were indicating major causative factors of violence against medical professionals from patients or caregivers, types of abuse faced by doctors, consequences of violence on mental health of doctors, deteriorated social image and other sub-themes with excerpts adapted from news articles.

Keywords: Content analysis, Indian News Articles, Violence, Medical Professionals

INTRODUCTION

The global increase in level of violence against medical professionals is a raising concern, resulting in stress, burnout, PTSD, depleting quality of life, poor work performance along with many other mental and physical health concerns[1].A recent study addressed two prominent types of violence, non-physical (may include use of threatening words, verbal abuse) and physical violence, to which men are more exposed than women healthcare professionals[2]. Medical professionals in surgery, psychiatric and emergency departments report higher cases of violence, particularly among young male doctors, and mainly by either patient or their relatives[3][4]. A study reports that 75% medical professionals have experienced some form of violence ranging from verbal abuse or hostile gestures and Indian Medical Association (IMA) stated that 82.7% doctors go through anxiety and stress because of multiple reasons[5].Aggressive outbursts and violence towards doctors have not only been a concern in India, rather prevalent across globes like USA, UK, Asia, China, Bangladesh[6]. In comparison to other professions, violence has been reported four times higher among medical professionals, which can be both physical and psychological or both[7]. Studies also suggest that there were no gender differences observed in level of violence witnessed among doctors, with 35.5% in surgery department and emergency ward due to any tragic situations such as demise of patient[8]. There are various causative factors associated with violence like infrastructural limitations, limited resources, commercialization of medical facilities leading to a gap between patient-caregiver expectations and reality, resulting in frustration, anxiety and anger outbursts[9][10].Such violence, distress and patient dissatisfaction is mostly observed in intensive units and emergency or surgical wards[11]. These are only statistical data of reported cases but there are majority of cases which are left unreported. The main reasons behind non reporting of work place violence were hesitancy among doctors, excessive time taking processes reported, lack of appropriate action and no provision for reporting violence leading to deteriorated mental health, stress and overall well-being[12]. Lack of appropriate grievance addressal system was another reason for patient-caregiver violence[13].The repetitive exposure to verbal and physical abuse, violence faced by doctors leads to anxiety, depression, post-traumatic stress disorder[14].The objective of this qualitative study was to analyse the reported cases of violence against by doctors, in-depth understanding of causative factors, types of abuse and consequences of violence on mental health of Indian medical professionals, based on reported media coverage between 2017-2023.

METHODS

An online search was conducted, in which key terms, 'violence against Indian doctors by patient- news articles', 'violence against Indian doctors - news articles', 'violence against Indian doctors - Indian news articles'. A total of 20 Indian e-news articles related with the aim of this study were narrowed down. The language of all articles was in English. The period of e-newspapers selected were between 2017 to 2023. The repeated articles were skipped during the selection of news articles for this study.The data was read and reviewed by two researchers separately. The steps of content analysis then were followed by extracting condensed meaning, coding, sub-themes and themes, using explicit content analysis. QDA Miner Lite was opted to analyse frequency.

RESULTS

The result findings are elaborated in Table 1, Table 2 comprising of list of news articles and codes including themes, sub-themes and frequency analysis. The detailed description with excerpts is as following:

Theme 1: Aggression

It is an unfortunate reality that violence is anticipated within certain professional realms, particularly within the caregiving sector. Individuals in these roles, are at a heightened risk of experiencing acts of violence, attributable to a variety of factors, by the caregivers or patients[10][12].

Excerpts (Estimated violence)

"the IMA said it has been estimated that healthcare workers are four times likely to be injured and require time away from work due to workplace violence than all other workers combined"

"No physician, however conscientious or careful, can tell what day or hour he may not be the object of some undeserved attack, malicious accusation, black mail or suit for damages"

"75% of the violence against doctors is verbal, including intimidation and threats. Most doctors who suffer them never report them; some notify their department seniors but are often told that these experiences are "part of the job"

Excerpts (Reported Cases of Violence)

The actual reported cases are mostly of extreme aggressive outbursts towards all forms of medical professionals, including para-medical staff, post-graduate residents, super-speciality doctors, in comparison to other professions. The excerpts below adapted from various articles explains that irrespective of young or old age, male or female gender, all medical professionals experience such violence during their work tenure by either the patient, family members of patient[2][6][15].

"healthcare professionals are facing an increasing trend of aggression and it's turning out to be a new epidemic. Almost every week, there are incidences of violence against doctors"

"The doctors often have to face the brunt of these deaths from the respective family members in the form of violence"

"Indian Medical Association, 75 per cent of doctors across the country are reported to have faced at least some form of violence, usually over advanced payment or withholding the deceased's body in case of non-payment"

"The 73-year-old doctor had succumbed to injuries after being assaulted by relatives of a tea garden worker who died while undergoing treatment.." "A majority of the respondents (31.7%) were doctors in government health service departments, followed by those working in private hospitals (28.4%), postgraduate residents (16%), interns (13.4%), doctors in medical colleges (8.2%), and super-speciality residents (2.1%). The study points out, quoting media reports, that 137 attacks on doctors had been recorded in 2022 alone" "But there are studies to say healthcare workers face more violence than others…" "Studies also show that female medical professionals with fewer years of experience are objectively more at risk of being on the receiving end of both physical and verbal workplace violence"

Excerpts (Types of Abuse Experienced by Doctors)

The majority of medical professionals face verbal abuse, verbal threats, non-verbal threats, physical assault during the working hours and within hospital premises, wherein patient's relative or caregivers were major perpetrators[3][14].

"In developing countries, more than 50% of doctors have faced patient-led verbal and physical abuse…Such violence has been on a rising trend in economically developing countries, and is lowest in the developed ones"

"Many people think of violence as a physical assault. However, violence in healthcare setup is a much broader problem; it is any act of aggression, physical assault, or threatening behavior that occurs in a health-care setting and causes physical or emotional harm to a health worker…Verbal abuse is the most common type of violence encountered but there seems to be some gender bias as well, sexual abuse being nearly exclusive in female workers"

"Over the years, there have been several episodes of physical and verbal violence. Each episode has the people at large passionately arguing the issue for a few days, only for their words to fade away until the next brutal incident"

"Among the 1,948 respondents, 65.6% experienced violence, predominantly verbal abuse (89.9%), and intimidation by gestures (32.7%). Most incidents happened during the day (84.7%), with 32% occurring after duty hours. Casualty triage had the highest incidence (57.5%), followed by outpatient departments (33.6%). Relatives or caregivers were the foremost perpetrators in 81.5% of the cases. Although 48.6% of the incidents were reported to authorities, only 13.5% had any sort of preventive steps taken. A significant 76.7% of doctors contemplated relocating abroad"

Excerpts (Causes of Aggression from Patient or Family Members)

The commonly identified reasons of repetitive violence by patient or caregivers against medical professionals are patient dissatisfaction, limited staff, lack of communication, perceived or actual deterioration of patient, expectation-reality gap of treatment or facilities provided within hospital premises, issues related to payment or during billing,

lack or improper grievance addressal system, improper sanitization and general lack of trust in healthcare facilitates. The lack of proper communication though can be explained due to high patient load at public or government hospitals and excessive workload[13][5][11].

"Patient dissatisfaction, long waiting time due to inadequate staffing, improper communication, lack of medicines or ot her adequate facilities, and frustration with the health care system could lead to such incidents"

"Violence against medical professionals in India is unique because it's not perpetrated by patients, but by their families and friends, strangers who join out of misplaced sympathy, random goons, and political leaders and party workers looking for the crowd's approval"

"In the absence of adequate grievance redressal mechanisms at hospitals and medical negligence cases taking decades to resolve, if at all, frustrated families vent their frustration in violence"

"..There has been a steady trickle of news reports from around the country of doctors and other healthcare workers facing violence at the hands of people who recently lost a loved one, and blame healthcare personnel for improper care"

"There has to be a proper grievance redressal mechanism of everything that goes wrong, in place, before you bring a law to settle scores with relatives of patients"

"Some perpetrators become violent over concerns for the patient's condition, such as actual or perceived deterioration of their condition or doubts about the wrong treatment being administered. Some ot hers become violent due to issues such as high payment dues and protracted waiting time"

"Often, patients or t heir relatives turn to violence because the healt hcare system hasn't met their expectations"

"Patients want quality of healthcare at the public hospitals to be as good as at the private hospitals. But public hospitals are overcrowded and lack infrastructure and resources to offer good quality healthcare. High patient load and working hours of up to 120 hours a week for doctors.That leaves them little or no time to effectively communicate with patients.Poor socioeconomic status of the patient and the everrising cost of the treatment cause frustration and anger in patients giving rise to mob mentality, and desire for instant justice"

"…the patient and their attendants are in a most vulnerable phase of their existence, i.e. faced with temporary or permanent disability even death. In this state they are fearful, anxious and in doubt…In many government hospitals there is overcrowding, long waiting time to meet doctors, absence of a congenial environment, multiple visits to get investigations done and then subsequently to consult doctors,…poor hygiene and sanitation. Even in private hospitals there could be prolonged waiting times: delay in attention or admission of sick patient or perceived delay in investigation and treatment. Perceived (and real) lack of availability of doctor (senior doctor)..It is a common knowledge that most incidents of violence occur at the time of preparing and payment of the medical bill.."

"The violence is due to multiple factors. The most important is an overall loss of trust in the health care delivery system,"

Theme 2: Consequences of Violence

Violence and aggressive outbursts towards medical professionals has been a major concerns leading to stress, burnout, post-traumatic stress disorder (PTSD), disturbed sleep patterns, anxiety, depression, trauma, constant fear, poor decision making skills due to extreme pressure and doubt towards career choices[9][16].

Excerpts (Mental health issues)

"..the effects of such violent episodes extend longer than the experience itself, where most doctors report to have faced insomnia, depression, anxiety, and an inability to see their patients without any fear of violence"

"The authors point out that violence against doctors can lead to injuries, trauma, stress, anxiety, and burnout. They also demoralise the doctors, making them question their career choices. It also disrupts the smooth functioning of medical facilities.."

"However, being on the receiving end of verbal or physical violence has an immense psychological impact. Some studies have reported symptoms of post-traumatic stress disorder, anxiety, and depression in doctors who have faced violence from patients or their kin the Indian Medical Association showed that 82.7% doctors feel stressed out in profession, 62.8% fear violence, and 46.3% say violence is the main cause of their stress. In the two years (2016-2018), twenty-two cases of grievous assault on doctors were reported in the media"

"The list of dangers is actually quite long..stresses that lead to extremely high rates of burnout, depression, substance abuse and suicide that outpace other professions (of similar level of education, gender, generation), serious occupational hazards like workplace violence both physical and verbal"

"On a long term basis, the threats and violence could have a bad impact on the physician's psychology leading to Post-Traumatic Stress Syndrome (PTSD) in majority of the physicians..This manifests as a physician feeling helpless, becoming irritable, introverted and having thoughts of abandoning medicine or even contemplating suicide"
"If doctors continue to work under the threat of violence, there will be a tremendous pressure on them, especially while dealing with critical cases where they have to take certain decisions instantly..Violence is surely not the way,"

Excerpts (Protest by Doctors)

The medical community has observed a growing trend wherein medical professionals are compelled to voice their discontent in response to the recurring instances of aggression from patients or their relatives. This has subsequently prompted widespread demonstrations aimed at protesting the consistent disregard for healthcare professionals[17][18].

"Doctors also stage protests but are ultimately honour-bound to return to duty, to reprise their roles as healers. The issue remains largely unaddressed"
"doctors' strikes, prompted by violence against doctors, were reported from some state or other almost throughout 2018 and 2019"
"With over 40 professional associations of doctors and hospital managements deciding to join the strike, the State is seeing one of the strongest protests by the medical fraternity in recent times"
"held protests here as part of a nationwide stir called by the IMA against the recent incidents of violence against healthcare professionals in some parts of the country , and to demand a central law to curb such cases"
"In Delhi, in 10 different places, including outside AIIMS, the protest was organised by the doctors, junior doctors and medical students"
"The doctors, both in government and private sectors, organised standing protest in front of the secretariat in Kerala, and in various district headquarters besides hospitals. About 35,000 doctors of the IMA Tamil Nadu branch also joined the nationwide protest"

Excerpts (Deteriorated Social Image)

The incongruence between the highly promoted medical facilities and readings published about the medical negligence, leaves the public with disbelieve in healthcare services. The theatrical media coverage also tends to play a role in creating one-sided communal image of medical care providers or the medical facilities, adding to the lack of faith among general population[17][19][20][13].

"On one hand the public is bombarded with unsupervised ads that promise short-cut cure, one stop solution to various ailments…easy alternatives and so on; on the other hand, there are news reports that scream of medical negligence (most often inaccurate or judgmental) shaking the faith and trust that the people have on doctors. While the news on achievements of hospitals and doctors are a few and subtle, the reports on medical negligence are sensationalised and blaring"
"A cycle of violent strikes and negative media coverage has tarnished the image of the medical community at large. Many people now view doctors with a feeling of troubled dependence. Doctors have turned a soft target not only to the public but the media too. Most mainstream channels and newspapers seldom highlight the other side"
"Negative portrayal of doctors by the media, sensational reports of patients' death, and sting operations against doctors creating negative image of doctors"
"Media has a very important role to play: They should also write positive things about the profession or at least both sides of the issue in situations like this; they should avoid journalism of sensa tionalism and avoid provocative head-lines. While in short term these kinds of reports get a few eye-balls but in long run might prove counter-productive for the society"

Excerpts (Disappointment towards Profession due to Frequent Violence Incidences)

The increased number of cases about aggressive outbursts towards medical professionals is making the aspirants doubtful towards their career choice. Many of the practicing medical professionals have altered their location preference for practice, led to resignations and lack of trust in organizations about the proceedings of such incidences or lack of hope for justice[21][22][23].

"Increasing violence against doctors can make the medical profession less attractive to aspiring doctors. Experienced doctors may leave their positions or relocate to safer environments, leading to a shortage of skilled healt hcare professionals"

"only 25% of doctors who experience such violence complained to the police and only 10% of them believed their complaint was addressed adequately. Most doctors don't report at all as they think that doing so will accomplish nothing"
"study found that doctors wish to stop offering emergency services, refer patients sooner to more specialists, and overinvestigate symptoms and prescribe more tests. They also tend to offer less of the lifesaving medical and surgical interventions that a patient may require, over fear that any risky procedure may provoke violent action. This also negatively affects the quality of healthcare"
"the patient's relatives threatened him because they believed the patient had been electroshocked to death. The senior doctor hasn't offered emergency services since that day"
"Violence against health workers adversely affects their psychological and physical well-being and affects their job motivation. And this lessens the quality of care and lessens delivery of healthcare especially to the lower strata of society"
"In 2019, there was a mass resignation of doctors in West Bengal after a mob attacked a junior doctor"

Theme 3: Coping Ways
Only a frequency of single instance addressed the reason behind non-reporting of such incidences from the point of view of medical professionals that they do not report such cases due to a positive emotion also, i.e. empathy towards patient and their families, who are undergoing extreme distress.

Excerpt (Empathy with Patients)
"Doctors often acknowledge the situation of the relatives of the patient who are in distress and do not report such cases. Mostly, those cases are reported where the doctor feels a serious threat of life"

DISCUSSION

The aim of this study was to understand the reported cases of violence against medical professionals, associated causative factors, types of abuse reported and mental health challenges faced by medicos through the recent news articles. There was a total of 20 articles selected based on violence against medical professionals to understand types of abuse, various reasons due to which patients or caregivers act aggressively and its influence on mental health of medicos. There were 03 themes and 09 sub-themes identified during content analysis. The first theme was Violence against Medical Professionals, which had 04 sub-themes; estimated violence (found in 3 cases with 15%frequency), reported cases of violence (found in 18 articles with 90% frequency), types of violence (found in 5 articles with 25% frequency), Causes of Violence against Medical Professionals from patient or family members (found in 08 articles with 35% frequency). The second theme identified was Consequences of Violence against Medical Professionals consisting of 04 themes; Mental Health Issues (found in 08 articles with 40% frequency), Protest by doctors (found in 05 articles with 25% frequency), Deteriorated Social Image (found in 03 articles with 15% frequency) and Disappointment towards Profession due to frequent Violence Incidences (found in 04 articles with 20% frequency). The third theme is Coping Ways which consists of one sub-theme, which is empathy with patients (found in 01 articles with 5% frequency). In the caregiving industry, instances of violence are regrettably prevalent. Medical personnel routinely encounter highly aggressive behaviors from both patients and caregivers[8]. Contributing factors include patient dissatisfaction, staffing shortages, ineffective communication, perceived or actual patient deterioration, disparities between treatment expectations and reality, billing discrepancies, inadequate grievance resolution mechanisms, insufficient sanitization, and a pervasive lack of trust in healthcare facilities[11][9]. Additionally, overwork and a high patient load exacerbate this issue. Recurrent acts of violence and hostile outbursts have led to compromised decision-making abilities, stress, burnout, PTSD, disrupted sleep patterns, anxiety, depression, trauma, and sustained apprehension among medical personnel[12][16].In response to these challenges, there has been a mounting trend within the medical community of healthcare professionals articulating their discontent, leading to widespread protests and public skepticism regarding healthcare services[22][23]. The media's portrayal of medical care providers and facilities contributes to a one-sided communal image, which in turn fosters doubt among the general population[17]. The increasing number of aggressive outbursts among aspiring medical professionals leads to uncertainty about career choices, resulting in resignations and diminished trust in organization[23]. Medical professionals often refrain from reporting such incidents due to their positive emotions

and empathy towards patients and their families. The study was limited to Indian news articles available online in English. Any articles available in other languages were not included due to researcher's language barrier. Only 20 articles included were between the period of 2017-2023, during which COVID19 pandemic was on its peak, which could have affected the reporting of such incidences or reduced the amount of violence against medical professionals due to lockdown and grieving families. An extensive qualitative analysis can be done to get a better understanding about the causative factors, coping ways of medical professionals and mental health challenges due to violence against medical professionals so that enhanced strategy plans can be developed and implemented to prevent such scenarios.

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Table 1: Name of Online Resources, Article Title and Publication Date (Original).

S.No.	Name of Online Resources	Article Title	Publication Date
1.	ABP news bureau	IMA writes to Amit Shah demanding effective law against violence on healthcare	01 June, 2021
2.	India TV	Doctors Day: Violence against medical professionals, our healthcare system and possible solution	01 July, 2021
3.	The Indian express	Doctors join IMA's nationwide protest over violence against healthcare professionals	18 June, 2021
4.	The Hindu	Resident doctors to join nationwide protest on Friday	June 17, 2021
5.	The Indian Express	Govt may introduce law to make violence against medical professionals a non-bailable offence: Report	January 3, 2017
6.	The new Indian express	Here's a treatment for mob violence against doctors in India	June 21, 2019
7.	The Hindu	IMA strike to protest violence against doctors disrupts functioning of hospitals in Kerala	March 17, 2023

8.	The Economic Times	IMA writes to PM Modi, seeks ordinance to check violence against health professionals	September 04, 2019
9.	The Hindu	Kerala doctors contemplate relocating abroad in face of increasing attacks	November18, 2023
10.	The economic times	Doctors Day: Docs attacked while treating patients speak up	01 July, 2021
11.	The New Indian Express	No separate law to prohibit violence against doctors, healthcare professionals: Centre	07 February, 2023
12.	The Hindustan Times	Stir held across country over violence against health workers	19 June, 2021
13.	The Hindustan Times	Stop violence against doctors in India	01 July, 2019
14.	The Wire	India's Doctors Are Still Facing Violence. So Where Are the Laws to Protect Them?	18 April, 2022
15.	The Hindu	Violence against doctors is a symptom. What is the disease?	23 May, 2023
16.	The times of INDIA	Violence against doctors	31 October, 2023
17.	The Daily Guardian	Violence against Doctors: Causes, Effects, and Solutions	16 August, 2021
18.	The New Indian express	Violence against doctors: IMA Telangana seeks protection for medicos	19 June, 2021
19.	The Times of India	Violence against doctors: Ways to weed out this social menace	7 Jul, 2023
20.	Deutsche Welle (DW)	What's behind violence doctors in India	6 September, 2023

Table 2: Showing Themes, Codes, Description of Codes and Frequency Data.

Themes	**Codes**	**Description of Codes**	**Cases**	**% Cases**
Violence against Medical Professionals	estimated violence	The general fear or expected violence (by patients or relatives) among medical professionals	3	15
	reported cases of violence	The actual number of cases reported or published in media	18	90
	types of abuse experienced by doctors	Forms of abuse- physical, verbal or other	5	25
	causes of aggression from patient or family members	Causative factors of violence	7	35
Consequences of violence against Medical Professionals	Mental health issues	The effect on mental health of medical professionals because of violence	8	40

	Protest by doctors	Protest on violence against medical professionals	5	25
	Deteriorated social image	Effect of violence and reported media coverage	3	15
	Disappointment towards Profession due to Frequent Violence Incidences	Feeling discouraged to sustain in constant fear	4	20
Coping Ways	empathy with patients	Doctor's attempt to empathize with patient and caregivers as a coping way	1	5

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RESEARCH ARTICLE

An Epidemiological Survey on the Diet and Lifestyle Related Causative Factors of the Migraine Headache among the Students of Karnal, Haryana

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ABSTRACT

Migraines, a complex neurological disorder, affect millions globally. A detailed 300-person poll helped us comprehend migraines' complexity. This study summarizes the survey's findings and emphasizes demographics, lifestyle choices, migraine prevalence, frequency, linked factors, and coping methods. Current survey found diverse age groups, educational levels, genders, heights, weights, and living regions. This diversity emphasizes the need for customized migraine treatment. Current survey examined the lifestyle characteristics like eating, drinking, drug use, screen time, skipping meals, food preferences, beverage preferences, fruit consumption, meal frequency, and hydration. Lifestyle choices provide context for understanding the various factors that may affect migraine development and management. The poll indicated that 187 respondents had migraines regularly. Migraines range from infrequent to chronic, highlighting the disorder's complexity and each person's peculiarities. Migraines can be caused by sleep habits, busy schedules, sudden weather changes, overheating, intestinal disorders, and hot or cold baths. These findings show migraine attack physiological, environmental, and behavioral components. Migraine attacks were managed by consulting a doctor, practicing yoga and meditation, using home remedies, taking over-the-counter drugs, and exploring additional therapies. This survey

analysis concludes that migraines are complex and affect people's lives. To be effective, therapy must include demographics, lifestyle preferences, migraine patterns, and coping methods. To understand the complicated causes of migraines and develop more effective treatments and prevention methods, further research is needed. By holistically treating migraines, the quality of life can be improved.

Keywords: Migraine, Diet, Lifestyle, Headache

INTRODUCTION

Migraines are severe neurological conditions that cause recurring, painful headaches, nausea, vomiting, and light and sound sensitivity. It affects all ages, but student rates are alarming. The (Friedman & De Ver Dye, 2009) study seeks to determine whether lifestyle, diet, and other factors affect migraine in students. Higher education causes students to adjust their sleep patterns, academic stress, and nutritional choices. These changes and academic stress may put this population at risk for migraine onset or exacerbation. Several factors make it important to understand student migraine prevalence and its causes (Ravishankar, 2004). First, migraines can impair academic performance by generating missed classes and decreased productivity. Second, by identifying student migraine-causing diet and lifestyle factors, effective preventive and therapy can be developed (Gardner, 2006). The comprehensive survey of 300 students from diverse educational institutions achieved these goals (de Vries *et al.,* 2009). This study quantifies migraine prevalence in this community and explores its links to food, gender, family history, and stress. The findings of this study are expected to inform migraine-reduction policies. A major global health issue, migraine is a complex neurological disorder that causes persistent, throbbing headaches, nausea, vomiting, and light and sound sensitivity (Terwindt*et al.,* 2000). Migraines affect people of all ages and socioeconomic backgrounds, but their incidence among students is a concern since it may affect academic performance and well-being. Higher education changes many young people's lives. This critical period often changes daily routines, sleeping patterns, stress levels, and food habits. These changes can greatly affect a person's physical and emotional health. In this context, Researchers examine student migraine prevalence and the complex relationship between lifestyle, nutrition, and migraines. The study could inform students, instructors, healthcare professionals, and legislators (Adoukonou*et al.,* 2014).

First, know how common migraines are among students. Migraine can cause missed assignments, fewer grades, and a lower quality of life. Quantifying the prevalence in this group will help us understand the problem (*Migraine Attacks and Relevant Trigger Factors in Undergraduate Nursing Students in Hong Kong: A Cross-Sectional Study - PMC*, n.d.). This study examines lifestyle factors and migraine prevalence. Students often have migraine causes such high stress, sleep troubles, and workloads. High caffeine and processed food intake may also contribute. These findings can be utilized to create customizedprogrammes to help students manage and prevent migraines. Another important element is migraine prevalence by gender. According to study, women get migraines more than males. Understanding student gender differences is crucial for targeted assistance and interventions. The final risk factor is a migraine-prone family history. This feature will be examined to assess the student cohort's hereditary component and understand migraine susceptibility genetics (Nandha& Chhabra, 2013). A comprehensive analysis of student migraine prevalence and its correlations with eating choices, gender, and family history is presented in this study. This will spark intelligent debates and aggressive efforts to improve students' academic performance and overall well-being while lowering migraines' daily impact. This study may assist educators, healthcare providers, and lawmakers develop healthier, more encouraging learning environments (Suen *et al.,* 2008). A student's life changes when they start college. It involves major changes to daily schedules, sleeping habits, stress levels, and diet. These changes and academic stress promote migraine onset or exacerbation. This study seeks to understand college student migraines and their many triggers and risk factors. This study affects all social classes. A statistic on student migraine prevalence is a rallying cry for attention (Al-Hashel*et al.,* 2014). Beyond the data, current study will reveal the complex links between migraine and students' lifestyle choices. Academic pressures can cause migraines by increasing stress, sleep disturbances, and effort. Students also struggle with dietary changes including eating more

processed foods and caffeine, which may increase migraine risk. These findings are the foundation for developing targeted therapies and support systems to address students' particular migraine prevention and management challenges (Devon *et al.,* 2007). A fascinating component of current study is gender disparities in migraine prevalence. Research showed that migraines affect women more than males. Understanding gender-based differences in students allows for tailored assistance and interventions to promote migraine management and care equity. Family history is a major migraine risk factor. Scientists plan to unravel the genetic component of migraine risk in the student cohort to improve genetic research and individualized healthcare (Wang *et al.,* 2015). This study seeks to understand student migraine prevalence and its relationship to nutrition, gender, lifestyle, and family history. Current study inspires well-informed discussion and strategies to promote students' general and academic welfare and reduce migraines' everyday disruptions (Zebenholzer*et al.,* 2016).

Related risk factors:

Migraines are complex neurological conditions with several risk factors. These risk factors vary by person but include

1. Family history: Migraine is strongly linked to family history. An individual's migraine risk increases if one or both parents suffer migraines (Gu &Xie 2018).
2. Gender: Men suffer less from migraine than women due to hormonal changes.Menstruation, pregnancy, and menopause can cause migraines in sensitive people.
3. Age:Migraines start in youth or early adulthood and diminish in frequency and intensity with age. However, they can last a lifetime.
4. Hormonal changes: In sensitive people, menstrual cycle or hormonal birth control variations might cause migraines.

Lifestyle factors: Several lifestyle variables can cause migraines. This includes:

1. Stress: Stress and stressful life situations can cause migraines in many people.
2. Sleep patterns:Insufficient sleep, irregular sleep patterns, or sleep routine changes can increase migraine risk (Rist*et al.,*2015).
3. Dietary choices: Some people get migraines from coffee, alcohol, old cheeses, and processed foods with MSG.
4. Dehydration:Dehydration can cause migraines in certain people.
5. Skipping meals: Some people get migraines from skipping meals or eating irregularly owing to blood sugar changes (Lipton *et al.,* 2003).
6. Environmental factors: In vulnerable people, bright lights, loud noises, strong odours, and weather or barometric pressure fluctuations can cause migraines.
7. Medical Conditions:Medical problems like high blood pressure, stroke, and epilepsy can increase migraine risk. People with neurological problems like aura may also have more migraines.
8. Medications: Hormone replacement therapy and vasodilators can cause migraines.
9. Smoking:Smoking increases migraine risk.
10. Obesity:Obesity may increase migraine risk, although the relationship is complicated.

Remember that these risk factors increase the likelihood of migraines but do not guarantee them. Migraines are varied and affected by genetic, environmental, and personal factors. Migraine prevention and treatment may require identifying and managing certain risk factors. Consult a doctor for a migraine diagnosis and treatment plan(Kuo*et al.,* 2015).

Associated side effects:

Migraine medicine side effects vary by type. It is important to realise that not everyone will suffer side effects and that they may vary in severity and duration. Several migraine medication groups have these adverse effects.

1. Triptans (e.g., sumatriptan, rizatriptan):The most common side effects are nausea, drowsiness, and vertigo. Sometimes patients feel chest pressure or tightness, but it passes rapidly. In cardiovascular risk factors, triptans may restrict blood arteries, therefore use caution (Wang *et al.,*2015).

2. Non-Steroidalanti-inflammatory drugs (NSAIDs) (e.g., ibuprofen, naproxen):Common side effects include stomach pain, heartburn, and gastrointestinal irritation. Long-term or high-dose use can cause stomach ulcers or bleeding.
3. Preventive medications (e.g.,beta-blockers, antiepileptic drugs, antidepressants):Drugs cause distinct side effects. Beta-blockers can cause extreme coldness, fatigue, and heart rate abnormalities.Antiepileptics can cause drowsiness, mood swings, and vertigo. Antidepressants can cause weight changes, dry mouth, and sexual problems. Work with a doctor to assess and manage side effects when taking preventive medications (Cheung 2000).
4. Antiemetics (e.g., metoclopramide, prochlorperazine):These drugs treat migraine nausea and vomiting. Common side effects include drowsiness, restlessness, and mobility issues.
5. Opioids (e.g., codeine, hydrocodone):Opioids are rarely prescribed for migraines due to the risk of addiction and negative effects. Hey can cause constipation, respiratory depression, and fatigue (Kim & Yoon 2013).
6. Botox injections (Onabotulinumtoxin-A): Botox injections for migraines can produce injection site pain, neck stiffness, and muscle weakness. Side effects include swallowing problems and flu-like symptoms.

Association between stress and dietary behaviors

Stress affects eating patterns in complex ways. Dietary choices can be influenced by stress, and vice versa, dietary habits can have an impact on a person's capacity to handle stress. The following are some critical elements of the connection between stress and eating habits:

1. Stress-induced overeating: Stress can cause emotional eating, which generally involves eating high-calorie comfort foods. Cortisol, a stress hormone, increases appetite (Balaban *et al.,* 2012).
2. Cravings for comfort foods: People may seek sweet, fatty, or carbohydrate-rich comfort meals when stressed. These foods may reduce stress and make you feel good.
3. Unhealthy food choices: Stress can cause people to eat fast food, processed snacks, and sugary drinks. Many choose convenience and immediate energy.
4. Skipping meals or irregular eating patterns: Due to time constraints or loss of appetite, stressed people may skip meals or eat irregularly. This can cause energy and nutrient imbalances.
5. Emotional eating: Stress-related emotional eating involves eating to cope with negative feelings such anxiety, sadness, and irritation. Emotional eating generally involves unhealthy food.
6. Increased caffeine and alcohol intake: Some people use caffeine and alcohol to cope with stress. Caffeine can enhance energy, but too much might cause anxiety. Alcohol can relax temporarily but harm mood and sleep (Watson *et al.,* 2008).
7. Reduced attention to portion control: Stress can cause thoughtless eating, where people eat more than they should.
8. Impact on digestion: Stress can cause indigestion, bloating, and bowel disturbances. These digestive issues can affect eating choices.
9. Bidirectional relationship: Stress affects diets both ways. Poor diets can worsen stress and diminish the body's ability to cope. A diet lacking critical nutrients can impact mood and cognition (Bicakci*et al.,* 2007).
10. Coping mechanisms: Diet can help manage stress. Making and eating healthy meals, eating mindfully, or choosing foods that promote mood and energy can be comforting.
11. Stress management and proper eating are essential for health. Maintain a balanced diet, practice stress-reduction (mindfulness, exercise, and relaxation), and seek therapy or medical treatment as needed. Understanding how stress and nutrition interact is crucial to developing effective stress management and healthy lifestyle strategies (Chan *et al.,* 2009)

Management of stress through nutrition

Dietary choices that enhance mental health and stress management help the body cope. A balanced diet can reduce stress, but not completely. Nutrition strategies for stress management:

1. Eat a balanced diet: Eat a balanced diet of fruits, vegetables, whole grains, lean proteins, and healthy fats. These foods contain critical nutrients for health and stress resilience (Ezeala-Adikai*et al.,*2013).

2. Complex carbohydrates:Complex carbs like whole grains (brown rice, oats, quinoa) stabilise blood sugar and provide energy. This can reduce blood sugar-related mood swings and irritation (Adams *et al.*, 2015).
3. Omega-3 fatty acids:Omega-3 fatty acids in salmon, mackerel, flaxseeds, and walnuts boost mood and reduce anxiety and sadness.
4. Magnesium-rich foods:Leafy greens, nuts, seeds, and whole grains contain magnesium, which relaxes muscles and calms.
5. Antioxidant-rich foods:Berries, citrus fruits, and dark leafy greens can reduce chronic stress-related oxidative stress.
6. Avoid or limit caffeine and alcohol:Excess caffeine and alcohol can increase tension and anxiety. Limit or avoid these drinks, especially at night, as they can impair sleep (Wang *et al.,* 2016).
7. Stay hydrated:Stress and weariness increase with dehydration. Drink water all day to stay hydrated.
8. Moderate sugar intake:Blood sugar rises and dips from high sugar intake can cause mood swings and irritation. Limit sugary foods and drinks.
9. Herbal teas:Chamomile and valerian root drinks can relax and promote sleep.
10. Portion control:Avoid overeating, which can cause stress and discomfort.
11. Regular meals: Avoid missing meals to avoid low blood sugar and irritation. Maintain energy with regular, balanced meals.
12. Mindful eating:Practice mindful eating by savoring each bite and noticing hunger and fullness. Avoid multitasking when eating.
13. Plan and prepare meals: Planning meals ahead can prevent stress-related snacking on unhealthy convenience foods.
14. Seek professional guidance:Consult a trained dietitian or healthcare provider for personalized nutrition advice if you struggle to manage stress or have specific dietary concerns.

Nutrition is only part of stress management. A stress management plan should also include regular exercise, relaxation techniques like deep breathing and meditation, enough sleep, and support from friends, family, or a mental health professional (Pavlovic *et al.,* 2014).The current survey examined mental health indicators and nutritional habits in a representative juvenile sample (N=300). Self-reported stress and dietary habits were examined. The four goals were to determine student migraine prevalence, investigate migraine causes, examine food and lifestyle, and create a migraine diet.

METHODOLOGY

The following headings have been used to discuss the materials and techniques used in this study:
Locale of study: The 300 participants in the current study were divided between residential areas (N = 172) and MMIM College (N = 128) in Karnal.

Sampling and design of the study
A sample is a subset of the population. Sampling saves time, money, and energy. Using easy sampling, 300 participants from the population of interest were randomly sampled. This study's findings can be confidently applied to the greater population.

Selection of sample
Study samples were selected using simple random sampling. The study has 300 participants. When little is known about a population, this is the simplest way of sampling.

Method used for study

The questionnaire method was utilized for this study since it was suitable for data collection. To ensure participant comprehension, questions should be vague, short, and simple. The questionnaire provided a standard evaluation method.

Formation of questionnaire

Formation sought accurate topic communication and response. Given the study's goals, the questionnaire required much thinking and rewriting. Open-ended questionnaires with specific questions were created.

Collection of data

The questionnaire comprised demographics, migraine-related questions, lifestyle and habits, and data analysis.

General information

The sample population provided generic data. The general information comprises education level and social demographic characteristics like age, marital status, employment status, and family type for effective questionnaire evaluation.

Demographic information

A large 300-person study studied personal and lifestyle characteristics and migraine prevalence. The responses showed migraine's complexity by age, gender, education, and region. The participants' marital status allowed for a complete study of migraines' impacts throughout life. Height, weight, lifestyle choices—hydration, screen time, nutrition, and sleep—were scrupulously tracked. This large dataset from 300 people helps us explore the complex links between characteristics, lifestyle choices, and migraine prevalence and treatment in different populations. Each of these 300 profiles was reviewed. The group's qualifications showed its diversified education. Age is a crucial indicator of migraine prevalence and lifetime experience. Gender-specific migraine study was needed due to responders' diversity. The migraine frequency and intensity were carefully tracked by weight and height. To study migraine prevalence and triggers by region, the respondents from diverse regions were selected. Migraines affect married and single people, highlighting their psychological impact. Researchers examined their diets and habits beyond demographics. Sleep patterns, an important migraine therapeutic tool, were evaluated to determine their effects on frequency and severity. Alcohol, smoking, and drug usage were investigated for migraine risks. Screen time on phones, laptops, and PCs was assessed to discover if digital exposure and migraine frequency are associated. Meal skips and fast food were explored as migraine triggers and cures. Migraine benefit was assessed by assessing daily fruit eating and revitalising beverage choice. Last, respondents reported their regular water intake, emphasising the relevance of hydration in migraine prevention and management.

Migraine-related questions

The thorough 300-person migraine poll was conducted. Many people mentioned migraines in their stories. Migraines were occasional to common. Several migraine-controlling methods were shown. Resting and relaxing during episodes, medication, and lifestyle changes were used. This extensive study updated migraine prevalence and coping methods. This 300-person study examined migraine concerns to better understand this neurological condition. Many participants admitted experiencing migraines. With infrequent to frequent migraines, the variety of reactions indicated their complexity. Responders also shed light on migraine management. Drugs, tranquil environments, and lifestyle changes occurred during episodes. This broad study of migraine-related queries highlighted the prevalence of migraine issues in this cohort and the different ways people cope with them, helping researchers understand migraines.

Lifestyle factors

In 300 respondents, researchers evaluated lifestyle factors and migraines. The study focused on average sleep hours and migraines. Alcohol, smoking, and drug use were evaluated. Participants also reported everyday phone, laptop,

and PC use. Also studied were meal skipping, processed or fast food consumption, and migraine-related beverage preferences. The poll found that some respondents ate fruits daily. Lifestyle factors affected 300 respondents' migraine symptoms, along with migraine issues. Sleep patterns were significant because participants reported their average sleep duration and migraine effects. The poll measured food, alcohol, smoking, and drug use. Participants said they used computers, laptops, and smartphones regularly. Evaluations included meal skipping, processed or quick food, and migraine drink preferences.

Analysis of data

The data was statistically analysed. Objective-based data was sorted andcollated, then analysed using statistical tools. This made data meaningful and relevant.

RESULTS AND DISCUSSIONS

Migraine sufferers' dietary and psychological stress profiles were evaluated in the study. Dietary habits and food consumption were documented. This study evaluated migraineurs in different places and found:

A. Demographic information
B. Lifestyle
C.Migraine related question
D. Analysis of data

Demographic information

A diverse 300 migrainers submitted demographic data for this investigation. A large proportion of 21-25-year-olds (153 respondents) are in the study cohort. The researchers included 24 under-20s, 85 25-30s, and 38 over-30s. Respondents' academic credentials varied. 87 graduated, 98 had bachelor's, and 112 had master's. Three respondents held doctorates, showing the research group's educational diversity. There were 198 women and 102 men. Comprehensive migraine gender-specific insights come from balanced gender representation. The survey captured height and weight. Researchers found a large proportion of 40-80-kilogram respondents. Five weighed 40-50 kg, 39 weighted 50-60 kg. Most participants (178) weighed 60–70 kilogrammes, indicating a concentration. 70–80 kg was reported by 78 respondents. This large weight variance highlights the importance of researching migraines individually because weight can alter migraine patterns and treatment options. Interval frequency varies. The respondents were 5'2" to 5'11". Participants' heights varied greatly in the survey. Eight responses were 5'4" and 43 were 5'2". Another 88 were 5'6" and 88 5'8". Also, 56 were 5'10" and 17 were 5'11". Height variation can affect migraine occurrence and management; hence participants' height variation can shed light on the relationship. To examine spatial effects on migraines, researchers collected household information from 91 urban and 209 rural participants. Of the survey sample, 106 were married and 194 were single. With this extensive demographic data, migraine trends, causes, and management methods can be examined by demographic group. Researchers can study how age, education, gender, physical features, residential background, and marital status affect migraine experiences in a diverse participant cohort.

Gender information

A 300-person survey found an intriguing gender distribution pattern. Of the participants, 198 were women, 66% of the sample. Males made up 34% of the total with 102 people. This gender distribution illuminates the study population's demographics, emphasizing the importance of female participants (Table 1, Figure 1).

Age information

A 300-person sample spans many life phases. The largest age group, 21-25, had 153 participants, 51% of the sample. The youngest cohort members were 24 (8%), under 20. The next significant group was age 25-30, with 85 people (29% of the total). Finally, 38 people—12%—were above 30. In the context of the study, different age groups may have different perspectives and behaviour, hence age should be considered while analyzing the data (Table 2, Figure 2).

Education related information

Migraine prevalence survey participants are educated differently. Postgraduates comprised 112 of 300 responses, or 37%, indicating a strong higher education student population. This survey included 98 undergraduates, 33% of the population. Just 29% of the sample—87 people—was educated. Only 3 individuals (1%), had Ph.D. degrees, indicating high-educated persons. Educational variability highlights the importance of incorporating educational levels while studying migraine prevalence and lifestyle and diet in students (Table 3, Figure 3).

Weight related information

Weight data from the migraine prevalence research helps explain participant weight distribution. The majority of 300 respondents—178 (59%), weighted 60–70 kg. This group makes up a substantial percentage of the study population, suggesting weight and migraine prevalence studies (Table 4, Figure 4). The 70-80 kg weight group was well-represented with 78 athletes (25%). Only 39 people (14%), were 50-60 kg. Final 5 participants, or 2%, were 40-50 kg. This weight distribution among survey participants underlines the importance of weight in assessing migraine prevalence and its relation to lifestyle, food, and other factors.

Height information of participants

Migraine prevalence survey participant height distribution. With 88 or 30% of 300 replies, most were 5'6". Thirty percent of the study participants (i.e.88 respondents) were 5'8". The majority of participants, 56 (18%), were 5'10". 43 (15%) were 5'2", 17 (4%) were 5'11". Finally, 8 (3%), were 5'4" (Figure 5). This large height variability across survey participants highlights the importance of height in understanding migraine prevalence and its potential linkages to lifestyle, food, and other factors in students.

Marital status

The marital status of the study group is revealed by information gathered from migraine prevalence survey respondents. 106 respondents, or 35% of the 300 totals, were married. There may have been a higher percentage of singles in the study population because 194 (65%) of the participants were single (Table 6, Figure 6). An important demographic component for examining the occurrence of migraines and any possible associations with food, lifestyle, and other factors is marital status. The diversity of respondents' marital status highlights the need for further research into how this factor can impact the occurrence of migraines in students.

Residential profile

Migraine prevalence survey residential profiles provide research participants' living situations. Rural areas housed 209 of 300 respondents, 70%. The survey's significant rural participation may alter its outcomes. The urban population was 91 (30%). Though small, this urbanite group is important to the study. The differences in urban and rural residential profiles are important for evaluating migraine prevalence and its potential links to lifestyle, food, and other variables in students. Migraine factors may vary by lifestyle (Table 7, Figure 1).

Lifestyle related information

The current comprehensive migraine survey revealed habits and experiences that may be linked to migraine occurrence and management. 208 individuals slept 8 h, 66 slept 6 h, and 20 slept longer. Of note, 85 respondents indicated sleep habits caused migraines, 77 said no, and 138 were unclear. Lifestyle choices showed 263 respondents did not drink, smoke, or use drugs, 9 did, and 28 occasionally. Screen time habits were also evaluated, with 163 spending 2–5 h, 76 5–10 h, and 61 more than 10 h. It's noteworthy that screen time may affect migraines (Table 8). Eat habits were another problem. 37 skipped breakfast, 26 skipped lunch, and 16 skipped dinners, while 221 did not. 100 respondents ate processed or fast food regularly, with varying frequencies, which may indicate migraine triggers (Table 8). During migraines, 89 chose lemon soda, 77 herbal tea, 56 ordinary tea, and 78 coffee. Understanding how drinks affect migraines is crucial (Table 8). Fruit was a beneficial diet habit for 122, 75 occasionally, and 103 not. 52 had three meals a day, 225 had two, and smaller groups had one or four. 164 respondents drank 1 litre of water daily, 92 drank 2, 37 drank 3, and 7 drank more than 3.

Sleep pattern

Sleep influences migraines are thought by 85 participants (28.33%), 77 (25.7%) not sure, and perhaps 138 (46%).

These responses show survey participants' various migraine sleep-related beliefs. There may be a correlation ("Maybe"), while others are split between those who think sleep affects migraines ("Yes") and those who don't ("No"). These varied responses show that sleep patterns and migraine are complex and require further study (Figure 8).

Skipping meals

Migraine prevalence survey data on meal skipping

Breakfast: 37 participants (12.3%)

Lunch: 26 participants (8.7%)

Dinner: 16 participants (5.3%)

None: 221 participants (73.7%)

Many individuals (73.7%) reported not skipping any meals, whereas fewer indicated skipping breakfast, lunch, or dinner (Figure 9). Skipping meals may be a role in student migraine prevalence and eating patterns.

Screen timings

The migraine prevalence survey data on electronic device use (mobile, laptop, PC) and screen time is:

2-5 hours: 56 participants (18.7%)

5-10 hours: 58 participants (19.3%)

More than 10 hours: 61 participants (20.3%)

0-2 hours: 125 participants (41.7%)

These results show that a considerable majority spends 0-2 hours on screens and an equal distribution spends 2-5 hours, 5-10 hours, and more than 10 hours on screens routinely. Screen time duration may be useful for investigating student migraine prevalence, lifestyle, and screen usage (Figure 10).

Smoke/drugs consumption

The migraine prevalence survey statistics on alcohol, smoking, and drug use:

Yes: 9 participants (3%)

No: 263 participants (87.7%)

Sometimes: 28 participants (9.3%)

Many participants (87.7%) reported not using alcohol, smoking, or drugs (Figure 11). Some participants do, while others do so infrequently ("Sometimes"). Understanding substance usage habits is crucial when studying lifestyle choices and student migraine prevalence.

Consumption of fast food

The data on how often participants consume processed or fast food in the migraine prevalence survey is as follows:

Regularly: 100 participants (33.4%)

Once a week: 95 participants (31.8%)

Twice a week: 59 participants (19.8%)

Thrice a week: 45 participants (15%) (Figure 12)

These replies show that most people eat processed or fast food weekly or regularly. The frequency of processed or fast-food consumption is significant when investigating its potential association with student migraine prevalence.

Preferring of drink during migraine

The migraine prevalence survey's data on migraineurs' refreshing drink preferences is as follows (Figure 13):

Lemon soda: 89 participants (29.6%)

Herbal tea: 77 participants (25.7%)

Tea: 56 participants (18.7%)

Coffee: 78 participants (26%)

These replies reveal migraineurs prefer different refreshing drinks. Most participants like lemon soda, coffee, herbal, and regular tea. Understanding these preferences can help researchers analyses diet and student migraines.

Fruits consumption

In the migraine prevalence survey, participants' daily fruit consumption was:
Yes: 122 participants (40.7%)
No: 103 participants (34.3%)
Sometimes: 75 participants (25%)
Many individuals (40.7%) reported eating fruits daily. Fruits were eaten infrequently ("Sometimes," 25%) and not daily (34.3%) (Figure 14). Dietary choices, including daily fruit intake, may affect student migraine prevalence.

Meals frequency

Daily meal frequency statistics from migraine prevalence survey participants:
1 time: 5 participants (1.7%)
2 times: 225 participants (75%)
3 times: 52 participants (17.3%)
4 times: 18 participants (6%)
5 times: 6 participants (2%)
This shows that 75% of individuals eat twice a day, followed by 17.3% who eat three times (Figure 15). Six percent and two percent reported eating four or five times a day, respectively. Daily meal frequency may be linked to migraine prevalence in students.

Water consumption in liters

Migraine prevalence survey participants' daily water consumption:
1 liter: 164 participants (54.7%)
2 liters: 92 participants (30.7%)
3 liters: 37 participants (12.3%)
More than 3 liters: 7 participants (2.3%)
Most participants (54.7%) drank 1 L of water every day, followed by 2 (30.7%) and 3 (12.3%) (Figure 16). Only 2.3% reported drinking more than 3 L of water daily. Adequate hydration is an important lifestyle factor that may affect student migraine prevalence.

Migraine related information

Many fascinating information were found in the migraine prevalence, frequency, related factors, and coping techniques survey. Migraines were reported by 187 individuals and not by 113. Migraines affected 136 people sporadically, 73 once a week, 41 twice a week, 20 continuously, and 30 thrice a week. Migraines' complexity and impact are shown by their variation (Table 9). Several migraine triggers were found. Changes in sleep habits harmed 108 respondents, while 72 claimed stressful schedules induced migraines. Weather changes affected 9, overheating 8, stomach troubles 90, and hot/cold baths 13. Migraines may be caused by environmental, behavioral, and physiological causes. Various migraine coping methods were used. 91 individuals sought medical care, whereas 106 tried yoga and meditation for migraines. Seven patients took OTC drugs and 23 employed home remedies. Additionally, 73 migraineurs tried various therapies. These methods demonstrate migraineurs' approaches (Table 9).
This collection of responses displays individuals' migraine triggers, experiences, and coping methods. It emphasizes individualized migraine care and management, giving insights that may improve therapies and quality of life.

Factors associated with migraine

Participants in the migraine prevalence survey reported the following migraine factors:
Sleeping pattern changes (Figure 17):
108 participants (36%)
Weather changes: 9 participants (3%)

Hectic schedule: 72 participants (24%)
Overheating: 8 participants (2.7%)
Digestive problem: 90 participants (30%)
Hot or cold bath: 13 participants (4.3%)
This list includes variables participants think may cause migraines. Sleeping patterns and stomach issues were the most common, but weather, hectic schedules, sweating, and hot or cold showers were also cited. Understanding these perceived relationships can help identify student migraine triggers and exacerbators.

Migraine problems
Among the participants in the migraine prevalence survey:
187 individuals (62.3%) reported having a migraine problem.
113 individuals (37.7%) indicated that they do not have a migraine problem (Figure 18).
These results reveal that most survey participants had migraines, whereas a large portion did not. Migraine prevalence in the study population is crucial for investigation.

Problems solutions during migraine
In the migraine prevalence study, participants' likely migraine solutions are:
Go to the doctor (for recommendations): 91 participants (30.3%)
Yoga/Meditation: 106 participants (35.3%)
Home remedies: 23 participants (7.7%)
Take normal medicines: 7 participants (2.3%)
Any therapy: 73 participants (24.4%) (Figure 19)
These responses demonstrate migraine treatment. Many seek expert counsel, while others employ yoga, meditation, home remedies, therapy, or medicines. Student migraine symptoms can be managed by learning participation coping skills.

Fellings of migration
In the migraine prevalence study, individuals reported the following migraine frequency:
Sometimes: 136 participants (45.3%)
Once a week: 73 participants (24.3%)
Twice a week: 41 participants (13.7%)
Thrice a week: 30 participants (10%)
Continuous: 20 participants (6.7%) (Figure 20)
This suggests participants have migraines at different frequencies. The most common response is "sometimes," with several individuals reporting weekly migraines. Investigating student migraine prevalence and lifestyle and other factors requires knowing migraine frequency.

Interpretation of survey data
The thorough migraine survey reveals the complexity of headaches, their triggers, and respondents' coping techniques. Researchers examine the important findings and their ramifications here:

1. Migraine prevalence: In the survey, 187 people reported migraines and 113 did not. This shows that migraines affect a large section of the population.
2. Frequency of migraines: Migraine frequency varied substantially among respondents, showing its heterogeneity.136 participants had occasional headaches, showing that migraines can be episodic.73 people reported weekly migraines, indicating chronicity.41 respondents had migraines twice a week, whereas 20 had constant migraines, highlighting the variety of migraine symptoms.
3. Factors associated with migraines: Respondents linked migraines to many causes. Sleep disturbances caused migraines in 108 people. This reinforces the role of sleep interruptions as migraine triggers. 72 respondents cited hectic schedules as a migraine trigger, showing how lifestyle affects migraines. Weather, overeating, stomach

issues, and hot or cold baths were also migraine triggers for smaller groups. These factors show migraine triggers' complexity.

4. Coping mechanisms: Migraines were managed in various ways. Over 90% of respondents sought medical advice from doctors. 106 respondents used yoga and meditation to manage migraines, emphasizing mind-body techniques. 23 people used home remedies, demonstrating a preference for natural or self-care. Seven respondents used OTC drugs. Additionally, 73 migraineurs tried various therapies, demonstrating their diverse coping techniques. This statistical analysis suggests that migraines are complex and affect people's lives. Each person has a different migraine prevalence, frequency, triggers, and coping methods. This variety must be acknowledged for optimal management and action. It emphasizes the importance of a customized approach to migraine patients and migraine research. Additional research and analysis are needed to understand migraines' complicated causes and give more specialized treatments and prevention.

CONCLUSIONS

Complex neurological illnesses like migraines affect millions worldwide. Researchers examined 300 people's demographics and lifestyles to assess migraine complexity. This review highlights migraine comprehension and therapeutic relevance of important survey results. Demographics differed greatly among poll respondents. This age group was well-represented with 153respondents of 21–25 yearsage group and 85 respondents of 25–30 years age group replies. Migraines affect varied ages, as 24 responders were under 20 years and 38 were over 30 years. The participants had 112 master's, 98 bachelor's, and 3 Ph.Ds. Education and migraine management must be examined due to the variance in educational backgrounds. Women (198) outnumbered males (102). Examine gender-specific migraine traits and balance gender representation. The respondents' height and weight varied substantially. 178 participants weighed 40-80 kg, typically 60–70. Test subjects were 5'2" to 5'11". Because 209 lived in rural areas and 91 in cities, geography may affect migraines. A varied sample included 194 singles and 106 married. Lifestyle factors that because migraines were examined. A major concern was sleep patterns, with 208 respondents reporting 8 h and 66 respondents reporting 6 h. Since 85 percent thought sleep induced migraines, it was possible. A total of 263 abstainers from alcohol, smoking, and drugs were studied. Nine mentioned such procedures, and 28 did so occasionally, including migraine lifestyle information. 163 respondents used screens 2-5 h, 76 5-10 h, and 59 less or more than 10 h. Screen time and migraines remain research priorities. 221 non-skipped-meal responders were studied. 37, 26, and 16 respondents skipped breakfast, lunch, and dinner, respectively. Up to 100 people ate fast food frequently. Migraine sufferers appreciate different drinks. Lemon soda, herbal tea, tea, and coffee were preferred by 89 respondents, suggesting migraine-causing drinks. A daily fruit diet improved 122 respondents.

A total of 225 persons had two meals a day, 52 had three, and smaller groups had one to four. 164 persons drank one liter of water daily, 92 two, 37 three, and 7 over three. A migraine survey was done. Most respondents i.e. 187 were reported migraines, 113 did not. 136 had migraines rarely, 73 weeklies, 41 twice, and 20 daily. Sleep habits harmed 108 respondents, and 72 claimed busy schedules induced migraines. Weather, heat, digestion, and hot or cold baths can cause migraines. Migraines need dealing. 106 practiced yoga and meditation, 91 saw a doctor. Seven patients took OTCs, 23 tried home remedies. The 73 individuals studied migraine therapy. This demographic and lifestyle study of migraineurs showed the complex relationship between personality, lifestyle, and headaches. Our diverse sample's age, education, genders, heights, weights, and marital status emphasize the need for personalized migraine management. Lifestyle choices include eating, drinking, screen time, skipping meals, food and beverage preferences, fruit consumption, meal frequency, and hydration. The complex neurological disease migraine causes throbbing headaches, nausea, vomiting, and light and sound sensitivity, a global health issue. Migraines affect all ages and socioeconomic categories, but students are at risk because they can affect academic performance and well-being.This essential time affects sleep, diet, stress, and everyday routines. These changes can significantly affect mental and physical health.College changes students' sleep, stress, nutrition, and schedules. Family history, gender, age, hormonal changes, lifestyle variables, stress, sleep habits, food, dehydration, skipping meals, environmental factors, medical concerns, drugs, smoking, and obesity are migraine risk factors. Migraines are connected to stress, sleep,

and work in many studies. Migraines affect women more than males. Students' demographic, migraine-related, and lifestyle characteristics may affect migraine symptoms, according to researchers.Drugs, alcohol, and smoking were examined for migraine risk. To determine if digital exposure and migraine frequency are linked, phone, laptop, and PC screen time was measured. Fast food and meal skips were studied as migraine triggers and treatments. Assessing daily fruit eating and revitalizing beverage choice assessed migraine benefit.This study found 62.3 percent of 21-25-year-olds get migraines. Omega-3 fatty acids, magnesium-rich foods, antioxidant-rich foods, caffeine and alcohol avoidance, hydration, moderate sugar intake, herbal teas, portion control, regular meals, mindful eating, meal planning and preparation, and professional advice to minimize risk factor adverse effects

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Table 1. Demographic profile of the population on the basis of gender

Gender	Frequency(n)	Percentage (%)
Females	198	66
Males	102	34
Total	300	100

Table 2. Demographic profile of the population on the basis of age

Age group	Frequency (n)	Percentage (%)
21-25 years	153	51
Under 20 years	24	8
25-30 years	85	29

Above 30 year	38	12
Total	300	100

Table 3. Demographic profile of the population on the basis of education

Education	Frequency (n)	Percentage (%)
School	87	29
Undergraduates	98	33
Postgraduates	112	37
Ph.D.	3	1
Total	300	100

Table 4. Demographic profile of the population on the basis of weight (kg)

Weight (kg)	Frequency (n)	Percentage (%)
40-50	5	2
50-60	39	14
60-70	178	59
70-80	78	25
Total	300	100

Table 5. Demographic profile of the population on the basis of height

Height	Frequency (n)	Percentage (%)
5 foot 2 inches	43	15
5foot 4 inches	8	3
5 foot 6 inches	88	30
5 foot 8 inches	88	30
5foot 10 inches	56	18
5 foot 11 inches	17	4
Total	300	100

Table 6. Demographic profile of the population on the basis of marital status

Marital status	Frequency (n)	Percentage (%)
Married	106	35
Unmarried	194	65
Total	300	100

Table 7. Demographic profile of the population on the basis of residential profile

Residential profile	Frequency (N)	Percentage (%)
Urban	91	30
Rural	209	70
Total	300	100

Table 8. Lifestyle related information of the population

Variables (N)	Answer choice	Frequency (N)	Percentage (%)
How many hours do you sleep?	▪ 6 hours ▪ 8 hours ▪ Less than 6 hours ▪ More than 8 hours	66 208 6 20	22 69 2 7
Does your sleep pattern affect your migraine problem?	▪ Yes ▪ No ▪ May be	85 77 138	28.33 25.7 46
Do you take alcohol/ smoke/ drugs?	▪ Yes ▪ No ▪ Sometimes	9 263 28	3 87.7 9.3
Do you use mobile, laptop, computer regularly and if yes, then how much time do you spend on screening?	▪ 2-5 hours ▪ 5-10 hours ▪ More than 10 hours ▪ 0-2 hours	56 58 61 125	18.7 19.3 20.3 41.7
Do you skip meals?	▪ Breakfast ▪ Lunch ▪ Dinner ▪ None	37 26 16 221	12.3 8.7 5.3 73.7
How often do you eat processed or fast food?	▪ Regularly ▪ Once a week ▪ Twice a week ▪ Thrice a week	100 95 59 45	33.4 31.8 19.8 15
Do you prefer refreshing drinks during migraine? If yes, then which one?	▪ Lemon soda ▪ Herbal tea ▪ Tea ▪ Coffee	89 77 56 78	29.6 25.7 18.7 26
Are you eating fruits daily (like banana, watermelon)	▪ Yes ▪ No ▪ Sometimes	122 103 75	40.7 34.3 25
How often do you have a meal in a day?	▪ 1 time ▪ 2 times ▪ 3 times ▪ 4 times	5 225 52 18	1.7 75 17.3 6
How many liters of water do you drink in a day (helps in keep hydrated)?	▪ 1 liter ▪ 2 liters ▪ 3 liters ▪ More than 3 liters	164 92 37 7	54.7 30.7 12.3 2.3

Table 9. Migraine related information of the population

Variables (n)	Answer choice	Frequency (n)	Percentage (%)
Do you have a migraine problem?	▪ Yes ▪ No	187 113	62.3 37.7
Factors associated with migraine?	▪ Sleeping pattern changes ▪ Weather changes ▪ Hectic schedule ▪ Overheating ▪ Digestive problem ▪ Hot or cold bath	108 9 72 8 90 13.0	36 3 24 2.7 30 4.3
What probable solutions do you do while suffering from migraine?	▪ Go to doctor (for recommendation ▪ Yoga/ meditation ▪ Home remedies ▪ Take normal medicines ▪ Any therapy	91.0 106.0 23.0 7.0 73.0	30.3 35.3 7.7 2.3 24.4
How often do you feel migraines?	▪ Sometimes ▪ Once a week ▪ Twice a week ▪ Thrice a week ▪ Continuous	136.0 73.0 41.0 30.0 20.0	45.3 24.3 13.7 10.0 6.7

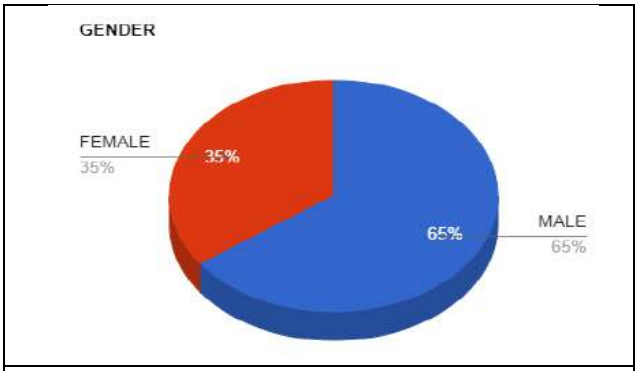


Figure 1 Graphical representation of the population on the basis of gender

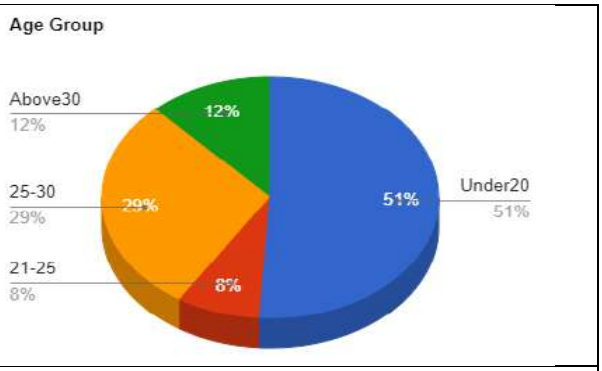


Figure 2 Graphical representation of the population on the basis of age

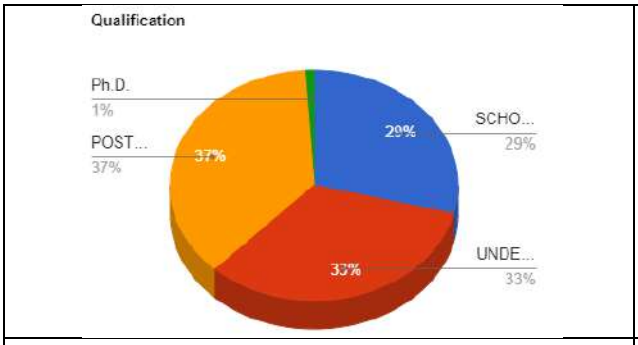


Figure 3. Graphical representation of the population on the basis of education

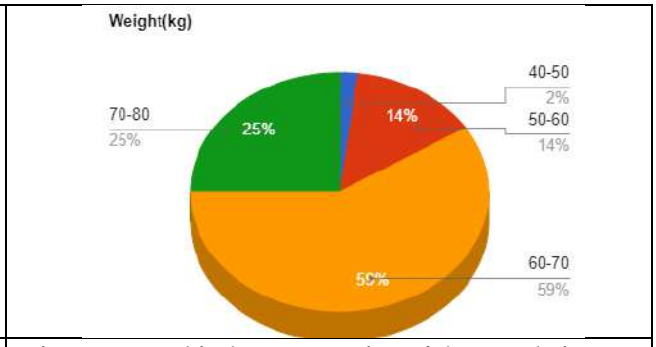


Figure 4. Graphical representation of the population on the basis of weight (kg)

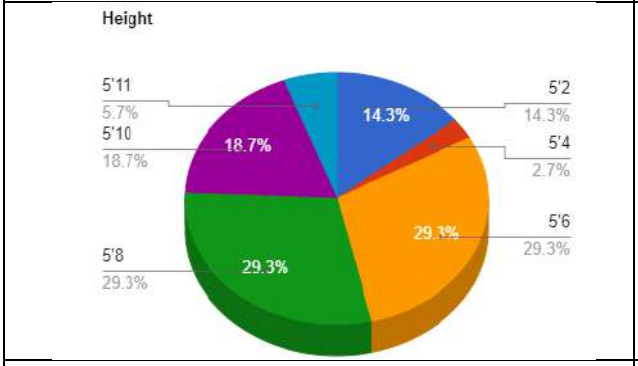


Figure 5. Graphical representation of the population on the basis of height

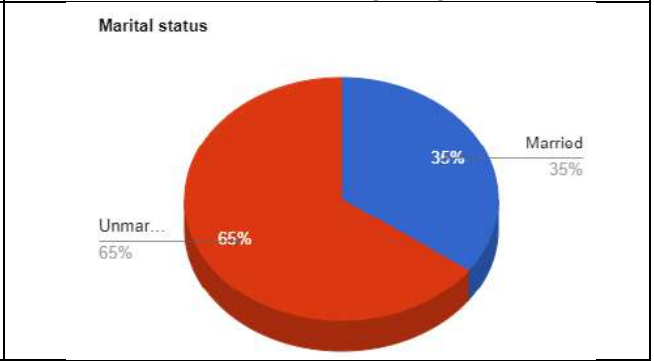


Figure 6. Graphical representation of the population on the basis of marital status

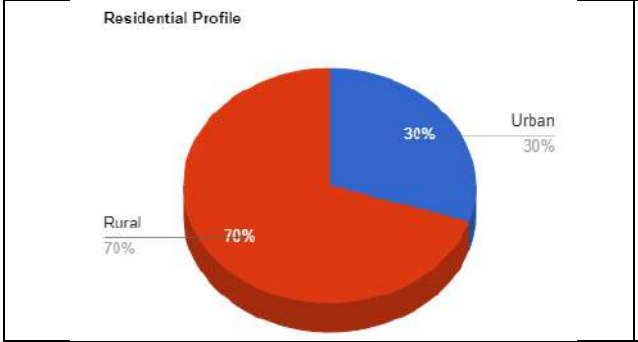


Figure 7. Graphical representation of the population on the basis of residential profile

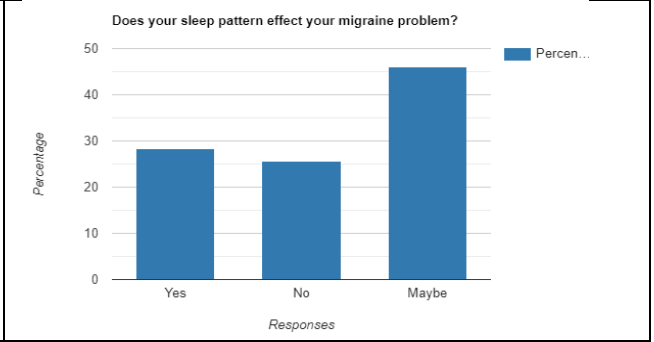


Figure 8. Graphical representation of the population on the basis of sleep pattern

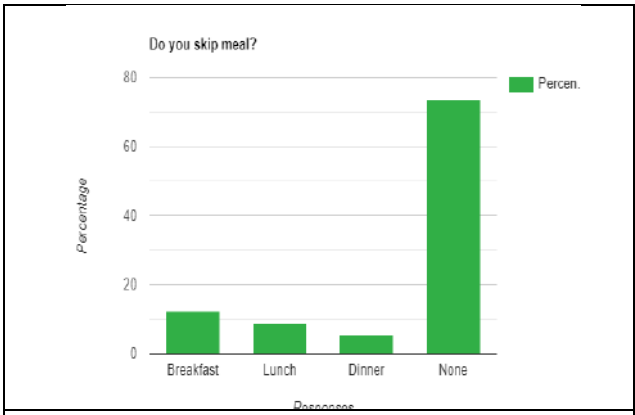


Figure 9. Graphical representation of the population on the basis of skipping meals

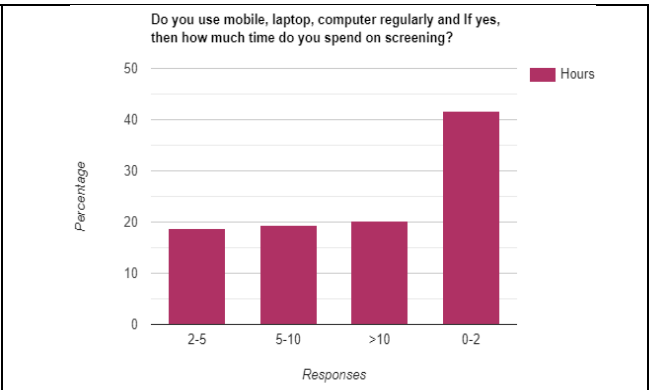


Figure 10. Graphical representation of the population on the basis of screening time

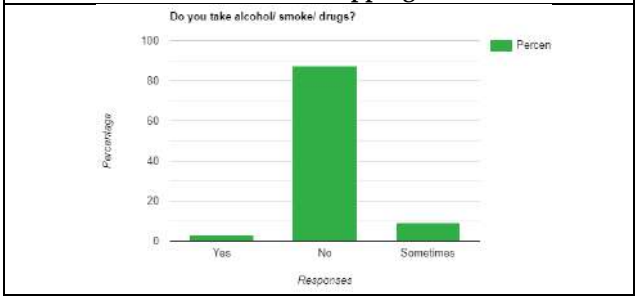


Figure 11. Graphical representation of the population on the basis of drugs

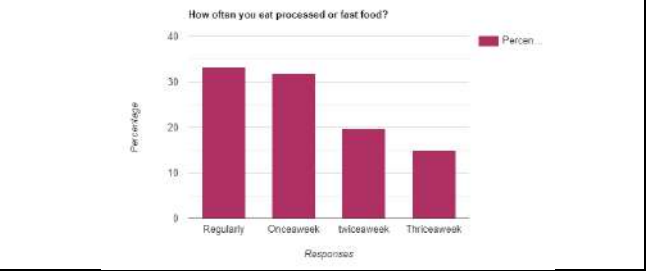


Figure 12. Graphical representation of the population on the basis of eating habits

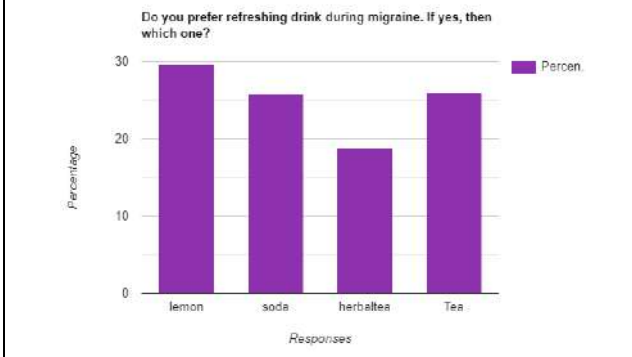


Figure 13. Graphical representation of the population on the basis of refreshing drinks

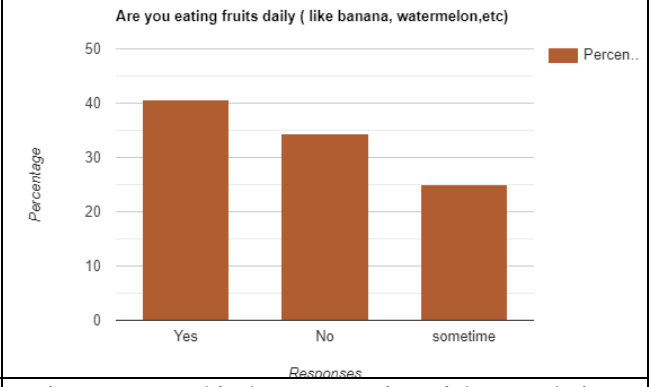


Figure 14. Graphical representation of the population on the basis of eating fruits daily



Figure 15. Graphical representation of the population on the basis of taking meal in a day

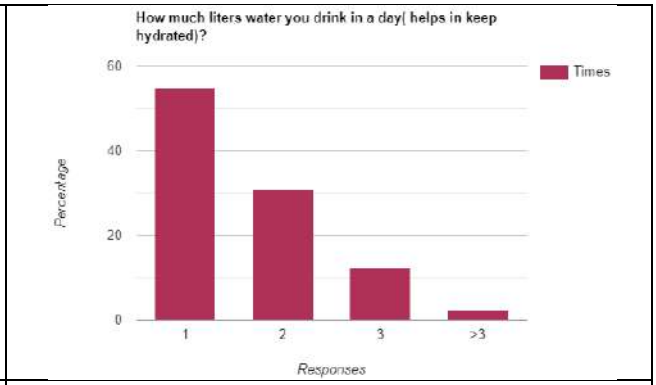


Figure 16. Graphical representation of the population on the basis of drinking water

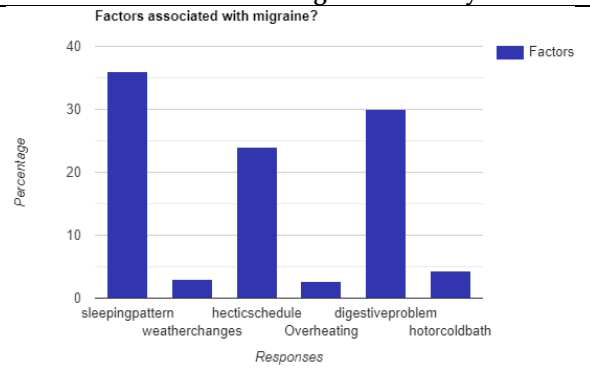


Figure 17. Graphical representation of the population on the basis of factors associated

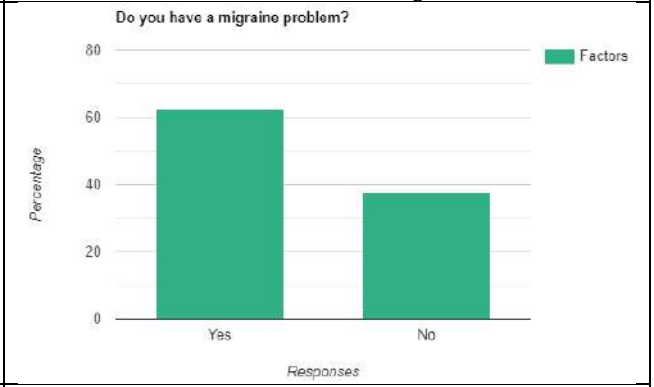


Figure 18. Graphical representation of the population on the basis of migraine problem

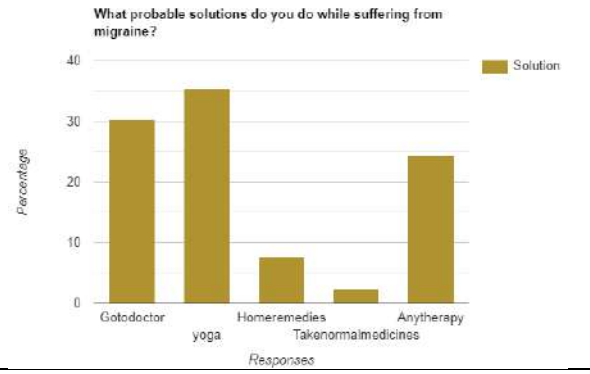


Figure 19. Graphical representation of the population on the basis of problem solution

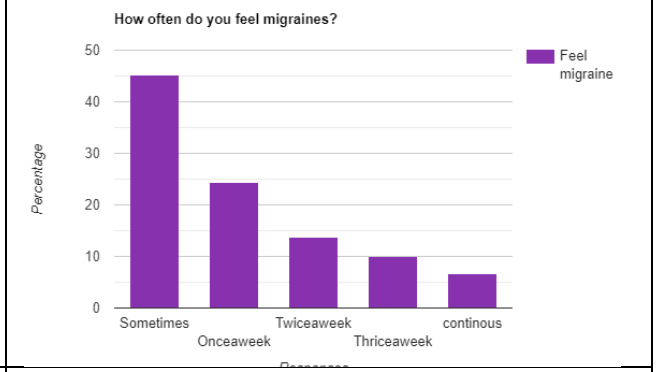


Figure 20. Graphical representation of the population on the basis of feeling migraine

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REVIEW ARTICLE

Drug Review on Siddha Polyherbal Formulation Kathalikantha Rasayanam (Internal) for the Management of Bala Karappan

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ABSTRACT

The Siddha system is the earliest Dravidian system of medicine that originated in south India. The word Siddha means established truth. The Siddha system plays a wide range of roles in the field of paediatrics. Skin-related diseases can affect an individual at any age. As per the Siddha literature, Bala Karappan is associated with the symptoms of erythema, intense pruritis, oedema, exudation, crusting with lichenification, and scaling. In the textbook of Kuzhandhai Maruthuvam (Bala Vagadam), Bala Karappan is described as one type of Karappan among 18 types. The signs and symptoms of Bala Karappan may be correlated with Atopic dermatitis. This article is going to review the herbal ingredients present in the *Kathalikantha Rasayanam* from *Bogar 700* and their effectiveness in treating Bala Karappan (Atopic dermatitis).

Keywords: Drug review, *Kathalikantha Rasayanam*, Atopic dermatitis, Bala Karappan.

INTRODUCTION

The Siddha system is known to be a complete medical system that consists of physical, psychological, philosophical, ethical, and spiritual health. The Siddha system can play a major preventive, curative, and promotional role in all types of disorders.Children's health reflects the Nation's health and wealth, and they are the most vulnerable group in society. According to Siddha medicine, Karappan occurs due to the derangements in Mukkutram (Vatham, Pitham,and Kabam) with the dominance of Vadham. AD, or Atopic dermatitis is the most frequent chronic, recurrent skin disorder with a broad clinical spectrum and is often linked with other allergies, such as food allergy, asthma, and allergic rhinitis (AR). AD occurs at any age, though 45% all cases begin within six months of life, with up to 80-90% developing their first symptoms by five years of age [1]. *Kathalikantha Rasayanam* is one of the polyherbal formulations that contains 12 ingredients which is mentioned in the Siddha text book *Bogar 700.* This review describes the phytochemicals, pharmacological action and medicinal uses of the ingredient in various research studies.

MATERIALS AND METHODS

Ingredients of *Kathalikantha Rasayanam*:

1. *Koshtam*(Costusspeciosus.Koen.) - 2 balam (140g)
2. *Kandathippili* (Piper longum.Linn) - 1 balam (70g)
3. *Chukku*(Zingiber officinale.Rosc) - 1 balam (70g)
4. *Sathikkai*(Myristica fragrans. Houtt) - 1 balam (70g)
5. *Kirambu*(Sygygiumaromaticum.Linn) - 1 balam (70g)
6. *Seeragam* (Cuminum cyminum.Linn) - 1 balam (70g)
7. *Milagaranai*(Toddaliaasiatica.Lam) - 1 balam (70g)
8. *Sangamver* (Azima tetracantha.Lam) - 1 balam (70g)
9. *Kathalipoo* (Musa paradisiaca.Linn)- 100 flowers
10. *Vangala seeni* (Saccharum officinarum.Linn) - 350g
11. *Pasumpaal*(Cow's milk) - 4.2 L
12. *Thaen* (Honey) - 525 ml

Purification [2]:

Koshtam: It will be cleaned and dried in the sunlight.
Kandathipili: It will be washed with purified water and dried.
Chukku: It will be added by doubling the amount of sunnakkal with one part of chukku for three hours, after which it will be washed and dried.After that, the external skin should be peeled off.
Jathikkai: It will be purified by removing the outer skin and cut into small pieces and dried under the sunlight.
Kirambu: It will be dried in the sunlight.
Seeragam: It will be purified by removing sand particle and dried under sunlight.
Milagaranai: It will be washed with purified water and dried.
Sangamver: It will be washed with purified water and dried.
Kathalipoo: Remove the waste particles.
Vangala seeni: It will be grinded with a pestle and mortar and taken by a pad, then smashed.

Preparation method: All the purified ingredients from 1 to 8 will be made into fine powder form and kept separately. Cut a hundred banana flowers in a pan, and dissolve them in cow's milk, and strain it. After that, the sugar will be mixedand boiled well to form a sticky consistency. Now all the powdered ingredients mixed with the already prepared sugar syrup and stirred well to become the medicine into rasayanam form. Finally, honey will be added, mixed well, and packed in an airtight container.

KOSHTAM (Costusspeciosus.Koen):
Synonyms [3]**:**Kottam, Kura, Oli
Vernacular names [3]**:**Eng: Costus root Sans: Koshtam
Part used [3]**:** Root
Organoleptic character [3]**: Taste:** Bitter**Character:** Hot **Division:** Pungent
Action [3]**:**Stomachic, Expectorant, Tonic, Stimulant, Diaphoretic

Botanical description [5]**:**It is a rhizomatous herb with erect or spreading stems. Simple, smooth, perennial leaves are spirally arranged around the trunk.The inflorescence is a 10 cm long spike around with huge bracts in sub terminal position. Bracts are oval or mucronate and bright red in colour. Fruit is capsule and red in colour. A white fleshy aril surrounds five black seeds. The flowers resemble crepe paper, thus commonly called crepe ginger.
Pharmacological activity [6]**:**Anti-inflammatory, Anti-fungal, Anti-microbial, Analgesic.**Bioactive compounds** [4]**:** Dioscin, Diosgenin, Costusosides, Linoleic acid, Carvacrol, Pinocarveol, Cineol, Cadinene, Methyl protogracillin, Lupeol Palmitates,Gadoleic acid.
Medicinal uses [6]**: (i)**It can be used to treat a wide range of medical conditions, including fever, asthma, tonsilitis, bronchitis, constipation, skin diseases and snake and insect bites.**(ii)**It was specifically advised for the treatment of pleurisy, tonsils and as an antidote for snake venom.

KANDATHIPILI (Piper longum.Linn):
Synonyms [3]**:**Aathi marunthu, Kozhaiyarukki, Soundi, Thanduli, Saadi, Kudaari, Kanam, Arkathi, Baanam, Thulavi, Kaaman, Pipili, Koli, Unsaram, Kolagam, Ulavai nasi, Saram.
Vernacular names [3]**:**Eng: Long pepper Sans: Pippali
Part used: Fruit
Organoleptic character [3]**: Taste:** Sweet**Character:** Hot**Division:** Sweet
Action [3]**:**Stimulant, Carminative

Botanical description [7]**:** It is a smaller shrub with a huge woody root and multiple creeping, jointed stems that are thickened at the nodes.The leaves are alternate, spreading, without stipules and blades varying greatly in size. Flowers grow in solitary spikes and fruits which grow in fleshy spikes 2.5-3.5 cm long and 5 mm thick, are oblong, blunt, and blackish- green.
Pharmacological activity [7]**:** Antioxidant, Anti-inflammatory,Antimicrobial,Analgesic,Anti-fungal,Immuno modulatory
Bioactive compounds [7]**:** Piperine, methyl piperine, piperlongumine, pellitorine, pipercide, longamide, brachystine, asarinine, piperettine, pipernonaline, palmitic&tetrahydropipericacid.
Medicinal uses [8]**: (i)**It is used for the treatment of respiratory diseases like cold, cough, bronchitis and asthma. **(ii)**It acts as an analgesic when applied locally in muscular pain and inflammation and internally as a carminative in conditions like loss of appetite, insomnia and obstruction in liver and spleen.

CHUKKU (Zingiber officinale.Rosc):
Synonyms [3]**:**Aarthragam, Chundisondi, Sowvarnam, Nagaram, Vichvapeshajam, Vidamoodiyaamirtham, Athagam, Ularnthainji, Sowpannam, Navasuru, Verkombu, Arukkan, Ubakullam, Kadupathiram, Manowshatham.
Vernacular names [3]**:**Eng: Dried Ginger Sans: Nagaram
Parts used [3]**:** Dried Rhizome
Organoleptic character [3]**:Taste:** Pungent **Character**: Hot **Division:** Pungent
Action [3]**:** Stimulant, Stomachic, Carminative

Botanical description [9]**:**The ginger plant has perennial, thick tuberous root or rhizome; the stems are erect, round oblique, annual and covered by the smooth sheaths of the leaves, 2 or 3 feet in height,and has yellow green flowers.
Pharmacological activity [10]**:** Analgesic, Anti-cancer, Antioxidant, Anti-inflammatory.

Bioactive Compounds [10]: Zingiberene, sesquiphellandrene, e- citral, z-citral, camphene, o-cymene, limonene, ar-Curcumene, bisabolene.
Medicinal uses [10]: (i) Western medicine uses ginger to treat digestive problems.**(ii)**For infantile colic, ginger and milk or water in the form of paste are used externally in Ayurvedic system.**(iii)**The combined form of ginger and honey is used for bronchitis& hiccups.

SATHIKKAI(Myristica fragrans.Houtt)
Synonyms [3]: Kulakkai, Jathikkai
Vernacular names [3]: Eng: Nut Meg Sans: Jatphalam
Parts used [3]: Fruit
Organoleptic character [3]:Taste: Astringent, Pungent **Character:** Hot**Division:** Pungent
Action [3]: Stimulant, Carminative, Narcotic, Aromatic, Aphrodisiac, Tonic
Botanical description [12]: It is a spreading evergreen tree usually that typically reaches heights of 5 to 13m, occasionally 20m.Watery pink or red sap present in the bark. The fruits are 6 to 9 cm long, yellow, fleshy, drooping, smooth, and have a longitudinal ridge.Nutmeg seeds have a broad ovoid shape 2 to 3 cm long, fleshy, firm, whitish and transversed by red-brown veins.
Pharmacological activity [13]: Antioxidant, Antimicrobial,
Bio active compounds [14]: Myristicin, elemicin, safrole, terpenes, alpha-pinene, beta-pinene, myristic acid, trimyristin, camphene, limonene
Medicinal uses [12]:(i) The nutmeg essential oil is used externally for rheumatism and contains analgesic and anti-inflammatory properties.**(ii)**It helps prevent hypercholesterolemia and atherosclerosis.**(iii)**It has also been seeming to be useful as tonic for the heart and brain and also in sexual and general debility.

KIRAMBU (Syzygiumaromaticum.Linn)
Synonyms [3]: Lavangam, Anjugam, Sosam, Thirali, Varaangam, Urkadam, Karuvaikirambu.
Vernacular names [3]: Eng: Cloves, Clove tree Sans: Lavangam
Parts used [3]: Bud
Organoleptic character [3]:Taste: Pungent**Character:** Hot **Division:** Pungent
Action [3]: Antispasmodic, Carminative, Stomachic
Botanical description [15]: Clove is an aromatic spice tree. It is conical myrtle, medium sized tree with straight trunk that can reach heights up to 10 to 12 m.Flowers are small, crimson in colour and are hermaphrodite(bisexual) borne at the terminal ends of small branches.Commercially cloves used are air- dried unopened flower buds, 2.5cm in length.
Pharmacological activity [16][17]: Antioxidant, Antimicrobial, Antiviral, Analgesic, Anticarcinogenic, Anti inflammatory

Bio active compounds [16][17]: Eugenol, gallic acid, caffeic, ferulic, elagic and salicylic acids, kaempferol, quercitin, farnesol, limonene, Biflorin, Myricetin, Campesterol, Vanillin, Rhamnetin, Stigmasterol, Oleanolic acid
Medicinal uses [18]: (i) It is used to treat asthma and various allergic disorders through oral administration. **(ii)**Clove tea has been known to helps relieve nausea and vomiting.**(iii)**It can also useful to relieve the pain of muscle cramps and some nerve condition.**(iv)**Clove oil is treated for diarrhea, bad breath and hernia.

SEERAGAM (Cuminum cyminum. Linn)
Synonyms [3]: Asai, Thuthasambalam, Bosanakudori, Seeri, Methiyam, Prathi-vika, Ubakumbapeesam, Narseeri.
Vernacular names [3]: Eng. Cumin seeds or fruits Sans. Jirakams
Parts used [3]: Seeds
Organoleptic character [3]:Taste: Pungent, Sweet**Character:**Coolent**Division:** Sweet
Action [3]: Carminative, Stimulant, Stomachic, Astringent

Botanical description [20]**:**Cumin is an herbaceous annual plant, with a slender branched stem, 20 -30 cm tall. The leaves have threadlike leaflets, pinnate or bipinnate, 5-10 cm long. The flowers are small, pink or white and borne in umbels.The fruit is a lateral fusiform or ovoid achene 4-5mm long containing a single seed.
Pharmacological activity [21][22]**:**Antioxidant, antimicrobial, immunomodulatory, antidiabetic, anti-inflammatory, anticancer, analgesic
Bio active compounds [19][21]**:**Cuminaldehyde, limonene, alpha and beta – pinene, 1,8- cineole, alpha and gama terpinene, safranal, linalool, Alkaloid, Anthraquinone, Coumarin, Flavonoid, Glycoside, Protein, Resin, Saponin, Tannin, Steroid
Medicinal uses [22]**:(i)**Cumin was effective to treat jaundice, hoarseness, dyspepsia, and diarrhoea.**(ii)**It prevents any microbial and fungal infection from affecting the skin.**(iii)**It is also beneficial in treating renal coli, poor memory or lack of concentration and insect bites etc.

MILAGARANAI (Todaliaasiatica.Lam)
Vernacular names [3]**:**Eng: Forest pepper, Lopez-root tree, Wild orange tree Sans: Kanchana
Parts used [3]**:**leaf, bark, root
Organoleptic character [3]**:Taste:** Astringent**Character:**Coolent**Division:** Pungent
Action [3]**:**Stimulant, Tonic, Carminative, Diaphoretic, Antiperiodic

Botanical description [23]**:**It is an evergreen climber (woody Liana) rambling stem can grow up to 15m high and 10 cm diameter. The plant's bark is light brown in colour, fairly smooth with numerous visible pale round lenticles.Flowers are polygamous, fruit orange to dark red yellowish, seeds dark brown, several reniform, surrounded by colourless mucilage.
Pharmacological activity [23]**:**Antimicrobial, Antioxidant, Anti-inflammatory, Anti diabetic, Antimalarial, Anti-HIV, Analgesic.
Bio active compounds [23]**:**Coumarins, Alkaloids, Terpenoids, Flavonoids, Cyclohexylamides, Benzopyrans
Medicinal uses [24]**:**The leaves are traditionally used to treat lung diseases and rheumatism, roots to treat indigestion and influenza and the fruits for cough and malaria.

SANGAMVER (Azima tetracantha.Lam)
Synonyms [3]**:**Sanganchedi, Narsangan, Mutchangan
Vernacular names [3]**:**Eng: Misletoeberry thorn, Four spined meneita Sans: Kundali
Parts used [3]**:**leaf, root, latex
Organoleptic character [3]**:Taste:** Bitter**Character:** Hot**Division:** Pungent
Action [3]**:**Diuretic, Stimulant, Astringent, Tonic, Antiperiodic, Expectorant
Botanical description [26]**:**It is a rambling spinous shrub flowering throughout the year, the leaves of the plant are elliptical in shape and are rigid, pale green coloured.Small, unisexual flowers in axillary fascicles are greenish white or yellow in colour.The berries are white in color, usually one seeded and edible.
Pharmacological activity [25][26]**:**Antibacterial, Analgesic, Anti-inflammatory, Wound healing.
Bio active compounds [26]**:**Friedelin, Azimine, Carpaine, Euphanol, Terpenoids, Azcarpine, Flavonoids, Glucosinolates, Fatty acids, N- methoxy-3- indolymethly-glucosinolate
Medicinal uses [26]**: (i)**As a treatment for rheumatism, the root, the root bark, and the leaves are added to food in India and Srilanka.**(ii)**Pickled leaves are used as an appetizer and as a remedy for colds in Malaysia.**(iii)**It is a potent diuretic used for chronic diarrhea, dropsy, rheumatism, and dyspepsia and as a stimulant tonic after confinement.

KATHALIPOO (Musa paradisiaca.Linn)
Synonyms [3]**:**Ambanam, Arambai, Osai, Kathali, Kavar, Sekili, Thiranapathi
Vernacular names [3]**:**Eng: The plantain tree Sans: Kadali
Parts used [3]**:**Flower
Organoleptic character [3]**:Taste:**Astringent **Character:**Coolent**Division:** Pungent
Action [3]**:**Styptic, Diuretic, Laxative, Demulcent

Botanical description [27]**:**It is an herbaceous plant that can grow up to 9m long, has a pseudo-stem and the large, elongated oval, deep green leaves with a prominent midrib.Each plant produces a single inflorescence that resembles a drooping spike and is ovate,15-20 cm long, concave, dark red in color and fleshy.Fruits are 5-7 cm long, oblong, fleshy and longer in the cultivated varieties.
Pharmacological activity: Antioxidant [28], Anti-inflammatory [28], Anti ulcerative [26], Anti-microbial [26], Anti diarrhoeal[26]

Bio active compounds [29]**:**Tanins, Saponins, Reducing and non-reducing sugar, Sterols, Triterpenes
Medicinal uses [28]**: (i)**The flower has been used in traditional medicine to resolve bronchitis, constipation and uler problems. It is also used to treat dysentery, diabetes and menorrhagia.**(ii)**It reduces menstrual cramps.**(iii)**one of the most effective treatments for excessive menstrual bleeding is consuming one cooked banana flower with one cup of curd or yogurt. The combination of curd and banana flower increases the level of progesterone in the body and thus reduces the bleeding caused by menorrhagia**(iv)**Eczema patients can use banana leaves (ashes) as cool dressings for blisters and burns.

VANGALA SEENI (Saccharum officinarum.Linn)
Synonyms [3]**:** Ikku, Punarpoosam, Vey
Vernacular names [3]**:**Eng: Sugarcane, Noble cane Sans: Ikshu, Rasalah
Parts used: Crystallised sugar
Action [3]**:**Demulcent, Antiseptic
Botanical description [31]**:**Saccharum officinarum is a clustered perennial plant and many strong unbranched stems. The stems can grow to a height of 5 cm (16ft) and are vary in colour of green, pinkish or purple.
Pharmacological activity [32]**:**Anti-inflammatory, Anti hypercholesterolemic, Diuretic, Analgesic, Anti thrombotic

Bio active compounds [33]**:**Water, Sucrose, Fiber, Cholinergic acid, Cinnamic acid, Flavones, Hydroxycinnamic acid, Sinapic acid, Caffeic acid
Medicinal uses [33]**: (i)**The root decoction is used to treat whooping cough while the leaf ash is used to treat sore eye.**(ii)**The dried stalk's hot water extract is applied topically for skin diseases and irritations, stomatitis, mouth lesions,dermatitis and inflammations.

COW'S MILK
Synonyms [34]**:**Bayam, Keeram, Suthai, Payasu, Paagu, Amuthu, Thutham, Chaaru
Bio nutrients in cow's milk [35][36]**: (i)**Cow's milk is generally composed of water (85-87%), fat (3.8-5.5%), protein (2.9-3.5%) and carbohydrates (5%).**(ii)**Casein is the primary protein found in milk and it contains a variety of bioactive substances such as vitamins, minerals, biogenic amines, nucleotides, oligosaccharides, organic acids and immunoglobulins.**(iii)**Milk and derivatives contain a variety of nutrients including proteins, lactose, calcium, magnesium, potassium, vitamins A, B1, B2, C, and D, as well as other substances and minerals in a fat emulsion.**(iv)**Milk and its derivatives are essential to a balanced diet because they are the best natural food for proper growth and development, strong muscles, strong teeth and bones, clear vision, and robust health.

Pharmacological activity [37]**:** Antimicrobial, Antifungal, Antibacterial, Antiseptic, Analgesic, Immunomodulatory
HONEY
Action [34]**:** Demulcent, Astringent, Antiseptic, Laxative, Stomachic, Expectorant, Narcotic

Pharmacological activity [38][39]**:** Antibacterial, Antiviral, Antimicrobial, Wound healing, Antioxidant, Immunomodulatory, Anti inflammatory
Bio active compounds [38]**:** Alkaloids, Flavonoids, Saponins, Anthraquinones, Steroids
Medicinal uses [38][40]**: (i)**Eczema, ringworm and all types of skin infections can be cured by applying honey in combination with cinnamon powder in equal parts on the affected areas.**(ii)**Regular use of cinnamon powder and honey fortifies the immune system and protects the body from bacterial and viral infections.

CONCLUSION

The above-mentioned medicine *Kathalikantha Rasayanam* is effectively used as internal medicine for the management of Bala Karappan. Herbal ingredients in *Kathalikantha Rasayanam* formulations have Anti-inflammatory, Antimicrobial, Antiviral, Antioxidant and Immunomodulatory activities. Finally concluded, *Kathalikantha Rasayanam* will make improvement in the skin diseases and safe for children. Further in-depth scientific research studies should also be carried out to justify in the future.

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Table 1: Taxonomic classification of Costusspeciosus [4]

Kingdom	Plantae
Division	Mangoliophyta
Class	Liliopsida
Order	Zingiberales
Family	Zingeberaceae/Coastaceae
Genus	Costus
Species	Speciosus

Table 2: Taxonomic classification of Piper longum [7]

Kingdom	Plantae
Division	Magnoliophyta
Class	Magnoliopsida
Order	Piperales
Family	Piperaceae
Genus	Piper
Species	longum

Table 3: Taxonomic classification of Zingiber officinale [9]

Kingdom	Plantae
Division	Magnoliopsida
Class	Liliopsida
Order	Zingiberales
Family	Zingeberaceae
Genus	Zingiber
Species	Z. officinale

Table 4: Taxonomic classification of Myristica fragrans [11]

Kingdom	Plantae
Division	Tracheophyta
Class	Magnoliopsida
Order	Magnoliales
Family	Myristicaceae
Genus	Myristica
Species	fragrans

Table 5: Taxonomic classification of Syzygiumaromaticum [15]

Kingdom	Plantae
Division	Magnoliphyta
Class	Magnoliopsida
Order	Myrtales
Family	Myrtaceae
Genus	Syzygium
Species	aromaticum (L.)

Table 6: Taxonomic classification of Cuminum cyminum [19]

Kingdom	Plantae
Division	Tracheophyta

Class	Magnoliopsida
Order	Apiales
Family	Apiaceae
Genus	Cuminum
Species	cyminum

Table 7: Taxonomic classification of Toddalia asiatica [23]

Kingdom	Plantae
Class	Magnoliopsida
Order	Rutales
Suborder	Rutineae
Family	Rutaceae
Genus	Toddalia
Species	asiatica

Table 8: Taxonomic classification of Azima tetracantha [25]

Kingdom	Plantae
Division	Magnoliophyta
Class	Magnoliopsida
Order	Brassicales
Family	Salvodoraceae
Genus	Azima
Species	A. tetracantha

Table 9: Taxonomic classification of Musa paradisiaca [27]

Kindom	Plantae
Division	Magnoliophyta
Class	Liliopsida
Order	Zingiberales
Family	Musaceae
Genus	Musa L.
Species	M. paradisiaca L.

Table 10: Taxonomic classification of Saccharum officinarum [30]

Kingdom	Plantae
Division	Angiospermia
Class	Monocortyledons
Family	Poaceae
Genus	Saccharum
Species	officinarum



Figure 1: Koshtam



Figure2: Kandathippili



Figure 3: Chukku



Figure 4: Sathikkai



Figure 5: Kirambu



Figure 6: Seeragam



Figure 7: Milagaranai



Figure 8: Sangamver



Figure 9: Kathalipoo



Figure 10: Vangala seeni



Figure 11: Pasumpaal



Figure 12: Thaen

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RESEARCH ARTICLE

Agrivoltaics Mapping in Al Batinah Region using Artificial Intelligence Techniques

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ABSTRACT

Agrivoltaics is the use of land for both agricultural and pastural purposes, as well as the installation of solar panels to generate photovoltaic electricity. It includes a solar greenhouse, elevated and ground-mounted photovoltaic panels, and it is one of the practices of cultivating range of crops under solar panels known as agrivoltaic farming. In agrivoltaic farming, the agronomic, soil, and photovoltaic site parameters are used to identify the agrivoltaics sites. This research work addresses the development of climatic resilience by making use of agrivoltaic sites for growing crops. Additionally, both green energy and agriculture can potentially reduce greenhouse gas emissions, safeguard biodiversity, and decrease reliance on fossil fuels. In this study, using artificial intelligence techniques such as supervised and unsupervised approaches are employed for identifying the various potential agrivoltaics sites in Al Batinah region of Sultanate of Oman. Even though few sites are suitable for solar panels but other factors like urban areas and vegetation areas negatively affect selecting such potential areas. It is concluded that various levels of suitability of agrivoltaics mapping have been given.

Keywords: Agrivoltaics, renewable energy, mapping, Artificial Intelligence, k-Means clustering, Decision Tree.

INTRODUCTION

Renewable energy has proven to be the energy source that is most resilient to COVID-19 lockdown strategies thus far. The demand for renewable power has declined in comparison to other uses of renewable energy. Globally, from Quarter 1 2019 to Quarter1 2020, the use of renewable energy increased by about 1.5% across all industries. An approximate 3% increase in the generation of renewable electricity was caused by the completion of new wind and solar photo voltaic (PV) projects in the past year, as well as the fact that renewable energy sources are usually dispatched before other sources of electricity. In Quarter1 2020, the number of biofuels—a renewable energy source—was used for road transportation at a lower rate than the number of blended fuels [1]. By putting solar panels on farms, the idea of agrivoltaics blends solar energy generation with agricultural techniques. The objective of this technique is to optimize the utilization of land by merging agricultural practices and photovoltaic systems. It describes the process of turning light into electricity using photovoltaic systems, resulting in the name 'agrivoltaics.' Agrivoltaics is a recent and rapidly expanding trend in solar development, where land is developed for both PV and agriculture. This deliberate co-location of PV with agriculture aims to reduce rivalry between land uses, while at the same time raising revenue for landowners, among other benefits. The technological feasibility of agrivoltaic systems has been the subject of numerous studies, with an emphasis on Solar crop cultivation with, Aquaculture with hydroponics, and Cattle farming. Lastly, it has been shown that agrivoltaic systems are a commercially and technically feasible use of agricultural land, Capable of enhancing land productivity by 35-73% and overcome the traditional split between food and energy production. The Middle East's solar map clearly demonstrates the region's great potential for producing solar energy (Figure 1a). The PV potential of Oman is shown in Figure 1(b), as it is clearly seen in Figures 1c,1d, 1e that Oman's solar energy output can be adequately met by the GHI and DNI. Figures. 2a and 2b show various average humidity measures and average high temperatures for each month in Oman.

LITERATURE REVIEW

There is a shortage of fossil fuels [2], and the consequences of combined energy sources, such as climate change [3-5], have necessitated a commitment to decarbonization [6] by transitioning to clean energy resources [7–10] such as solar power, wind power, etc. [11]. Photovoltaic technology is widely used to meet human energy demands by harnessing clean, sustainable energy [12-13]. The agrivoltaic system, also known as agroforestry, integrates crops and trees [14]. Food and energy production have historically been practiced on separate parcels of land [15], but nowadays, the same land can be used for both purposes [16]. Although the concept of agrivoltaics was first proposed in the early 1980s, the first comprehensive agrivoltaic farm trials were recently conducted in Montpellier, France, employing the area between photovoltaic rows for crops [17]. The agrivoltaic system is one of the smart farming technologies that enhances the efficiency and long-term viability of both agriculture and energy production [18-20].

MATERIAL AND METHODS

Decision tree Algorithm [21]

Step 1: Create a tree with the root node R, consisting of the dataset.
Step 2: Apply an attribute selection measure to identify the best feature in the dataset.
Step 3: Make a subtree within node R, containing the values of the best feature.
Step 4: Create a decision tree centered on the best attribute.
Step 5: Use step 3 recursively to generate dataset subtrees, creating new decision trees.
Continue the above steps until no further classification is possible, resulting in leaf nodes.

K-Means Algorithm [21]

Step 1: Identify the number of clusters. Ck Set the centroid
Step 2: by interchanging the dataset, and then select the data points Ck for the centroid.
Step 3: Continue the process until there is no modification in the centroid, which means that there is no change in clusters in terms of data assignments.
Step 4: Evaluate the sum of the squared distance between the data points and centroids.
Step5: Allocate closest cluster centroid for each data points and assign it accordingly.
Step 6: Evaluate the centroids values by calculating the mean of all the data points in each cluster.

METHODOLOGY

In this research work, various parameters related to agrivoltaics were collected. The parameters include power transmission lines, farmland, elevation, main roads, and city/urban areas, which were used for the experiments.
After collecting the values for each parameter, we applied feature selection techniques to identify the significant parameters. These selected parameters were then utilized for both supervised and unsupervised analysis. Using the supervised technique, suitable sites for agrivoltaics were identified, which are potential locations for agrivoltaic mapping. Through the unsupervised technique, data points were segregated using distance methods to identify different cluster centroids, resulting in the formation of various clusters. These processes enabled the determination of various potential agrivoltaic sites, which are beneficial for farming.

RESULT AND DISCUSSION

Study Area

Our study area spans 554 km² in Oman, with position points chosen between (24°29'29.65"N,56°29'40.36"E) and (23°18'0.00"N,57°53'60.00"E). Within this area, we utilized 56 sites to conduct agrivoltaics mapping using both supervised and unsupervised learning techniques, as shown in Figures 5a, 5b, 7a and 7b. Table 1 and Figure 6presents the values of the confusion matrix obtained using the cross-validation method: 29 instances are correctly classified as suitable (Class 'a'), 2 instances are misclassified as exclusion zones (Class 'b'), 3 instances are misclassified as suitable (Class 'a'), and 22 instances are correctly classified as exclusion zones (Class 'b'). Table 2 displays the distribution of suitable sites for agrivoltaics mapping. Among the total sites based on the experimental parameters, 31 are categorized as suitable for agrivoltaics mapping, while 25 sites are classified as exclusion zones. Table 3 reveals the various distributions of cluster assignments using the K-means method, 25 sites are silhouetted as exclusion zones (Cluster 0), and 31 sites are silhouetted as suitable sites (Cluster 1). The exclusion zone cluster occupies 44.64% of cluster assignment in cluster 0, and 55.35% of cluster assignment occupies cluster 1. A sub region has been demarcated from the study area to find the available classes in the region. The region has been segmented using k-means cluster for 10 segments (Figure 7b). From the clusters and from the ground verification a binary output has been taken for deeper study. In Figure 7c, there are only two classes displayed namely land and sea. Similarly in Figure 7d, it is categorized as two classes, such as sand and others. Since the potential place for agrivoltaics is sand area, it is given importance to identify the sand region. Figures 7e and 7f represent two types of sand vs other classes. The other classes like vegetation, urban, are negligible in the study area.

CONCLUSION

The problem of site adaptations for agrivoltaics mapping is addressed in this study. The machine learning algorithms are employed in this work to locate sites in the Al Batinah Region. Certain locations in the Al Batinah Region might not be ideal due to various factors such as the sea, residential areas, etc. By utilizing the various parameters by AI techniques through supervised and unsupervised approaches it is employed to determine the sites, further this is

used to choose appropriate sites for agrivoltaics mapping. 56 sites were chosen for our experiment. Then, on these 56 sites, unsupervised and supervised algorithms are used to determine which sites are appropriate for agrivoltaics depending on the parameters. From the 56 sites, decision trees and K-means approaches determined 29 sites. The supervised and unsupervised results reveal that the sites are highly potential based on the parameters.

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Table 1: Confusion matrix for Agrivoltaics Parameters

Cross Validation		**Predicted**	
		a	b
Actual	a	29	2
	b	3	22

Table 2: Agrivoltaic Sites Mapping

Suitability	Sites	Class
Suitable	w11, w31, w32, w33, w41, w42, w43, w51, w52, w53, w54, w55, w56, w57, w58, w61, w62, w63, w64, w65, w66, w67, w68, w71, w72, w73, w74, w75, w76, w77, w78	Class a
Exclusion Zones	w12, w13, w14, w15, w16, w17, w18, w21, w22, w23, w24, w25, w26, w27, w28, w34, w35, w36, w37, w38, w44, w45, w46, w47, w48	Class b

Table 3: Cluster Assignments of Agrivoltaics Sites Mapping

Clusters	Cluster 0	Cluster 1
Number of clusters	25	31
% of Each cluster assignments	44.64%	55.35%
Sites	w12, w13, w14, w15, w16, w17, w18, w21, w22, w23, w24, w25, w26, w27, w28, w34, w35, w36, w37, w38, w44, w45, w46, w47, w48	w11, w31, w32, w33, w41, w42, w43, w51, w52, w53, w54, w55, w56, w57, w58, w61, w62, w63, w64, w65, w66, w67, w68, w71, w72, w73, w74, w75, w76, w77, w78

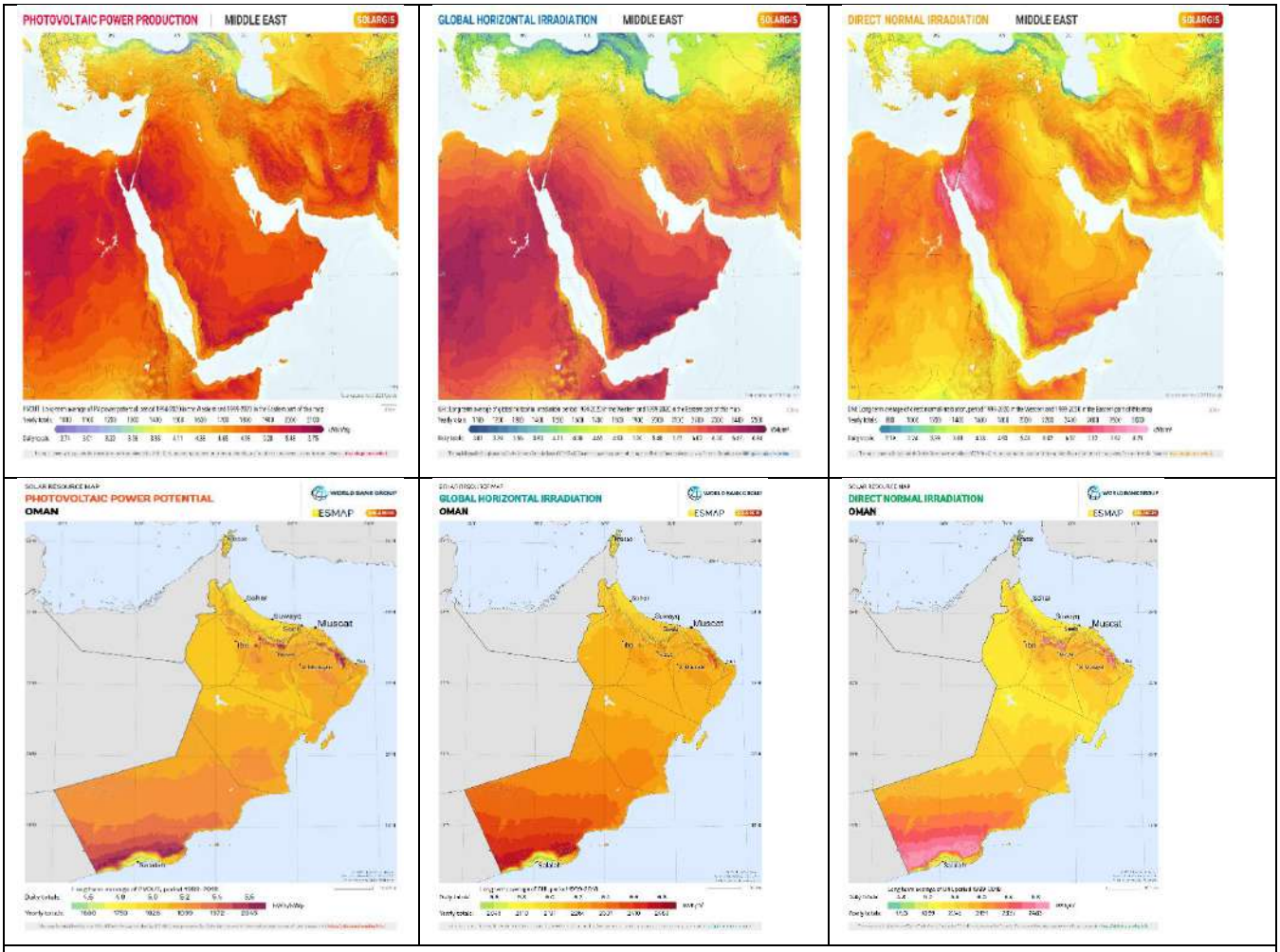


Figure 1: a. Solar energy distribution map of the Middle East b. Horizontal solar radiation across the Middle East c. Solar radiation incident on a surface perpendicular to the sun's rays in the Middle East. d. Solar power capacity estimation for Oman. e. Horizontal solar radiation in Oman.f. Beam solar radiation in Oman

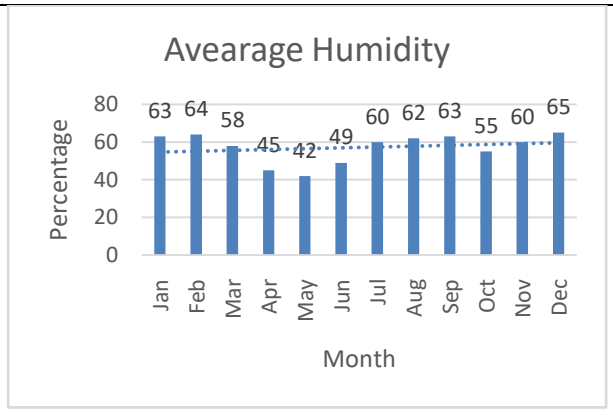


Figure 2a. Average humidity values of each month

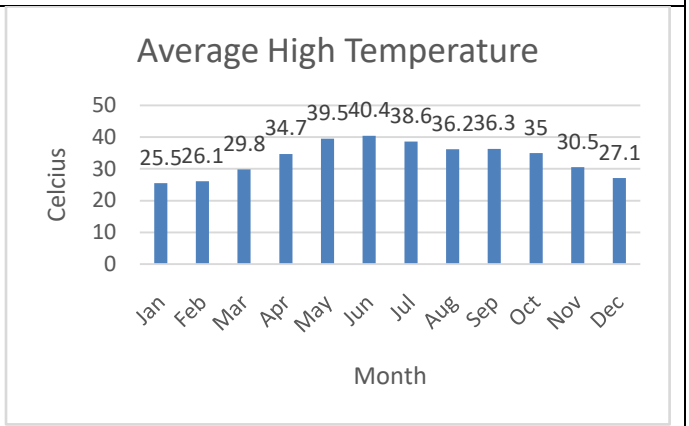


Figure 2b. Average high temperature of each month

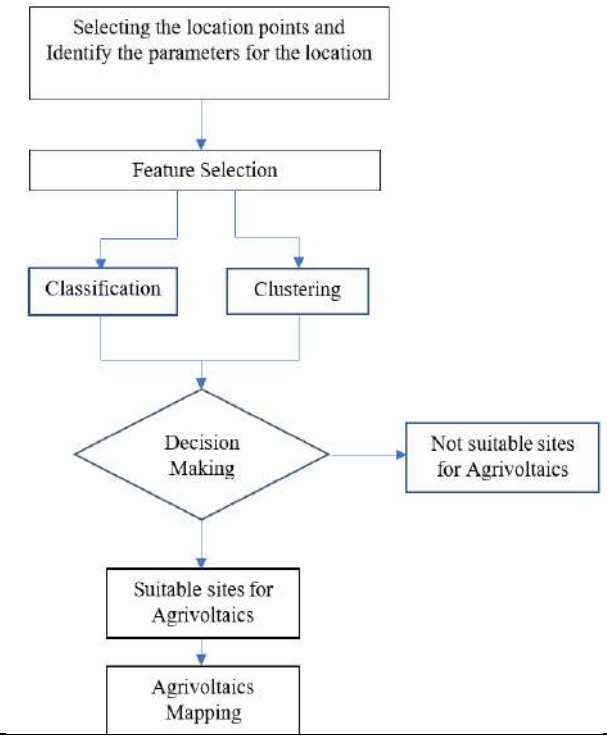


Figure 3: Flowchart for Agrivoltaics mapping

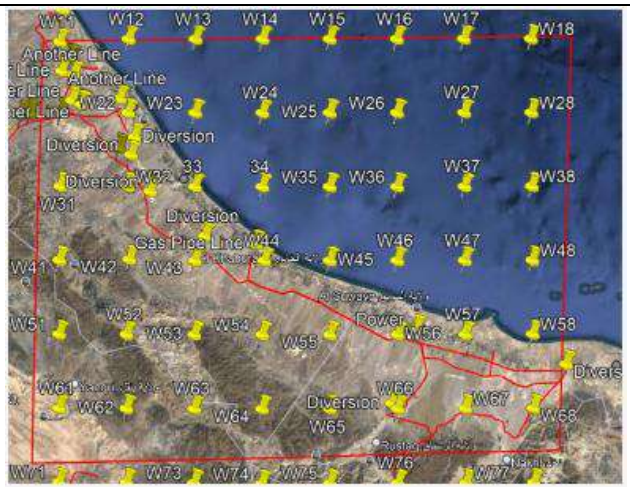


Figure 5a: Agrivoltaics Mapping



Figure 5b: A portion of study area for classification demarcated from the entire study area

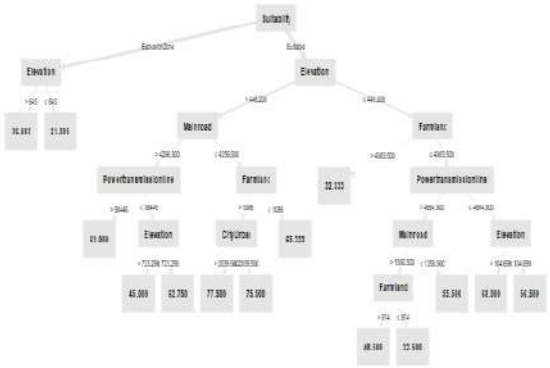


Figure 6. Decision tree



Figure 7a: The portion of study area for classification

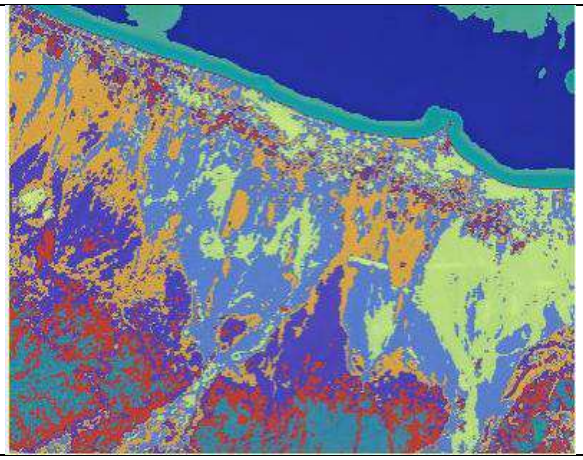
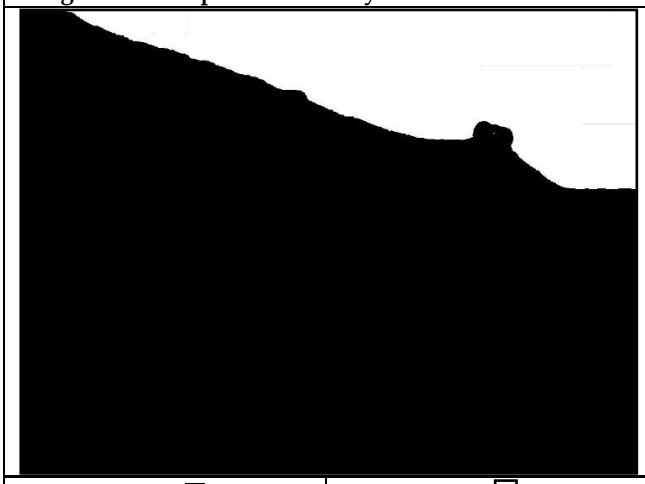
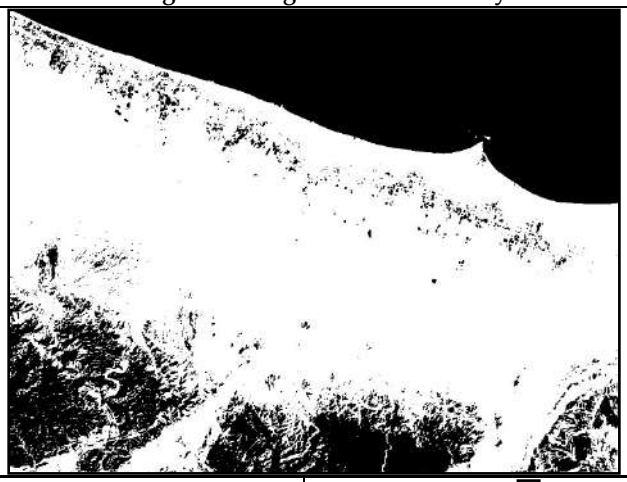


Figure 7b: Segmentation of Study area



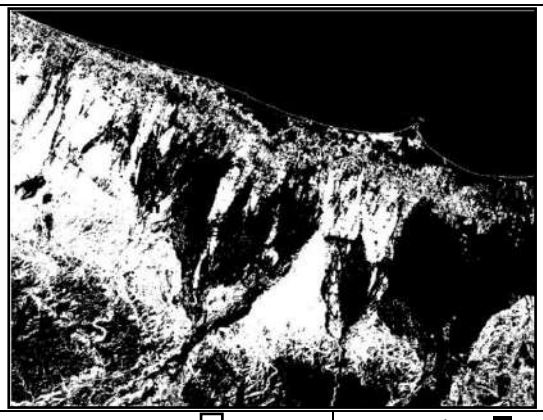
Land ■ **Sea□**

Figure 7c: Classification of Land vs Sea



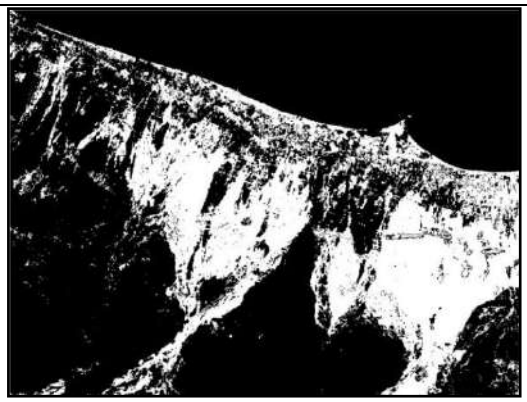
Sand■ **Others□**

Figure 7d: Classification of Sand vs others



Sand Type 1 □ **Others ■**

Figure 7e: Sand Type 1



Sand Type 2 □ **Others ■**

Figure 7f: Sand Type 2

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RESEARCH ARTICLE

Retrospective Study on Anticancer Drugs

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ABSTRACT

Even though there are new advanced cancer treatment strategies, chemotherapy is still a popular therapeutic choice. As chemotherapy medications have a narrow therapeutic index and are very toxic in nature, it is crucial to ensure the appropriate use of these medications. Therefore we conducted a retrospective observational study to evaluate the drug use pattern of chemotherapeutic agents in the oncology department of Mallige Hospital. A total of 171 cancer cases treated with chemotherapy were collected and the data was analysed, interpreted using MS Excel. According to study findings, the age group of 60–80 years old accounted for the greatest number of cancer cases, with 75 cases (43.85%) followed by 40-60 years i.e. 74 cases (43.28%). Females were more susceptible and patients with comorbidities exhibited a higher incidence of cancer, and cancers of the reproductive, GI and respiratory systems were more prevalent. The most commonly prescribed drugs were Carboplatin, Paclitaxel, Capecitabine, Cyclophosphamide, Oxaliplatin making platinum-containing antineoplastics, antimetabolites, bisphosphonates, alkylating agents be the most common class of chemotherapy drugs prescribed and regimen 13, 9 and 7 were highly used where Regimen 13 contains Oxaliplatin and Capecitabine, Regimen 9 contains Paclitaxel and Carboplatin and Regimen 7 contains a combination of Cyclophosphamide and Doxorubicin respectively. We observed that all patients received chemotherapy through the IV route in those 43 of them also received via oral and the most commonly used supportive medications were found to be Pantoprazole, Granisetron, Dexamethasone, Ranitidine, and mostly used CSF is Pegfilgrastim.

Keywords: Cancer, chemotherapy, chemotherapeutic agents, supportive medications, drug use pattern.

INTRODUCTION

Cancer is an illness characterised by abnormal cell proliferation in somatic cells that can spread to other regions of the body. These alterations can be attributed to genetic or epigenetic modifications[1]. Cancer is one of the biggest causes of death in both industrialised and developing nations, it poses a serious threat to global society[2]. Around 19.3 million new cancer cases were diagnosed and approximately 10 million deaths occurred globally in the year 2020[3]. According to an ICMR study, the cancer burden is rising in India as well. It is reported that in the year 2022 around 14.61 lakh cancer cases were observed and 8,08,558 people died and it estimates that cancer will strike 1 in 9 Indians at some point in their lives. Lung cancer affects 1 in 68 males, whereas breast cancer affects 1 in 29 women[4]. By 2025, there will be an estimated 420 million new cancer instances yearly, indicating an increase in cancer incidence over the years[1]. Looking into the Cancer treatment, it has always been an extremely challenging procedure. Traditional treatment modalities like surgery, chemotherapy, and radiotherapy are still in use, despite recent notable advancements in stem cell therapy, targeted therapy, ablation therapy, nanoparticles, natural antioxidants, radionics, chemo dynamic therapy, sonodynamic therapy, and ferroptosis-based therapy[5].

Even though there is mounting evidence that a methodical and tailored strategy for treating cancer may be the way of the future, chemotherapy is still a popular therapeutic choice where chemicals are used to decrease tumours that are causing pain and other issues while also killing or reducing the growth of cancer cells[6]. chemotherapy medications have a narrow therapeutic index and are very toxic in nature[7]. It has been observed that the medications are given at very high dosages, which causes harm to other healthy cells as well as a number of adverse impacts. One major challenge is the illness's recurrence. It is well known that during recurrence, cancer cells become resistant to treatment after prolonged medication exposure. Prolonged use of these drugs may have a negative impact on a patient's physical and mental health, making it difficult to continue the treatment [6]. Therefore, it is crucial to ensure the appropriate use of chemotherapeutic agents. A study conducted by ***D. Vijayalakshmi et.al (2020), Raghavendra A. G. et.al. (2019), and Asmatanzeem Bepari et.al (2019)*** on the drug use pattern revealed the trends in prescribing patterns and cancer incidence in relation with the demographic features of the patient[8,9,10]. Hence, to understand the current chemotherapy pattern it is necessary to conduct drug utilisation research on these anticancer medications. This allows health authorities to bring new recommendations and guidelines to encourage the proper use of chemotherapeutic drugs and also provides researchers and healthcare professionals an understanding of the current prescribing trends. In this study, we will examine and assess the current patterns of chemotherapy treatment prescriptions, as well as the most often prescribed chemotherapeutic agents, supportive medications, route of administration, system and disease-wise distribution of cancer, and pattern of comorbidities in cancer patients.

MATERIALS AND METHODS

This was a retrospective observational study conducted in the Mallige Hospital, Bengaluru, Karnataka for the period of 6 months from January to June 2022. The Institutional Ethics Committee granted the required ethical approval before this study could be carried out (Approval No: MCP/RRB/008/21-22). The data for the study was gathered from the hospital's Medical Record Department. Patients with recently detected cancer, known cases of carcinoma of both genders that required treatment, along with patients of all ages undergoing chemotherapy were included in the study; patients case file with incomplete information, patients unwilling to participate, patients receiving treatments other than chemotherapy, and pregnant and lactating women were excluded. We collected all the cancer cases from the past two years 2020 and 2021 while considering the casefile with a first visit in those years. A total of 171 cases found and data were recorded in specially structured patient data collection form and entered into Microsoft Excel. Descriptive statistics were used to analyse the clinical and demographic data that was gathered.

RESULTS AND DISCUSSION

Cancer incidence varies among different age groups, gender, and comorbidities[11,12, 13]. When selecting a chemotherapy regimen, many factors are typically taken into account. These include aspects that are specific to each patient, such as preferences and medical condition, as well as aspects that are of concern to the treating physician (such as treatment preferences) and the environment (such as economic, regulatory, and scientific aspects) [6, 14].
Looking into our study, 171 cancer cases were collected and the results are found as below.

Age

Out of the 171 patients, the highest number of cancer cases were seen in the age group 60-80 years i.e. 75 cases (43.80%) followed by 40-60 years i.e. 74 cases (43.28%) as shown in *Figure 1* indicating that the cancer is more prevalent in the age group between 40-80 years. The similar results were found in the study conducted by ***Raghavendra A. G. et.al.(2019)*** *[9],* ***Darshan J. Dave et.al (2014)****[15],* ***Mary Rohini Pentareddy (2015)****[16],* also only a 1.75% of patients over the age of 80 were affected with cancer. Altogether our study results indicated that the risk of getting cancer increases with age between 20-80 years.

Gender

Out of 171 cancer patients, the highest number of cases was found in females i.e. 103 cases (60.2%) and the rest 68 cases (39.8%) were males as shown in *Figure 2* indicating that females were more susceptible to cancer.
Out of 103 female cases, around 63 cases were affected by reproductive system cancers which were commonly seen between the ages of 40 and 80 years. A comparable outcome was observed in the study conducted by ***Raghavendra A. G. et.al (2019)*** [9] showing that 79.63% of the cases were affected by cancer of the reproductive system. Among 68 male cases over 50% were affected with gastrointestinal cancer (oesophagus, stomach, duodenum, colon) followed by 10% respiratory system (Lung cancer). A 7-year retrospective study conducted by ***Yasemi Massod et.al (2015)*** showed that the Gastrointestinal cancer prevalence was seen more in the male than females making the males to be at higher risk of GI cancer than females [17].

Cancer type & system affected

Out of 171 patients studied, 52 patients (30.40%) were diagnosed with breast cancer, 17 (9.94%) were diagnosed with colon cancer, 14 (8.18%) were diagnosed with lung cancer and 10 (5.84%) were diagnosed with ovarian cancer as shown *figure 3*.The most common system affected in the study was the reproductive system and the second most common system affected was the gastrointestinal system followed by the respiratory system and others were least seen as shown in *figure 4*. The study conducted by ***Raghavendra A. G. et.al. (2019)*** [9] showed that 85.18% belongs to cancer which affects the reproductive system, 7.4% fall under cancer in the respiratory system, and 4.62% of cancer affects the digestive system. The increasing incidence of breast cancer in transitioning countries is attributed to factors such as female sex, age, family history, and changing reproductive patterns. Noteworthy contributors include earlier age at menarche, late first childbirth, lower parity, and shorter breastfeeding duration. Post-menopausal breast cancer is also influenced by overweight and obesity. In the context of cervical cancer, major risk factors include human papillomavirus (HPV) subtypes, immune suppression (especially HIV), and smoking[18]. In our study the second highly affected system is GI (colon, stomach and duodenum etc.,), in which colon cancer cases were more. The studies mention that the occurrence of colorectal cancer is associated with modifiable and non-modifiable risk factors [19]. Lung cancers are high in incidence which may be associated with modifiable risk factors like active and passive smoking, exposure to radon, asbestos, chromium, cadmium, arsenic, radioactivity, and coal products, concerning socioeconomic status, lifestyle, dietary, and obesity [20].

Chemotherapeutic agents

In our study, we found that the most common drugs prescribed were Carboplatin (18.12%), Paclitaxel (18.12%), Capecitabine (17.54%), Cyclophosphamide (16.37%), Oxaliplatin (15.78%) as shown in *figure 5* and *table 1.* Platinum containing antineoplastics (36.25%), Antimetabolites(33.91%), Bisphosphates(22.21%), Alkylating agents(18.12%)

were the most common class of chemotherapy drugs prescribed as shown in *figure 6.* Even the study conducted by the ***Kamlekar S.K. et.al (2019)*** also found that Carboplatin was the most highly prescribed followed by the Paclitaxel [21]. Carboplatin and Paclitaxel were mostly used for reproductive system cancers (breast, ovary, cervix cancer), gastrointestinal cancer (oesophagus, stomach, duodenum) followed by lung cancer. Capecitabine was highly used for gastrointestinal cancers like colon cancer followed by rectum cancer.

Route of administration

In our study, we observed that all patients 171 (100%) received chemotherapy through the IV route. Among 171, 43 (25.14%) patients received via oral as shown in *Table 2.* A study conducted by ***Spandana et.al (2017)*** also showed that 92.46 % of chemo drugs were administered via the parenteral route and 7.53% through the oral route [22].
Since the data is overlapping so it will not add up to 100%

Chemotherapy regimen

As a standardised nomenclature for regimen was not established [23], manual allotment of drugs to the regimen was done based on combination of drug prescribed for each patient viz., regimen 1, regimen 2 and so on as shown in *Table 3.* In comparison with other regimens, regimens 13 (9.94%), 9 (8.77%) and 7 (5.84%) were used on more patients. Regimen 13 contains Oxaliplatin and Capecitabine, Regimen 9 contains Paclitaxel and Carboplatin and Regimen 7 contains a combination of Cyclophosphamide and Liposomal Doxorubicin as shown in *Table 3.* On the other hand, research by ***Darshan J. Dave et al. (2014)*** and ***Mary Rohini Pentareddy et al. (2015)*** revealed that the combination of 5-FU and platinum was most commonly administered [15,16]. Regimen 13 was mostly given for treating gastrointestinal cancer (Colon, stomach, rectum), Glandular cancer and regimen 9 was used for treating gastrointestinal followed by respiratory cancer and regimen 7 was used for treating lymphatic system cancers like Hodgkin's and non-Hodgkin lymphomas.

Number of drugs in a regimen

A regimen containing 2 chemo drugs was prescribed to about 54.97% of the subjects in the study, whereas a regimen containing 4 different chemo drugs was prescribed to about 4.6% of the subjects as shown in *Figure 7.* The research by ***Maneesha Mathew et al. (2019)*** revealed similar results, indicating that the doublet regimen (60.4%) was mostly given [24].

Supportive medications

In our study, we witnessed that the most commonly used supportive medications are Pantoprazole (95.32%), Dexamethasone (81.28%), Granisetron (71.92%), Ranitidine (55.55%) and mostly used CSF (Colony Stimulating Factor) is Pegfilgrastim (47.95%) as shown in *figure 8* indicating that gastrointestinal, and haematological toxicity was most common in patients receiving chemotherapeutic agents. Pantoprazole was given with almost all chemo drugs, but mainly it is given with zoledronic acid (23.31%), Capecitabine (18.40%), Paclitaxel (18.40%), Carboplatin (17.79%), Oxaliplatin (15.95%), Cyclophosphamide (15.95%) for the management of gastrointestinal side effects. Dexamethasone is given with Capecitabine (21.58%), Paclitaxel (20.86%), Carboplatin (20.14%), Oxaliplatin (19.42%), Cyclophosphamide (17.98%) for the management of nausea and vomiting. Granisetron given with Paclitaxel (24.39%), Capecitabine (22.76%), Oxaliplatin (21.13%), Carboplatin (21.13%) for the management of Gastrointestinal side effects. Pegfilgrastim was given with Capecitabine (34.14%), Oxaliplatin (30.48%), Carboplatin (23.17%), Paclitaxel (20.73%), Cyclophosphamide (19.51%), Liposomal doxorubicin (18.29%) for the management of neutropenia. Zolendronic acid is a osteoclast inhibitor used as a prophylactic measure against bone-related occurrences in cancer patients who have bone metastases, such as those with lung, prostate, and breast cancers [25] here it was mostly prescribed for breast cancer (53.84%), Prostate cancer (12.82%), and Multiple myeloma (12.82%).
Pheniramine was most given with Paclitaxel (60.52%) and Carboplatin (39.47%) for the management of allergic symptoms.

Comorbidities

Out of the total 171 subjects in the study about 126 (74 %) subjects had comorbidities and 45 (26 %) subjects were without comorbidities as shown in *figure 9.* Among 126 cases 53 (30.99%) of patients had a history of Hypertension making it the most common ailment which is seen in the study sample and 42 (24.56%) patients had a history of Type 2 Diabetes Mellitus and 14 (8.18%) were having a history of Hypothyroidism whereas ischemic heart disease, asthma and seizure were around 2.3%, 1.1% and 1.1% respectively as shown in *figure 10*. Among 30.99% of hypertensive patients most were affected with breast cancer (18.86%), Colon Cancer (15.09%), Lung cancer (11.32%), Prostate cancer (7.54%) and 24.56% of Diabetes patients affected with According to a 2019 study by ***Seretis, A. et al*** people with hypertension had an increased risk of renal, colorectal, and breast cancer [26]. Multiple illnesses can influence the biology of tumours, which can alter the chance of developing cancer. For instance, diabetes has been connected to a twofold increased likelihood of pancreatic and liver cancer, and it also raises the risk of breast, cholangiocarcinoma, colorectal, endometrial, and gallbladder cancer. On the other hand, it may be protective against prostate cancer. Comorbidities have been associated with an increased risk of fatalities specific to carcinoma, indicating that coexisting conditions could accelerate the fundamental cause of cancer deaths, which is the metastatic spread of malignancy [27]. This study on the drug utilisation of chemotherapeutic agents aided in knowing and understanding the current trends in prescription patterns, and patient population of cancer. There are several limitations in the current work such as the study being retrospective, the cost component of the drug therapy could not be computed due to the unavailability of relevant data, the study was conducted only among inpatients and for a very short period, the study did not extend in-depth of chemotherapy treatment, samples were collected only from one hospital and therefore the results obtained cannot be used to generalise the drug use pattern of chemotherapy.

Drug selection, dose calculation, dilution procedure, administration techniques frequency, and duration, contribute significantly to the effective outcome through the appropriate utilisation of chemotherapy drugs. To explore further, prospective, long-term follow-up studies can be conducted on a large number of patients to assess the long-term safety and efficacy of chemotherapeutic agents. Overall, this study provided an overview of the utilisation of anticancer drugs among study patients in Mallige Hospital and could serve as a basis for further research to study various aspects of treatments, risks and benefits associated with drug use and also helps in educating and training health care professionals and patients on appropriate drug use promoting the rational use of chemotherapeutic agents.

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COMPETING INTERESTS

"There are no competing interests, as declared by the authors."

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Table 1:Most commonly prescribed chemotherapeutic agents

SI.NO	DRUGS	Number	Percentage
1	Carboplatin	31	18.12%
2	Paclitaxel	31	18.12%
3	Capecitabine	30	17.54%
4	Cyclophosphamide	28	16.37%
5	Oxaliplatin	27	15.78%
6	Liposomal doxorubicin	17	9.94%
7	Gemcitabine	13	7.60%
8	Anastrazole	11	6.4%
9	Irinotecan	10	5.84%
10	Docetaxel	10	5.84%
11	Other drugs	<10	<5.84%

Table 2:Route of administration for chemotherapy drugs.

SI.NO.	ROUTE OF ADMINISTRATION	NO.OF CASES	PERCENTAGE %
1	Intramuscular	00	0.0%
2	Subcutaneous	00	0.0%
3	Oral	43	25.14%
4	Intravenous	171	100%

Table 3:Frequency of different regimen prescribed

SI.NO	REGIMEN	NUMBER	PERCENTAGE
1	Regimen 13	17	9.94%
2	Regimen 9	15	8.77%
3	Regimen 7	10	5.84%
4	Regimen 5	5	2.92%
5	Regimen 40	4	2.33%
6	Other regimens	<4	<2.33%

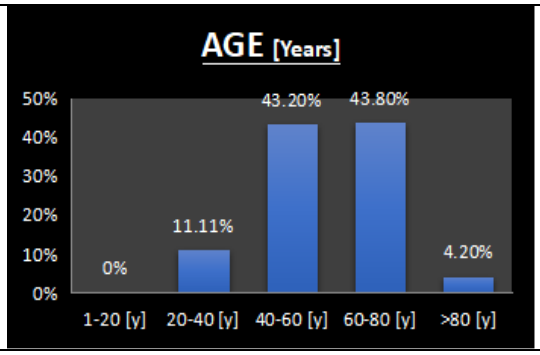


Figure 1 - Age distribution observed in the study. The highest number of cancer cases were seen in the age group 60-80 years (43.80%) followed by 40-60 years (43.28%) indicating that the cancer is more prevalent in the age group between 40-80.

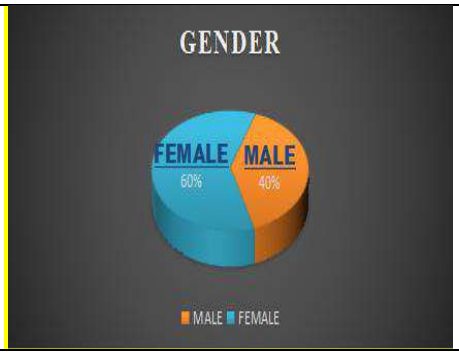


Figure 2 – Gender distribution observed in the study. The highest number of cases were found in females i.e. 103 cases (60.2%) and the rest 68 cases (39.8%) were males indicating that females were more susceptible to cancer.

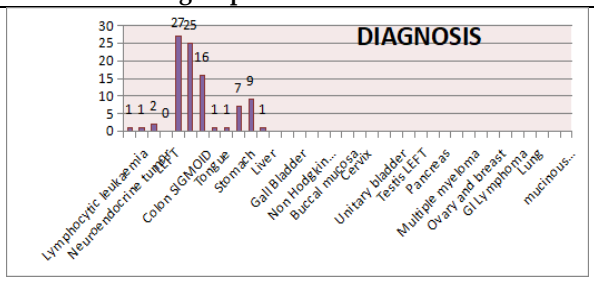


Figure 3-Different types of cancers observed in the study

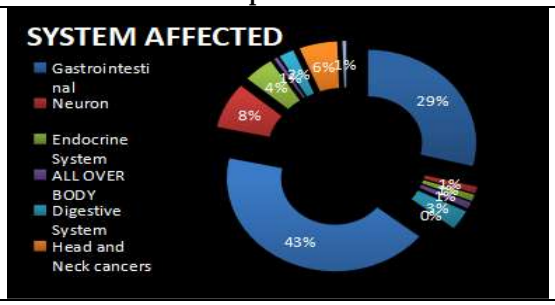


Figure 4 -Different physiological system affected with cancer observed in the study.

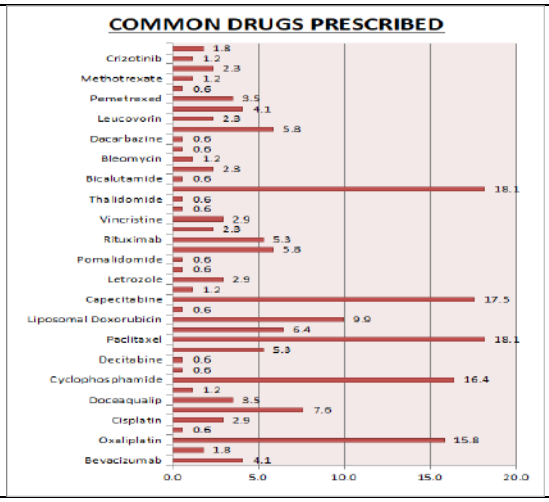


Figure 5-Most commonly prescribed chemotherapeutic agents

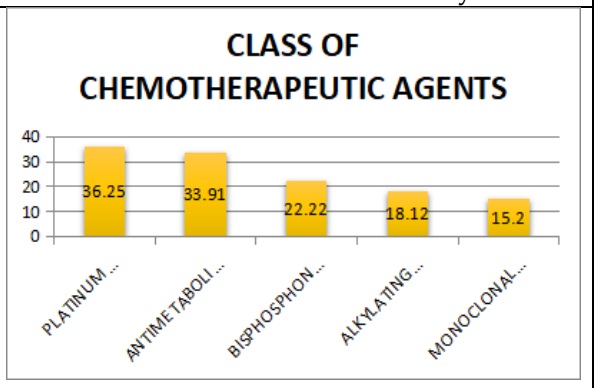


Figure 6-Class of chemotherapeutic agents prescribed

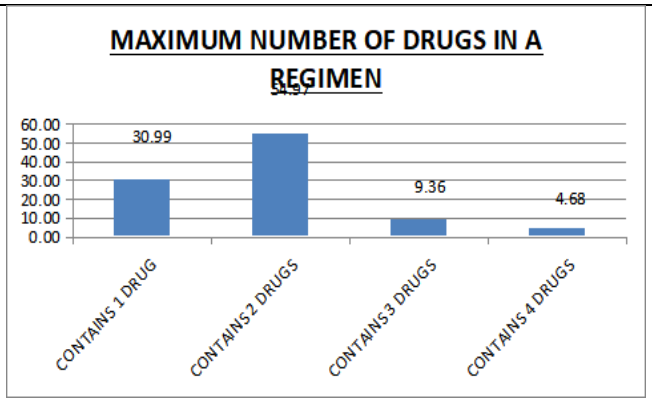


Figure 7-Maximum number of drugs in each regimen prescribed

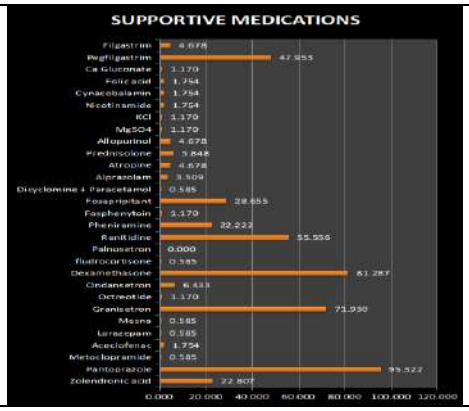


Figure 8-Most commonly prescribed supportive medications.

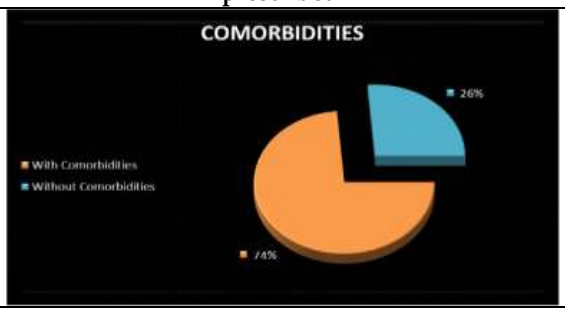


Figure 9-Comorbidities observed in the study. Out of the total 171 subjects in the study about 126 (74 %) subjects had comorbidities and 45 (26 %) subjects were without comorbidities.

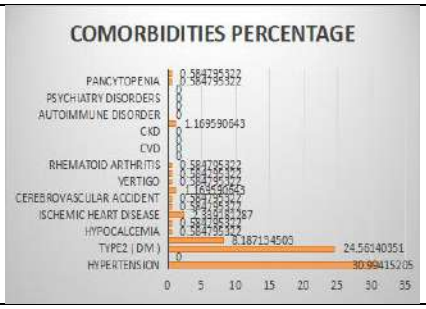


Figure 10-Comorbidities of patients observed in the study. Among 126 cases 30.99% of patients have a history of Hypertension making it the most common ailment which is seen in the study sample. 24.56% have a history of Type 2 Diabetes Mellitus and 8.18% were having a history of Hypothyroidism whereas ischemic heart disease, asthma and seizure were around 2.3%, 1.1% and 1.1% respectively.

RESEARCH ARTICLE

Method Development and Validation of Reverse Phase-High-Performance Liquid Chromatography (RP-HPLC) for the Simultaneous Determination of Ceftriaxone Sodium and Sulbactam Sodium in Pharmaceutical Dosage

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ABSTRACT

The analysis of ceftriaxone sodium (CFT) and sulbactam sodium (SB) in vial dosage forms was completed in three minutes using an isocratic HPLC technique.The components were separated at room temperature using a mobile phase consisting of a 75:25 (v/v) mixture of acetonitrile and phosphate buffer, which has a pH of 5.5. Working with a 1 ml/min flow rate and an HPLC-PDA detector set up at 245 nm, the experimental conditions were designed to find the highest absorption level.The retention time of ceftriaxone is 1.39 min, while sulbactam has a retention time of 2.06 min, confirming a shorter analysis length of time. A significant level of sensitivity was indicated by the limits of detection for ceftriaxone and sulbactam, which were 2.61×10^{-7} and 2.42×10^{-5} µg/ml, respectively. Following that, we confirmed its compliance with the FDA's established standards for drug measurement in vial dosage form.

Keywords: Ceftriaxone, Sulbactam, Validation, Accuracy, Precision, Dosage.

INTRODUCTION

The broad-spectrum third-generation cephalosporin ceftriaxone (CFT) is recommended for parenteral administration in a number of infectious illnesses [1]. It is highly resistant to breakdown by β-lactamases and has strong penetration into extravascular areas. In order to keep patients undergoing orthopedic surgery from getting infections, it is often given to them [2]. In chemical terms, ceftriaxone sodium is known as, "(Z)-7-[2-(2-aminothiazol-4-yl)-

methoxyiminoacetylamido]-3-[(2,5-dihydro-6-hydroxy-2-methyl-5-oxo-1,2,4-triazin-3-yl)thiamethyl]-3-cephem-4-carboxylic acid, disodium salt" [3,4].The 3-thiamethyl group of ceftriaxone is heterocyclic and very acidic. The molecule's exceptional pharmacokinetic features are thought to be attributed to its distinctive dioxotriazine ring structure. The CFT molecular structure is shown in (Figure 1). The USP (United State Pharmacopeia)[5], BP(British Pharmacopeia) [6], and IP (Indian Pharmacopeia) [7] all list ceftriaxone (CFT) as an authorized drug respectively. Sulbactam sodium is a chemical compound with the molecular name "(2S,5R)-3,3-dimethyl-7-oxo-4-thia-1-azabicyclo[3.2.0]heptane-2-carboxylate4,4-dioxide". It is classified as a penicillanic acid sulfone [5]. Compared to CFT, Sulbactam (SB) has a stronger affinity for binding to bacterial β-lactamases, making it an effective bacterial β-lactamase inhibitor. The effectiveness of sulbactam against a broader variety of β-lactamase-producing bacteria is enhanced when it is used with ceftriaxone. But it is ineffective against germs when administered singly. The SB molecule structure is shown in (Figure 2).

A number of analytical techniques have been used to measure CFT either alone or in combination with other drugs. These methods include spectroscopic analysis [8–11], the use of liquid chromatography [12–14], differential-pulse adsorptive stripping voltammetry [15], as well as thin-layer liquid chromatography [16–17]. Spectroscopic procedures such as ampicillin, ceftriaxone, and cefotaxime are all accessible for SB. In addition to a drug called Tazobactam[22], Piperacillin [23], and Amoxicillin [24], HPLC methodologies are available for SB.There are a few drawbacks to using ion pairing reagents [25] and high-performance liquid chromatography [26] to analyze SB in combination with CFT; however, it has been done. This study details the first-ever analysis of CFT and SB in sterile powder for injection dosage form, without the use of any ion pairing reagent. We have developed and validated the method.There are a few documented methods for the simultaneous measurement of CFT and SB, including HPLC methods [28–35] and spectrophotometric methods [36], but no official method exists for determining their combination. Only three HPLC methods [33–35] were available as stability-indicating methods for CFT and SB simultaneous analysis, out of the few published methods. These processes are linear, moderately accurate, and less recoverable. The relatively lengthy chromatographic period of approximately 12 minutes and the low sensitivity lead to a high value of the limit of quantification. These are two drawbacks. Issues with these procedures abound, such that they are time-consuming and laborious, as well as excessively complex, confusing, inaccurate, and lengthy (Table 1).

In order to analyze CFT and SB in their pure and medicinal dose forms simultaneously, this research was designed to develop a fast, accurate, and user-friendly RP-HPLC method. This research primary goal was to find a simple way to measure the concentrations of CFT and SB in both their pure and pharmaceutical forms within 2 minutes.

EXPERIMENTAL

Apparatus

The HPLC tests used apparatus from the Shimadzu (UFLC) Corporation of Kyoto, Japan. The apparatus included a DGU 20A5 prominence degasser, a SIL-20A prominence auto sampler, a solvent supply pump system (LC-20AD), and an SPD-prominence diode array detector.The data analysis products from Lab Solutions were utilized more often. The ideal temperature is maintained by renowned columns using CTO-20A ovens.The Irish-made Waters XTerra RP-18 was the equipment used for the separation process. Its measurements are 5 μm by 250×4.6 mm.

Materials and reagents:

Alkem Laboratories Ltd. provided a free sample of ceftriaxone and sulbactam. Acetonitrile, Sodium dihydrogenphosphatemonohydrate, and orthophosphoric acid were among the HPLC grade solvents which were obtained from Merck Specialities Pvt. Ltd., an Indian company. A pharmaceutical formulation was bought from a nearby medical store.

Stock solutions

The concentration of the standard solution was 1000 μg/ml, which was accomplished by mixing ceftriaxone and sulbactam into the mobile phase.A volumetric flask was used to dissolve the drug in the mobile phase, resulting in a sufficient quantity of the solution containing the concentration of 1000 μg/ml. Storing a solution at 35 °C necessitated keeping it in the dark. The stock solution (1000 μg/ml) was diluted in series with the mobile phase to create calibration curves at concentrations of 0.2, 0.4, 0.8, 1.6, 3.2, and 6.4 μg/ml. To obtain a therapeutically appropriate dose, ceftriaxone and sulbactam were dissolved together with a mobile phase and filtration through a 0.2 μm membrane. For five minutes, it was submerged in an ultrasonic bath. For performing estimation, we use the working solution.

Mobile phase

For separation, the mobile phase is made up of a 75:25 v/v mixture of acetonitrile (ACN) and phosphate buffer, pH 5.5. It was filtrated and degassed using an effective degasser and a 0.2 μm membrane filter before the mobile phase was used. A buffer formulation was prepared by dissolving 1.37 grams of sodiumdihydrogenphosphatemonohydrate in 1000 ml of water. A pH of 5.5 was achieved by adding a little amount of diluted orthophosphoric acid. The solution was filtered using a membrane filter with a diameter of 0.2 μm.

Pharmaceutical dosage forms

All of the pharmaceutical formulations were bought from local pharmacies: Xone SB 250 mg by Alkem Lab, Alvitrox S 500 mg by Alarius Health care, and Monocef SB 1000 mg by Aristo Pharmaceutical Ltd.

PROCEDURES

Development of calibration standards curves

The CFT and SB stock solutions were adjusted to final concentrations of 0.2, 0.4, 0.8, 1.6, 3.2, and 6.4 μg/ml by diluting them in 10 ml volumetric flasks. The chromatogram was produced by introducing 10 μl of each mixture into a column and then taking measurements at 245 nm. Here is a concentration-response graph that illustrates the correlation between drug concentration and the constructed response graph, specifically the peak area. For validation of the quality control (QC) sample, low (LQC), medium (MQC), and high (HQC) values are indicated by levels of 1.6 and 6.4 μg/ml, respectively.

Pharmaceutical procedure

The following vial formulations were used for the analysis: Monocef SB, Alvitrox S, and Xone SB. In the mobile phase, dissolve a specific amount of substance, equivalent to 10 mg of each drug. Dilute the filtered solution using the mobile phase till it reaches the desired volume, then transfer it to 100 ml measuring flasks.As previously stated, the procedure was subsequently finished by employing conventional addition methods.

RESULTS AND DISCUSSION

Chromatographic conditions optimization

The full specifications of the different chromatographic parameters are shown in Table 2. The optimal chromatographic detection wavelength was determined by using a 245 nm PDA detector. The SPD-prominence diode array detector, SIL-20A prominence auto sampler, LC-20AD solvent delivery pumps system, and DGU 20A5 prominence degasser are just a few of the instruments made by the Kyoto, Japan-based Shimadzu (UFLC) Corporation. After much trial and error, the ideal composition ratio and pH for the mobile phase were determined through a series of testing. Operating at a flow rate of 1 ml/min, the optimal mobile phase consisted of a 75:25 (v/v) solution of acetonitrile and a phosphate buffer with 5.5 pH.Under these circumstances, it is possible to separate and elute ceftriaxone and sulbactam in both their pure form and pharmaceutical dosage (Figures 3 and 4) at 1.39 and 2.06

min., respectively. The recommended (HPLC-PDA) approach, which is described in detail in Table 2, can be used to analyze the drug in its pure forms or in synthetic combinations.

Validation of Method

Accuracy, precision, linearity, specificity, and robustness were the criteria used to validate the developed method [27, 28].

Linearity

For testing linearity, five distinct dosages of drug combinations were used. Plotting peak area against concentration showed that the calibration curves (Figures 5 and 6) showed a linear connection between concentration limits of 0.2-6.4 µg/ml for both drugs. The CFT variable's linear regression equation is Y = 22962 + 541032C, and the SB variable's equation is Y = 248 + 2757015C. As indicated in Table 3, the results demonstrated an excellent degree of linearity for both pharmaceuticals, with calculated coefficients of regression (R^2) of 0.9999 and 0.9999, respectively.

Accuracy

The accuracy of the method was assessed by examining the amount recovered of commercially accessible CFT and SB at various concentrations within the designated concentration range. The typical addition technique was followed to make three duplicates of each concentration. Following the method provided, the experiment entails adding a certain quantity of every drug at different concentrations. Based on the findings presented in Table 4, both examined drugs had excellent rates of recovery, estimated by calculating the percentage of drugs recovered.

Precision

Both the method's intra- and inter-day precision was measured to determine its accuracy. The validation process was carried out using QC samples with concentrations ranging from 1.6, 3.2, and 6.4 µg/ml. Three independent measurements were taken with a solution containing pure drugs to evaluate intra-day precision. The standard deviation (S_D) of these measurements was then calculated. A very precise method is shown by the S_D (standarddeviation) figures, which varied between 1.08 and 1.6. For inter-day repeatability, the CFT standard deviation was within the acceptable range of 0.06-0.49 and the SB standard deviation was within the range of 0.10-0.58, as shown in Table 4. This study's findings indicate that the suggested method is capable of accurately measuring both drugs in pharmaceutical dosages at the same time.

Selectivity and Specificity

CFT and SB solutions were injected into the column separately to evaluate the method selectivity. As a result, two separate peaks emerged with retention durations of 1.39 min. for CFT and 2.06 min for SB. The blank solution did not show these peaks. In addition, the specificity testing showed that the vial formulations containing excipients did not interfere with the well defined peaks of CFT and SB due to impurities (Figures5 and 6).

Detection and quantification limits

The limits of detection (LOD) were determined at a signals-to-noise ratio of 3:1, while the limits of quantification (LOQ) were set at 10:1.According to the results, the limits of detection for CFT were 2.61×10^{-7} µg/ml and for SB, 2.42×10^{-5} µg/ml. In Table 3, it can be shown that the limits of quantification for CFT and SB were found to be 8.62×10^{-7} µg/ml and 7.98×10^{-5} respectively. The results obtained by CFT and SB were 0.959 µg/ml for quantization and 0.316 µg for detection, according to El-Hassan et al. The results indicate how sensitive the method is.

Robustness

The method's robustness was tested by making minor, intentional adjustments (± 0.05) to the flow speed and composition of the mobile phase ratio, while keeping the other chromatographic parameters constant. The standard deviations and recovery percentages of the two drugs were compared in order to evaluate the impact of the modifications. The relatively low standard deviation (S_D) values of 0.05 for CFT and 0.08 for SB show that the changes has little impact on the results, as shown in Table 5.

APPLICATIONS

Analysis of vial formulations

The proposed method was utilized to accurately evaluate three pharmaceutical formulations, namely Monocef SB, Alvitrox S, and Xone SB vials, which contain CFT and SB obtained from the formulations of Biotax, Taxim, and Opitax.The F-test and student t-test were computed using statistical analysis. Being unaffected by contaminants or excipients is a sign of this procedure's significant degree of specificity. The obtained results were compared with the reference methods using an F-test and Student t-test. According to Table 6, both the reference as well as proposed methods was equally precise and accurate. This is because the computed't' and 'F' values for CFT and SB both less than the tabular ones.

CONCLUSION

The simultaneous determination of a mixture of CFT and SB was achieved by utilizing an isocratic RP-HPLC technique. The present study developed and validated a method that determines CFT and SB concentrations simultaneously with high efficiency and accuracy; the entire process required only 3.0 minutes. The results show that the suggested method is fast, accurate, selective, reliable, and easy to reproduce. The tested drugs, CFT and SB, showing linearity across the concentration range from 0.2 to 6.4 μg/ml. Analyzing commercially available vials of Monocef SB, Alvitrox S, and Xone SB for quality control purposes has shown promising results using this method, which is particularly useful when time and money are of the essence. Routine analysis of CFT and SB combinations can be performed using the suggested method in quality control laboratories.

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Conflict of interest

The authors confirm that there are no conflicts of interest with the manuscript**.**

Ethical approval

No research involving humans or other animals is contained in this manuscript.

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Table 1: Comparison of the proposed HPLC technique to those currently in use

Sl. No.	Method	Experimental details	Detection wavelength	LOQ in µg/ml	Linear Range in µg/ml	Remarks	Ref. No.
1	RP-HPLC	A Hypersil ODS C-18 column was used to separate the two drugs via chromatography. Acetonitrile and tetrabutylammonium hydroxide were mixed in a 70:30 (v/v) ratio to create the mobile phase. Orthophosphoric acid was used to lower the mixture's pH to 7.0.	220 nm	0.49 CFT 1.49 SB	125 – 750 CFT 62.5-375 SB	In terms of high retention time, CFT is 5.982 min., while SB is 3.426 min., and maximum quantification limit.	[29]
2	RP-HPLC	Chromatographic separation was achieved with an ODS Hypersil C-18 column (250mm × 4.6mm, 5µ). The mobile phase was 50 Mm ammonium phosphate buffer solution and 90:10% v/v methanol pH 7.0 set with triethylamine at 1.0 ml/min.	230 nm	4.0 CFT 2.0 SB	20–100 CFT 10-50 SB	Less sensitivity and accuracy are associated with a linear working range that is high and a retention time that exceeds 10.6 min. for CFT and 3.25 min. for SB.	[30]
3	HPLC	A mixture of a methanol a buffer with potassium phosphate (pH 7.0), with triethylamine is used as the mobile phase. This mixture is introduced onto a stainless steel column with dimensions 625 x 4.6 i.d.mm with a rate of flow of 1.15 ml/min.	230 nm	NA	125–150 CFT 10-75 SB	The sample retention time for CFT was 5.0 min and for SB it was 4.35 min; both have a high linear working range but were less specific.	[33]
4	RP-HPLC	The mobile phase consisted of 86:14 acetonitrile to 0.05M sodium dihydrogenorthophosphatedihydrate, a 2 µm C18 column, and 0.1M sodium	254 nm CFT 195 nm SB	0.027 CFT 0.083 SB	10-70 CFT 5-35 SB	Detection wavelengths for the two drug components were	[34]

		hydroxide or orthophosporic acid to achieve a pH of 4.5.				varied in simultaneous estimation, which is both a time-consuming and insensitive procedure.	
5	RP-HPLC	A 250*4.6mm Intersil ODS C18 column having a 5 µm particle size is being used in this isocratic mode. The mobile phase is supplied with a rate of flow of 1.0 ml/min and is composed of a 45:55 proportion of acetonitrile to a buffer with phosphate (pH 5.6).	210 nm	9.18 CFT 1.42 SB	60-140 CFT 30-70 SB	Less accuracy and precision, but a large quantification limit and linear performance. Duration of 4.29 min. is recorded.	[35]
6	Spectrophot-ometric	UV spectrophotometry with a multi-component study mode.	251 nm CFT 259 nm SB	1.5 CFT 2.5 SB	4-20 CFT 2-10 SB	This method has a high detection limit, two different wavelengths for detection, and poor accuracy and precision.	[36]
7	RP-HPLC	A mobile phase made of a 75:25 (v/v) combination of acetonitrile with phosphate buffer solution, pH-adjusted to 5.5, was used during the separation procedure on a Waters XTerra RP-18 column (250 x 4.6 mm in length and 5 µm in i.d.) operated at 245 nm.	245 nm	8.62×10^{-7} CFT 7.9810^{-5} SB	0.2-6.4 (CFT and SB)	The micro level of limit of quantification, an extremely short retention period of 1.39 min for CFT and 2.06 min for SB, and the ease of use, accuracy, precision, and user-friendliness of the method make it an excellent choice.	Current Method

Table 2: Chromatographic parameters for the planned RP-HPLC method

Parameter details	Conditions
HPLC Column	The Waters XTerra RP-18 column has an internal diameter of 4.6 mm and a 5 µm diameter.
Mobile Phase	The mobile phase consisted of a 75:25 (v/v) ratio of acetonitrile to phosphate buffer with a pH of 5.5. At room temperature, the degasser was set up at the 20A5 prominence.
UV Detection	245 nm
Flow Rate	1.0 ml/min
Injected Volume	10 µl
Temperature in ºC	Ambient
CFT retention time	1.39 min.
SB retention time	2.06 min.

Table 3: The proposed method results and parameters

Parameters	Ceftriaxone			Sulbactam		
	Conc. Taken (µg/ml)	**Conc. Found (µg/ml)**	**% Recovery**	**Conc. Taken (µg/ml)**	**Conc. Found (µg/ml)**	**%Recovery**
	1	0.998	99.80	2	2.001	100.05
	3	3.001	100.03	4	3.999	99.97
	5	5.001	100.02	6	6.002	100.03
Mean recovery*			99.95			100.02
N			3		3	
±SD			0.13		0.038	
±RSD			0.1301		0.039	
Regression Equation** Slope (b) Intercept (a)	5491032 22962				2757015 248	
LOD	2.61×10^{-7}				2.42×10^{-5}	
LOQ	8.62×10^{-7}				7.98×10^{-5}	
Correlation Coefficient	0.9999				0.9999	
Accuracy (mean ±SD)			100.05±0.13			99.98±0.05
Precision Repeatability (±%RSD)			99.95±0.24			99.97±0.17
Intermediate precision			99.95±0.47			99.98±0.18

*Average of three independent procedure.

**Y=a+bC, where Y is the peak area, C is the concentration of the drug in (µg/ml).

Table 4: Findings of the standard addition recovery method

Vial of Injection studied	**Proposed Method**							
	CFT in Injection µg/ml	**Pure CFT added µg/ml**	**Total CFT found µg/ml**	**Pure CFT Recovered Percent ± SD***	**SB in Injection µg/ml**	**Pure SB added µg/ml**	**Total SB found µg/ml**	**Pure SB Recovered Percent ± SD***
Xone SB 250 mg	2.995	1	4.001	100.15±0.06	1.995	2	3.996	100.03±0.42
	2.995	3	5.998	99.98±0.12	1.995	4	5.993	99.97±0.58
	2.995	5	9.997	99.96±0.44	1.995	6	7.993	99.97±0.15
Alvitrox S 500 mg	4.997	1	5.994	99.95±0.31	3.996	2	5.993	99.95±0.34
	4.997	3	7.995	99.97±0.23	3.996	4	7.995	99.99±0.42
	4.997	5	9.996	99.99±0.14	3.996	6	9.994	99.98±0.11
Monocef - SB 1000 mg	6.996	1	9.998	100.01±0.22	5.995	2	7.993	99.97±0.53
	6.996	3	11.94	99.99±0.34	5.995	4	9.992	99.97±0.14
	6.996	5	15.993	99.98±0.49	5.995	6	11.993	99.98±0.10

*Mean value of three determinations.

Table 5: Results of robustness at different temperate

Flow rate in ml/min	Temperature in ºC	CFT Conc. Found in (µg/ml)	% of Recovery	SB Conc. Found in (µg/ml)	% ofRecovery
0.9	22	6.42	100.31±0.25	3.22	100.62±0.11
1.0	24	6.40	100.00±0.05	3.20	100.00±0.21
1.2	26	6.48	101.25±0.14	3.25	101.56±0.08

Table 6: Statistical data of Pharmaceutical dosage*vs* reference method

Name of pharmaceutical dosage*	Nominal quantity	Labelled % standard deviation (SD)		
		Reference method	Proposed method for CFT	Proposed method for SB
XoneSB[a]	250 mg	99.96 ± 0.22	99.92 ± 0.45, t = 0.22, F = 0.24	99.94 ± 0.17, t = 0.13, F = 1.67
AlvitroxS[b]	500 mg	99.98 ± 0.15	99.95 ± 0.17, t = 0.37, F = 0.78	99.97 ± 0.13, t = 0.14, F = 1.33
Monocef - SB[c]	1000 mg	99.97 ± 0.47	99.86 ± 0.35, t = 0.21, F = 1.80	99.93 ± 0.32, t = 0.19, F = 2.16

*Manufactured by: a. Alkem Laboratories Ltd.; b. Alarius Healthcare.; c. Aristo Pharmaceutical Ltd. The t-value determined at the 95% level of significance is 2.365. A tabulated F-value of 3.79 indicates a level of confidence of 95%.

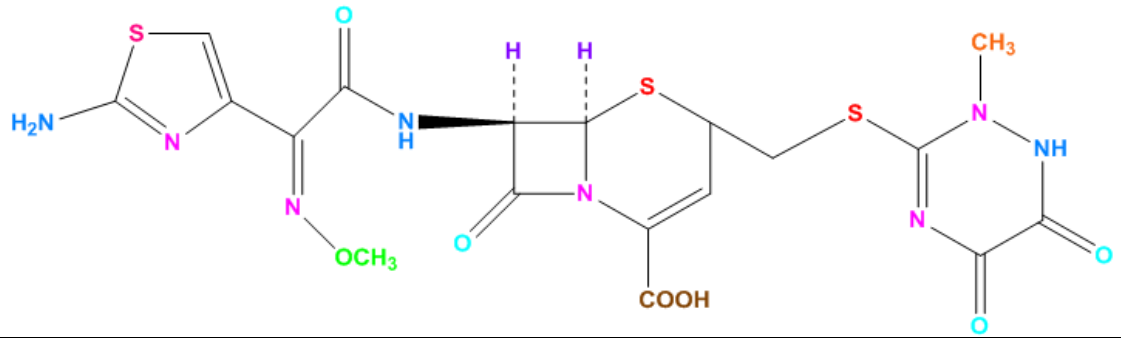


Figure 1: Chemical structure of ceftriaxone

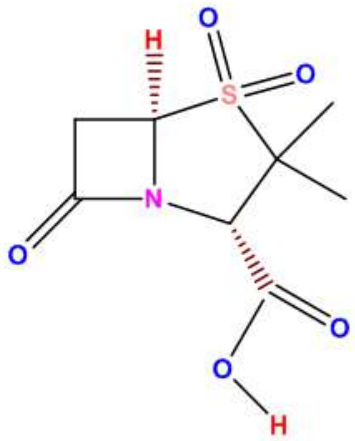


Figure 2: Chemical structure of sulbactam

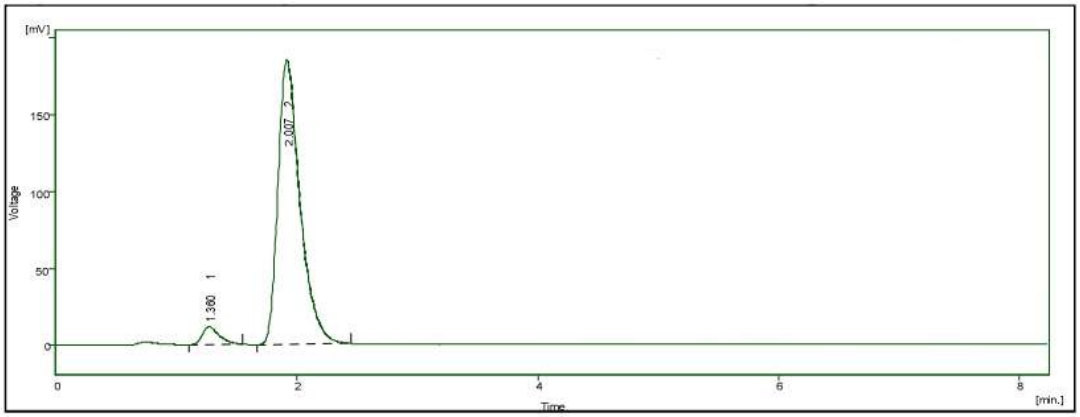


Figure 3: Chromatogram of standard ceftriaxone and sulbactam.

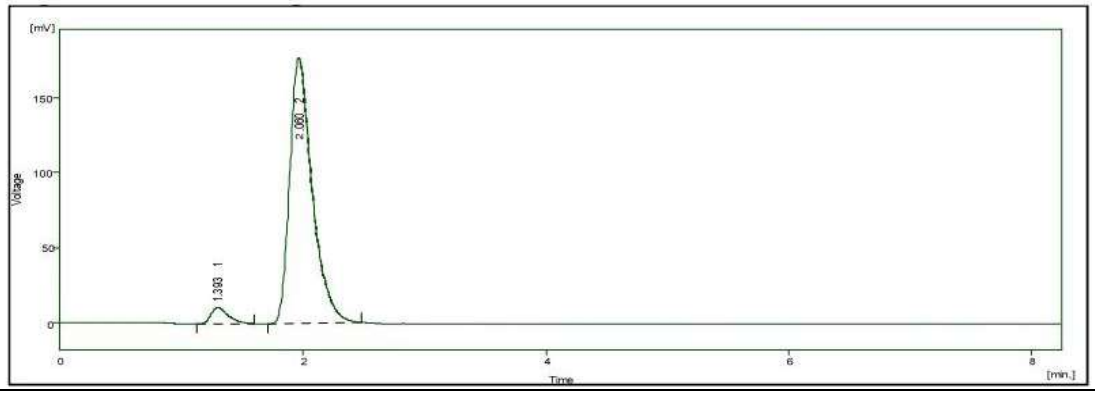


Figure 4: Chromatogram of pharmaceutical dosage of ceftriaxone and sulbactam.

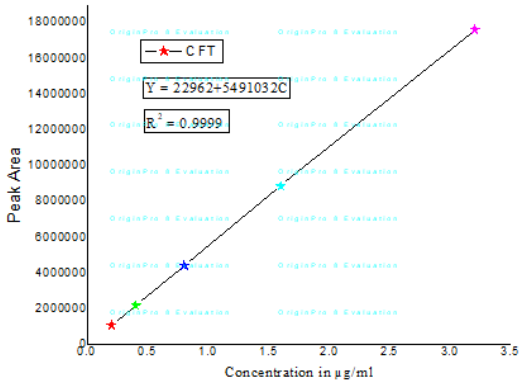


Figure 5: Calibration plot of CFT concentration*vs* peak area

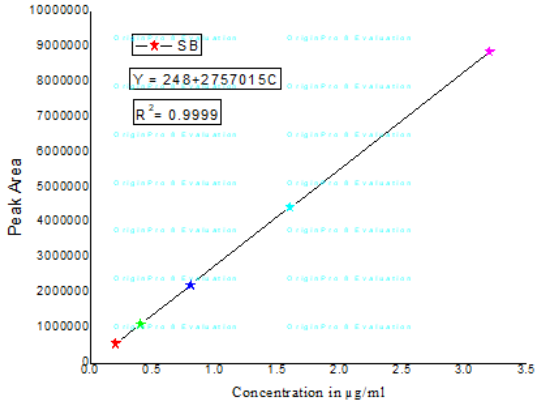


Figure 6: Calibration plot of SB concentration*vs* peak area

RESEARCH ARTICLE

Investigation of Salivary Biochemical Parameters for Diagnosis of Type - II Diabetes Mellitus – A Non-Invasive Approach

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ABSTRACT

Heterogeneous disorders of metabolism whose main feature is chronic hyperglycemia are collectively referred to as diabetes mellitus (DM). Poor insulin secretion, poor insulin action, or both may be the cause of DM. Millions of people around the world are still burdened with DM. The total number of DM sufferers is expected to increase from 643 million by 2030 to 783 million by 2045. Blood has been the most commonly used diagnostic fluid for the analysis of its various constituents. This conventional method of diagnosis has a lot of demerits like invasive, painful, need technically trained people. There is urgent need to find a more convenient and comfortable sampling procedure that is non-invasive, reliable, cost effective and requires less expertise. Hence the present study is focused on finding the best salivary biochemical markers for diagnosis purpose. After obtaining ethical clearance and written consent, in fasting condition unstimulated whole saliva was collected from 200 healthy control and 200 type -II diabetic patients. The samples are used for analysis of biochemical parameters like glucose, creatinine, urea, insulin, HbA1c and C-peptide and other basic parameters like saliva flow rate and pH also measured by using standard method. From the study results, it was observed that, saliva screening showed that glucose (69.377 ± 14.329 mg/dl), creatinine (0.782 ± 0.320 mg/dl), urea (53.00 ± 14.047 mg/dl), insulin (4.061 ± 1.251µU /ml) HbA1c (8.804 ± 1.181 %) and C-peptide (0.329 ± 0.211(ng/ml) were significantly higher in diabetic patients compared to control people ($p< 0.0001$). Whereas, in diabetic patients salivary flow rate (0.146 ± 0.024 ml/min) and pH 6.191 ± 0.226 were significantly lower than the control people (flow rate 0.287 ± 0.048 ml/ min and pH6.976 ±0.131). There were notable differences between healthy control and diabetic patients in the physical and biochemical salivary parameters. The

study concludes that by analyzing salivary factors it can be a less expensive and non-invasive substitute for blood testing in the detection, diagnosis and follow-up of diabetes.

Keywords: Saliva, biochemical markers, salivary glucose, Non-invasive tool, Diabetes mellitus.

INTRODUCTION

Diabetes, commonly known as diabetes mellitus (DM), is a collection of metabolic diseases marked by elevated blood sugar levels brought on by deficiencies in either or both of the hormones that secrete or act on insulin. It is anticipated that there would be 783 million DM patients worldwide by 2045, up from 643 million in 2030.Diabetes mellitus is a chronic disease linked to long-term illness, malfunction, organ failure, particularly to the kidneys, nerves, heart, eyes and blood vessels. Diabetes-related morbidity and deaths are caused by a continuous increase in blood sugar levels and the emergence of related comorbidities such cardiovascular disease, nephropathy, retinopathy, neuropathy and amputations of the lower limbs. To reduce the incidence of diabetes worldwide, routine screening, early diagnosis and committed management of the disease are now essential [Mascarenhas *et al*.,2014; American Diabetes Association, 2017].Identification of asymptomatic disease at an opportune time for action to improve prognosis is known as early diagnosis [Narula, 2008]. When choosing a course of treatment to improve clinical outcome, assessing risk, and accurately diagnosing a patient all depend on biochemical indicators. Serum examination of renal function markers, including urea, creatinine, uric acid and electrolytes, usually replaced with urine analysis; however, this may cause discomfort for patients. [Gowda *et al*., 2010]. In dentistry, physiology, internal medicine, pediatrics, endocrinology, immunology, clinical pathology, forensic medicine, and sports medicine, salivary diagnosis is also becoming more and more significant. Saliva can be used to fast and accurate monitor to find the increasing number of medications, antibodies, and hormones (Mandel, 1990; Smith *et al*., 1991 and Tabak, 2001). Salivary diagnosis is therefore expected to be especially helpful in situations when it is necessary to take repeated samples of bodily fluids but blood extraction is either impractical, unethical, or both. When a diabetic people are monitored for blood sugar level, blood samples either intravenously or by frequent finger pricks are used to estimate the plasma glucose levels. Saliva is also an ideal medium for diabetic patients since it may be collected in a non-invasive, stress-free manner, allowing for many collections without causing the patient undue discomfort. It is also simple to transport, store and gather. Unlike the collection of blood samples, this one does not require highly skilled personnel. Hence the present investigation was undertaken to study the significance of salivary biomarkers as precise, reliable and non-invasive diagnostic tool instead of blood to diagnose Type -II DM.

METHODOLOGY

Study population

The present study area, Thiruporur is situated in Chengalpattu district of Tamil Nadu. Diabetic camp was conducted in different villages like Amma pet, Venbedu, Kottamedu and Nellikuppam village to collect the sample from 200 control groups and 200 Type - II diabetic people belonging to different age groups from the selected study area of Thiruporur.

Inclusion and exclusion criteria

The study was approved by the members of the Institutional Ethical Committee. Pregnancy, alcoholism, smoking, chronic illnesses and a history of diabetes within the previous five years were the study's exclusion criteria. The inclusion criteria for the study voluntary participation • Age inclusion: 21years to 70 Years • Sex included both the genders.

Saliva collection and Measurement of saliva flow rate

The saliva collection was done by using standard procedure. In this study, the unstimulated whole saliva was taken for the estimation, there is a possibility of alteration in the salivary composition (Harrison *et al.,* 1987 and Ferguson, 1995). The study participants were placed straight in a relaxed position in a quiet, isolated room and the collection of the fasting salivary sample took place in the morning between 7.30 and 10.30 a.m. The research participants were directed not to consume any food or liquids before the saliva sample was taken. Before the saliva was collected, people who wear dentures were requested to take them off. The subjects washed their mouths with water prior to being collected. The samples that were taken in the first thirty seconds were thrown away, and the participants were initially told to spit out or swallow any saliva that was in their mouths. The method of collecting saliva samples in the ice-cooled tubes with a funnel was spitting. The process of collecting saliva took at least five minutes (Sharon *et al*., 1985; Thorstensson *et al.,* 1989; Darwazeh *et al*., 1991; Chávez *et al.,* 2001; Pal *et al.,* 2003 and Aydin *et al.,* 2007). Following the collection, the reading in the graduated collection tube was used to calculate the saliva flow rate. A flow rate was measured in milliliters (ml) of saliva secreted per minute. To eliminate any particles, the saliva samples were centrifuged for 15 minutes at 4000 rpm. The supernatants were then quickly moved to a sterile vial, frozen at -20°C, and kept for future research.

Estimation of salivary pH

As soon as the unstimulated saliva samples were collected, the salivary pH was measured to prevent any time-related pH variations or CO_2 loss. Salivary pH was measured with the help of a single electrode digital pH meter.

Estimation of HbA1C

HbA1c measurement has some advantages over blood glucose measurement when diagnosing diabetes. Salivary HbA1c measurement estimation using the Chromatographic-Spectrophotometric Ion Exchange Method. After hemolysate preparation, which eliminates the labile fraction, hemoglobins are retained by a cationic exchange resin. After washing away hemoglobin A1a + b fraction 1 (HbA1a+b), hemoglobin A1c (HbA1c) is specifically eluted and quantified by direct photometric measurement at 415nm. By measuring the total hemoglobin concentration using a direct photometric reading at 415 nm, one can estimate the relative concentration of HbA1c.

$$\frac{\text{A Hb1c}}{\text{A Hb Total}} \times \frac{100}{3} = \%\ \text{HbA1c}$$

Estimation of salivary glucose: (GOD/POD method)

In the presence of glucose oxidase, glucose is oxidized to gluconic acid and hydrogen peroxide. Through the catalytic action of peroxidase, hydrogen peroxide further interacts with phenol and 4-aminoantipyrine to generate a red-colored quinoneimine dye complex. The amount of glucose contained in the sample is directly correlated with the intensity of the color that forms.

$$\text{Total glucose concentration in mg / dl} = \frac{\text{Abs. T}}{\text{Abs.S}} \times 100$$

Estimation of creatinine (Jaffe's method)

In an alkaline media, creatinine and picric acid combine to generate an orange-colored complex that is then combined with alkaline picrate. The quantity of creatinine in the sample directly correlates with the color intensity that developed within the allotted period.

Creatinine + Alkaline picrate Orange colored complex.

Calculation

$$\text{Creatinine in mg / dl} = \frac{\text{AT}}{\text{AS}} \times 2$$

Estimation of urea (Berthelot method)

This method fundamental idea is that urea is hydrolyzed by urease to produce CO_2 and ammonia. A green-colored complex is created when the ammonia that is produced combines with hypochlorite and a phenolic chromogen. The quantity of urea in the sample directly correlates with the color's intensity.

Urea + Water Urease Ammonia + CO_2

Ammonia + Phenolic chromogen + Hypochlorite Green coloured complex.

Calculation

$$\text{Urea in mg / dl} = \text{urea} \frac{\text{Abs. Test}}{\text{Abs. Standard}} \text{X40}$$

Estimation of Insulin and C-Peptide by ELISA Microwells method

High affinity and specificity antibodies (Ab) (enzyme attached and immobilized) with distinct and varied epitope recognition, in excess, and native antigen (Ag) are important reagents needed for an immune enzyme metric test. In this process, the native antigen and the antibodies react without competition or steric hindrance to create a soluble sandwich complex. This reaction occurs when the monoclonal bio tinylated antibodies, the enzyme-labeled antibody, and a serum containing the native antigen are mixed together. The interaction is illustrated by the following equation:

$k_a {}^{Enz}Ab\ (M) + AgC\text{-}PEP + {}^{Btn}Ab\ (M) \rightleftharpoons {}^{Enz}Ab\ (M)\text{-}\ AgC\text{-}PEP\text{-}\ {}^{Btn}Ab(M)\ k\text{-}a$

Simultaneously, the complex is deposited to the well through the high affinity reaction of streptavidin and biotinylated antibody. This interaction is illustrated below:

$${}^{Enz} – Ag\ C\text{-}PEP\ -\ {}^{Btn}Ab + \underline{\textbf{Streptavidin}}\ CW \Rightarrow \text{Immobilized complex}$$

Streptavidin C.W. = Streptavidin immobilized on well

Immobilized complex = sandwich complex bound to the solid surface. After equilibrium is attained, the antibody-bound fraction is separated from unbound antigen by decantation or aspiration. The natural antigen concentration is directly correlated with the enzyme activity in the fraction bound to the antibody. A dosage response curve that can be used to determine the antigen concentration of an unknown can be created by using multiple serum references with known antigen values.

Calculation

- To determine the C-peptide concentration in unidentified specimens, a dosage response curve is utilized.
- Note the absorbance that you were able to obtain from the microplate reader printout.
- Plot the absorbance for each reference duplicate against the corresponding insulin and C-peptide levels in nanograms per milliliter on a linear graph paper (do not average the serum reference duplicates prior to displaying). Draw the best-fit curve through the plotted points. Locate the average absorbance of the duplicates for each unknown on the graph's vertical axis, locate the point where the curves intersect, and read the concentration (in mg/ml) from the graph's horizontal axis to find the concentration of insulin and C-peptide for an unknown (the duplicates of the unknown may be averaged as indicated).

STATISTICAL ANALYSIS

Statistical analysis was performed using GraphPad software. Descriptive statistics on each study variable including mean and standard deviations were analyzed. The results obtained from the analysis were expressed by using Mean ± SD with their level of significance at $p< 0.0001$

RESULT AND DISCUSSION

Healthy humans typically yield 500–1500 ml of saliva daily, at a rate of about 0.5 ml/min. However, a number of physiological and pathological disorders, such as diabetes and other diseases, can alter the quantity and quality of saliva produced. The content and flow rate of saliva affect its ability to function. Salivary pH is also modulated by the

flow rate of saliva. Quite a few studies have (**Chavez *et al.,* 2001 and Lopez *et al.,* 2003**) reported the higher prevalence of hypo salivation in DM population.Because of this, the current study concentrated on salivary flow rate as one of the diagnostic criteria for Type II diabetes (Tables 1 and 2). In this study, salivary flow rate was observed to be lower in diabetic male patients (0.141 ± 0.0138 ml/min) and female (0.146 ± 0.024 ml/min) as compared to non-diabetic control subjects. In the present investigation control male has saliva flow rate of nearly 0.3 ml /min, but little less in control female. A significant difference in salivary flow rate was observed between the control and diabetic people at $p< 0.0001$. When the salivary pH of diabetic patient and non-diabetic people were compared, it was found that the diabetic patients had lower salivary pH values. This is because their metabolic processes were altered, leading to an increase in glucose levels and an environment that was more acidic. The usual pH range for saliva is 6.2–7.6, with 6.7 serving as the average. The salivary pH decreased significantly in both managed and uncontrolled diabetics, regardless of food, the current study implies that diabetes may directly affect salivary pH, lowering it from normal values and affecting the oral environment. The present result observed that diabetic male (6.210 ± 0.205) and female (6.191 ± 0.226) has a less mean salivary pH value when compared with mean salivary pH of healthy control male (6.964 ± 0.142) and female (6.976 ±0.131). The results were observed to be highly significant at $p< 0.0001$. The percentage of hemoglobin linked to glucose during a 90-days period is determined by the HbA1c test. HbA1c levels less than 7% are thought to be consistent with the disease's good metabolic management, whereas levels greater than 7% are associated with patients' poor metabolic control and increased risk of complications. One advantage of using HbA1c for diagnosis is that the test does not require a fasting blood sample. The HbA1c level of diabetic male and female were significantly high than the control people (Table – 1 and 2)

Salivary biochemical parameters

Numerous biochemical alterations may occur in the blood during Type II diabetes mellitus; these alterations in blood composition also impact bodily fluids. A crucial bodily fluid for determining the biochemical variance in diabetics is saliva. The goal of the current study was to compare and assess the biochemical alterations in the saliva of a subset of the study population both diabetics patient and controls people. The observed data were reported as mean ± SD, with a p-value indicating significance. Table -3 clearly shows the alteration in salivary biochemical parameters in diabetic and non diabetic people. Glucose molecule due to its tiny size and ease of diffusion through semi-permeable membranes, it can be easily found in saliva, particularly in situations where blood sugar levels are high. Diabetic membranopathy, or changes in the salivary glands' basement membrane that causes glucose to escape into the saliva, is another insight for the presence of glucose in saliva. Sugar level in saliva of diabetic people was found to be (69.377 ± 14.329 mg /dl) significantly higher as compared with control subjects (49.271 ± 13.795 mg/dl).

Similar to this, creatinine finds it difficult to diffuse through the salivary gland's tight intercellular connection and cells due to its physical characteristics in a healthy state. But in a disease state, its value increases in saliva, perhaps because of changed permeability of salivary gland cells (**Guyton and Hall, 2006**). Moreover, the high serum creatinine levels in patients produce a concentration gradient that promotes the diffusion of creatinine from serum into saliva. Salivary creatinine should be between 0.05 and 0.2 mg/dl, while serum creatinine should be between 0.6 and 1.5 mg/dl. The mean creatinine level in diabetic saliva (0.782 ± 0.320 mg/dl) were observed to be higher than the control value of saliva (0.113 ± 0.079 mg/dl) of the study population. In renal failure, the kidneys are unable to remove urea from the body, each increase in blood urea is also accompanied by an increase in salivary urea.This higher serum urea causes a greater concentration gradient, which increases the diffusion of urea from serum to saliva (**Suresh *et al.,* 2014**). Normal blood urea concentration is 30-40mg/dl where as normal salivary urea is 12-70 mg/dl. In the present study a significantly elevated level of urea in saliva (53.00 ± 14.047mg/dl) was observed in the diabetics than in the control saliva (49.937 ± 7.50mg/dl). C-peptide has a longer half-life than insulin and is not removed by the liver, it is a more accurate measure of insulin secretion. A high C-peptide level may be present in individuals with obesity, insulin resistance and type 2 diabetes. Therefore, C-peptide and insulin levels are best markers for ß-cell function and diagnosis of disease condition. The present results revealed a, significantly higher level of insulin and C-peptide in saliva of diabetic patients when compared with the control saliva. The increased level of Insulin in Diabetic saliva (4.061 ± 1.251µU /ml) were observed as compared to control saliva (3.444 ±1.142 µU /ml). Similarly,

highly increased level of C-Peptide was observed in saliva (0.329 ± 0.211) of diabetics' people than the control saliva (0.055 ± 0.023 ng/ml). The present observation was highly significant at $p < 0.0001$.

DISCUSSION

The Salivary flow rate in the present study was found significantly decreased in diabetic patients when compared with healthy control. Present results were corroborated with Chavez *et al., (*2000); Lin *et al.,* (2002) and Mata *et al.,* (2004) also observed that, the diabetic patients showed a statistically greater percentage of hyposalivation compared to non-diabetic patients. Survey of literature revealed a decreased salivary flow rates in diabetic subjects (Chavez *et al.,* 2001 and Lopez *et al*., 2003). In the present investigation also the salivary pH rates was observed to be decreased significantly ($p<0.0001$) in diabetic patient when compared with non-diabetic healthy people. Many other research findings demonstrated that, diabetic patients had decreased salivary pH values when compared with healthy people. This may be due to changes in the metabolic processes and increased glucose levels, resulting in more acidic environment (Brain *et al.,* (2006). In the present study a significantly higher level of HbA1c in diabetic male and female was recorded than the control male and female. Every one percent increase in HbA1c is associated with a one percent increase in the relative risk of cardiovascular disease. HbA1c is a useful indicator of long-term glycemic management (Selvin *et al.,* 2004). In diabetic people Fasting Blood Sugar level had significant positive linear correlation with the HbA1c as compared with normal healthy people. Rohlfing *et al.* (2002) demonstrated strong positive and linear relationship between Mean plasma glucose and glycated hemoglobin HbA1c. Similar finding of correlation between FSG and HbA1c has been reported by Satish *et al.,* (2014) in their study. Carlson and Ryan (1908) reported the presence of sugar in the saliva of diabetic patients and other authors have also reported increases in salivary glucose levels in diabetes mellitus patients in comparison to non-diabetics (Reuterving *et al.,* 1987, Ben-Aryeh *et al.,* 1988, Thorstensson *et al.,* 1989, Darwazeh *et al.,* 1991, Belazi *et al*.,1998, Borg Andersson *et al*., 1998, Amer *et al*., 2001, Lopez *et al.,* 2003, Aydin *et al.,* 2007, Sreedevi *et al*., 2008 and Jurysta *et al.,* 2009).Similar results were observed in the present study also. The study by Daquan, (2002); Zúñiga *et al*., (2012); Peng *et al.,* (2013) and Venkatapathy *et al.,* (2014) correlated the serum urea and creatinine with salivary urea and creatinine level and highlighted up on the low-cost and non-invasive diagnostic method to be used for screening patients in early stages of kidney disease especially in diabetic people, in developing countries where resources are limited. The present findings conclude with similar research report as reliable and precise one for screening. The IDDM is characterized by complete destruction of beta cells, resulting in little or no production of insulin as well as C-peptide. In hyperglycemia condition (NIDDM), the increase in serum and salivary C - peptide values may be due to the retention of these biomolecules in the serum and saliva and partly due to improper filtration of C-peptide by kidneys which is the major organ to eliminate it (Wasada *et al.,* 1995). In present study also we have observed the similar kind of results.

CONCLUSION

From the present study, significant differences in salivary parameters between DM patient and control was observed. Saliva screening showed that glucose (69.377 ± 14.329 mg/dl), creatinine (0.782 ± 0.320 mg/dl), urea (53.00 ± 14.047 mg/dl), insulin (4.061 ± 1.251μU /ml) HbA1c (8.804 ± 1.181 %) and C-peptide (0.329 ± 0.211(ng/ml) were significantly higher in diabetic patients compared to control people ($p< 0.0001$). Whereas, in diabetic patient salivary flow rate (0.146 ± 0.024 ml/min) and pH 6.191 ± 0.226 were significantly lower than the control people (flow rate 0.287 ± 0.048 ml/ min and pH6.976 ±0.131). Our results indicate that unstimulated fasting salivary glucose, urea, creatinine, Insulin, C-peptide, flow rate and salivary pH have potential and should be further investigated for use as screening, diagnostic and prognostic tools. Due to its noninvasive nature, saliva can easily be used in place of blood in a variety of point-of-care devices for self-monitoring. This allows us to monitor therapy and conduct frequent screenings on patients to gain insight into the course of their disease.

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CONFLICT OF INTEREST
The authors declare no conflict of interest.

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None

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Table-1: Comparison of Flow Rate, Saliva pH and HbA1c Level of the Control and Diabetic Male Patients (Mean / SD)

S.NO	Parameters	Control Male (n-200)	Diabetic Male (n-200)	p- value (Between control and diabetic Male)
1	Saliva Flow (ml /min)	0.292 ± 0.051	0.141 ± 0.0138	0.0001 ***
2	Saliva PH	6.964 ± 0.142	6.210 ± 0.205	0.0001 ***
3	HbA1c (%)	4.494 ± 0.885	8.764 ± 1.121	0.0001 ***

- Not Significant, ** - Significant, *** - Highly statistically significant

Table-2: Comparison of Flow Rate, Saliva pH and HbA1c Level of the Control and Diabetic Female Patients (Mean / SD)

S.NO	Parameters	Control Female (n-200)	Diabetic Female (n-200)	p- value (Between control and diabetic Female)
1	Saliva Flow (ml /min)	0.287 ± 0.048	0.146 ± 0.024	0.0001 ***
2	Saliva pH	6.976 ±0.131	6.191 ± 0.226	0.0001 ***
3	HbA1c (%)	4.670 ± 0.8125	8.804 ± 1.181	0.0001 ***

- Not Significant, ** - Significant, *** - Highly statistically significant

Table – 3: Biochemical Parameters in Saliva Sample of the Control and Diabetic Patients (Mean / SD)

S.NO	Parameters	SALIVA		p- value (Between control and diabetic)
		Control People (n-200)	Diabetic patients (n-200)	
1.	Fasting Glucose (mg /dl)	49.271± 13.795	69.377 ± 14.329	0.0001 ***
2.	Creatinine (mg/dl)	0.113± 0.079	0.782 ± 0.320	0.0001 ***
3.	Urea (mg/dl)	49.937 ± 7.500	53.00± 14.047	0.0068 **
4.	Insulin (μU /ml)	3.444 ±1.142	4.061 ± 1.251	0.0001 ***
5.	C-Peptide (ng/ml)	0.055 ± 0.023	0.329 ± 0.211	0.0001 ***

* - Not Significant, ** - Significant, *** - Highly statistically significant

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RESEARCH ARTICLE

Fuzzy Multi - Criteria Decision Model for the Effective Selection of Pediatric Treatment using the ELECTRE I Method

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ABSTRACT

This paper focuses on introducing a novel multiple-criteria decision-making model termed fuzzy Elimination and Choice Translating Reality (ELECTRE) I Method. The model utilizes a unique centroid of centroids method and determines weight through the entropy method. The proposed method aims to address the challenges in medical diagnosis by analyzing a patient's symptoms and indications to accurately determine their illness. A methodology is used that involves a fuzzy ELECTRE-I approach, employing concordance and discordance methods, to determine the most suitable treatment for children affected by diseases.

Keywords: fuzzy concordance, fuzzy discordance, ELECTRE I, outranking relations
Mathematics subject Classification: 03E72. 68R10

INTRODUCTION

Multiple-criteria decision-making (MCDM) methods organize and analyze multi-criteria decisions and planning issues. These models help choose the most convenient solution from possible alternatives, saving time and money and ensuring accurate selections. A preference intelligence system and several decision-making concepts drive MCDM models. MCDM models organize and solve decision-making problems in economics, management consulting, telecommunications, social sciences, and health. Finding unclear, convoluted values for subjective criteria is fuzzy decision-making. Multi-criteria decision-making applies to this choice. The traditional approach ignores subjectivity and ambiguity. MCDM evaluates risk assessment scenarios with several criteria to find the best

solutions. Fuzzy decision-making has become an interesting research subject since Bellman and Zadeh suggested it in 1970.The fuzzy ELECTRE (Elimination and Choice Translating Reality) Method is an MCDM decision-making method. The optimal alternative is chosen by comparing alternatives' Concordance and Discordance values. The ELECTRE technique and its variations are crucial to this family of MCDM systems.

First, Benayoun et al.'s 1966**[1]** outranking relation for pair-wise comparisons in ELECTRE shows which choice is preferred. These linkages exclude actions or alternatives rated by competing criteria to produce the most likely right and desired group of choices. Roy described and renamed this method ELECTRE I in 1968. The ELECTRE technique identifies concordance and discordance sets, which represent alternate benefits as well as drawbacks. Since ELECTRE I was created, several varieties have been produced, including II, III, IV, IS, and TRI.Medical diagnosis identifies diseases based on signs and indicators. In the past, numerous medical diagnosis-related theories were prevalent, including rough set theory and soft set theory. In medical diagnosis systems, multi-criteria decision-making is regarded as an important tool for assessing patients' medical information.Yu et al. **[2]** suggested prioritizing MCDM-ELECTRE approaches.Luo et al. **[3]** find a gap between intuitionistic fuzzy sets and medical diagnosis.G. Sivakumar et al. **[4]** used fuzzy mathematical modelling to analyses the distribution of communicable disease treatments using optimization strategies.Adeel et al. **[5]** proposed ELECTRE-I for mHF/HmF multi-criteria decision-making. In Pythagorean fuzzy information, Akram et al. **[6]** introduced ELECTRE I multi-criteria group decision making. Govindan et al. **[7]** suggested the selection of a sustainable third-party reverse logistics provider using ELECTRE I and SMAA robustness analysis of an outranking graph kernel.Xiao **[8]** proposed the Pythagorean fuzzy set divergence measure and its use in medical diagnostics.In medical diagnostics, Akram et al. **[9]** used bipolar fuzzy TOPSIS with ELECTRE I.Chen **[10]** New Chebyshev distance measurements for Pythagorean fuzzy sets for multiple-criteria decision analysis were presented using an enhanced ELECTRE approach. Pythagorean fuzzy information is used in hybrid TOPSIS and ELECTRE I solutions for failure modes and effects analysis to estimate risk **[11]**. Akram et al.Rocha **[12]** presented health and safety problem-solving using AHP and ELECTRE I decision-making.Akram et al. **[13]** proposed an integrated ELECTRE rehabilitation center selection approach using m-polar fuzzy N-soft information.The m-polar fuzzy set ELECTRE-I has improved Simos' and AHP's weight calculation algorithms for non-traditional machining process selection, as demonstrated by Jagtap et al. **[14]**. Kang et al.**[15]** evaluated wave energy converters using integrated ELECTRE.This article describes several medical diagnosis applications using $\mathcal{CCE}$-ELECTRE I.The diagnostic procedure is shown to be feasible and efficient by the proposed methods.

In Section 2, we explain the $\mathcal{CCE}$**-**ELECTRE I method and Algorithm.In Section 3, $\mathcal{CCE}$**-**ELECTRE I technique to solve various difficulties in medical diagnostics with numerical examples.In Section 4, We conclude with future directions.

The $\mathcal{CCE}$- ELECTRE-I Method:

A new MCDM model, the centroid of centroid fuzzy, is presented in this article. This approach, $\mathcal{CCE}$-ELECTRE I, simplifies MCDM issues. This section provides a ranking of generalized trapezoidal fuzzy numbers by distance using fuzzy number conversion. Utilizing the centroid of centroids, the trapezoid balancing point is presented to arrange fuzzy numbers by distance.Specifically, for triangular fuzzy numbers, the centroid can be determined using the formula$\mathcal{G}$= $\left(\frac{3\alpha+4\beta+2\delta}{9}\right)$ **[4].**

Construction of a Decision Matrix

Suppose a decision maker evaluates g alternatives $\mathcal{D}_i, i$ =1, 2,...,g under each of h attributes, $\mathcal{T}_j, j = 1,2,\ldots,h$, attributes based on the decision maker's inquiry. Assume each alternative's h-criteria suitability grade. Each alternative is assessed using g criteria. Each criterion's possibilities form a decision matrix.

$$\mathcal{X} = [x_{ij}]_{g\times h} = \begin{bmatrix} x_{11}, x_{12} & \cdots & x_{1h} \\ \vdots & \ddots & \vdots \\ x_{g1}, x_{g2} & \cdots & x_{gh} \end{bmatrix}$$

The decision maker assigns weights to each criterion in accordance with the normality condition, where$\mathcal{W}$ = $[w_1, w_{2,\ldots,} w_k]^T \sum_{j=1}^{h} w_j = 1$, where w_j is the weight for j^{th}.Weight is determined using the entropy method.

$$w_j = -k\sum_{j=1}^{h} x_{ij} \ln x_{ij}\,,\ j=1,2,\ldots,g \quad (1)$$

Computing a fuzzy weight decision matrix involves multiplying the decision matrix by

$$\mathcal{X} \otimes \mathcal{W} = [r_{ij}]_{g\times h} = \begin{bmatrix} r_{11}, r_{12} & \cdots & r_{1h} \\ \vdots & \ddots & \vdots \\ r_{g1}, r_{g2} & \cdots & r_{gh} \end{bmatrix}$$

$\mathcal{CCE}$-fuzzy Concordance Set and Discordance Set:

The main idea behind the ELECTRE I method, which is also known as the "outranking relation," is to find the preference link between each pair of alternatives that are compared using different criteria. Outranking approaches use concordance and discordance to determine the link between two alternatives.

$\mathcal{CCE}$-fuzzy Concordance set

For each pair of alternatives $(\mathcal{T}_x, \mathcal{T}_y)$ {x, y =1, 2,..,h, x≠y},the $\mathcal{CCE}$-fuzzy concordance set includes all the attributes or criteria n for which $\mathcal{T}_x$ has a higher membership value than $\mathcal{T}_y$. This means that $\mathcal{T}_x$ is better than $\mathcal{T}_y$ in terms of these attributes or criteria.

The $\mathcal{CCE}$- fuzzy concordance set $\mathcal{C}_{xy}$ is defined as

$$\mathcal{C}_{xy} = \{j \setminus t_{xj} \geq t_{yj}\,, x\neq y,\ x, y = 1,2,\ldots,\} \quad (2)$$

$\mathcal{CCE}$-fuzzy Discordance set:

Discordance sets complement concordance sets. $\mathcal{CCE}$-fuzzy discordance set for pair of alternatives $(\mathcal{T}_x, \mathcal{T}_y)$ {x, y =1,2,…,h, x≠y}, includes criteria h that $\mathcal{T}_x$ is not better than $\mathcal{T}_y$ for n.

The $\mathcal{CCE}$- fuzzy discordance set $\mathcal{D}_{xy}$ is defined as

$$\mathcal{D}_{xy} = \{j \setminus t_{xj} < t_{yj}\,, x\neq y,\ x, y = 1,2,\ldots,\} \quad (3)$$

Concordance and Discordance Matrices:

Comparing the relative measures of each pair of alternatives' concordance and discordance sets determines their indices. Use these indices to generate concordance and discordance matrices.

$\mathcal{CCE}$-fuzzy Concordance matrix:

The $\mathcal{CCE}$ -fuzzy concordance dominance matrix is

$$\dot{\mathcal{L}} = \begin{bmatrix} -\ell_{12} & \cdots & \ell_{1g} \\ \vdots & \ddots & \vdots \\ \ell_{g1}\ell_{g2} & \cdots & - \end{bmatrix}$$

Where the values ℓ_{ij} are defined as $\ell_{ij} = \begin{cases} 1, if\, c_{ij} \geq \bar{c}^* \\ 0, if\, c_{ij} < \bar{c}^* \end{cases}$

$\mathcal{CCE}$-fuzzy discordance matrix:

The $\mathcal{CCE}$ -fuzzy discordance dominance matrix is

$$\dot{\mathcal{M}} = \begin{bmatrix} -m_{12} & \cdots & m_{1g} \\ \vdots & \ddots & \vdots \\ m_{g1}m_{g2} & \cdots & - \end{bmatrix}$$

Where the values m_{ij} are defined as $m_{ij} = \begin{cases} 1, if\, d_{ij} \leq \bar{d}^* \\ 0, if\, d_{ij} > \bar{d}^* \end{cases}$

Construction of Outranking Relations:

This subsection establishes an outranking connection using the concordance and discordance indices for each pair of alternatives. The decision-maker initially establishes the concordance and discordance threshold values or levels in order to facilitate a more accurate evaluation of alternatives $\bar{c}^* = \frac{1}{m(m-1)} \sum_{\substack{x=1 \\ x\neq y}}^{m} \sum_{\substack{y=1 \\ x\neq y}}^{m} c_{xy}$, $\bar{d}^* = \frac{1}{m(m-1)} \sum_{\substack{x=1 \\ x\neq y}}^{m} \sum_{\substack{y=1 \\ x\neq y}}^{m} d_{xy}$

Aggregated dominance matrix

The $\mathcal{CCE}$ −fuzzy aggregated dominance matrix is defined as

$$\dot{\mathcal{N}} = \begin{bmatrix} -n_{12} & \cdots & n_{1g} \\ \vdots & \ddots & \vdots \\ n_{g1} n_{g2} & \cdots & - \end{bmatrix}$$

Where the values n_{ij} are defined as

$$n_{ij} = \ell_{ij}\, m_{ij} \tag{4}$$

Construction of Outranking graph:

In the concluding step of this procedure, alternatives are ranked according to their outranking values. The procedure concludes with the evaluating of alternatives according to the mentioned outranking values n_{ij}'s. Alternatively stated, an arrow from. For any pair of alternatives $\mathcal{T}_i$ and $\mathcal{T}_j$ exist exclusively if n_{ij}=1.

Consequently, three potential scenarios exist.

(i) A distinctive arrow connects $\mathcal{T}_i$to $\mathcal{T}_j$.

(ii) Two possible arrows exist between $\mathcal{T}_i$and $\mathcal{T}_j$.

(iii) No arrow exists between $\mathcal{T}_i$and $\mathcal{T}_j$.

We conclude that $\mathcal{T}_i$ is preferable to $\mathcal{T}_j$ for case 1. In the second scenario, $\mathcal{T}_i$ and $\mathcal{T}_j$ are distinct. In case 3, $\mathcal{T}_i$ and $\mathcal{T}_j$ cannot be compared.

Algorithm: $\mathcal{CCE}$- ELECTRE I method

1. Construct a $\mathcal{CCE}$-fuzzy decision matrix with each alternative's performance values for the form's criteria. Using entropy, normalize criterion weights. (1).
2. Calculate $\mathcal{CCE}$-fuzzy concordance and discordance using equations (2) and (3).
3. Construction of the $\mathcal{CCE}$-fuzzy matrix requires calculation of the concordance indices.
4. Construct the $\mathcal{CCE}$ -fuzzy matrix by calculating the discordance indices.
5. Calculate outranking relations using equations (4).
6. Graphical outranking of alternatives.

Numerical Example

In order to provide a step-by-step explanation of the $\mathcal{CCE}$ − ELECTRE Iapproach that was previously described, solve numerical problems in this part.

Selection of a best treatment:

Suppose the child is experiencing a typicalmonsoon illness and is advised to consult a physician for the purpose of diagnosing the condition.The kids are exposed to a variety of disorders in this application, along with the most effective treatments. The model that uses the following set of linguistic values is selected solely for illustrative purposes: Based on a thorough analysis of the child's examination, it was determined that the child may be cured by one of the following treatments: Discuss the MCDM problem with the possibilities $\mathcal{D}_1$ = bronchitis, $\mathcal{D}_2$ = Cholera, $\mathcal{D}_3$ = Typhoidand $\mathcal{T}_1$ = Naturopathy, $\mathcal{T}_2$ = Ayurvedic, $\mathcal{T}_3$= Homeopathy and $\mathcal{T}_4$ = Allopathy.

Step 1: Table 1 presents the normalizing outcomes for the $\mathcal{CCE}$- ELECTRE I for the kids to have the treatments corresponding to the disease

Step 2: Weight is calculated by using equation (1).

(0.4819064,0.227392,0.290701)

Step 3: A decision matrix is multiplied with a weight matrix,as shown in Table 2.

Step 4: The$\mathcal{CCE}$-fuzzy Concordance Matrix, use equation (2).

$$\mathcal{C}_{xy} = \begin{pmatrix} - & 0.290701 & 0 & 0 \\ 0.709299 & - & 0.709299 & 0 \\ 1 & 0.290701 & - & 0 \\ 1 & 1 & 1 & - \end{pmatrix}$$

Step 5: The$\mathcal{CCE}$-fuzzy Discordance Matrix,use equation (3).

$$\mathcal{D}_{xy} = \begin{pmatrix} - & 1 & 1 & 1 \\ 0.107408 & - & 1 & 1 \\ 0 & 0.69025 & - & 1 \\ 0 & 0 & 0 & - \end{pmatrix}$$

The $\mathcal{CCE}$ -fuzzy concordance level is $\bar{c}^* = 0.5$ and$\mathcal{CCE}$- fuzzy Discordance levelis $\bar{d}^* = 0.52$.

Step 6: The $\mathcal{CCE}$ -fuzzy concordance and discordance dominance matrices are calculated as

$$\dot{\mathcal{L}} = \begin{pmatrix} - & 0 & 0 & 0 \\ 1 & - & 1 & 0 \\ 1 & 0 & - & 0 \\ 1 & 1 & 1 & - \end{pmatrix}, \dot{\mathcal{M}} = \begin{pmatrix} - & 0 & 0 & 0 \\ 1 & - & 0 & 0 \\ 1 & 0 & - & 0 \\ 1 & 1 & 1 & - \end{pmatrix}$$

Step 7: The$\mathcal{CCE}$-fuzzy aggregated dominance matrix by using eqn. (4)

$$\dot{\mathcal{N}} = \begin{pmatrix} - & 0 & 0 & 0 \\ 1 & - & 0 & 0 \\ 1 & 0 & - & 0 \\ 1 & 1 & 1 & - \end{pmatrix}$$

Hence,$\mathcal{T}_4$is the best alternative.Table3 provides $\mathcal{CCE}$-fuzzy ELECTRE I result for treatment selection, and alternatives are ranked graphically in Fig. 1.

CONCLUSION

This study presents a novel methodology for the centroid of centroids with the fuzzy ELECTRE I method. The kids are affected by monsoon diseases like bronchitis, cholera, and typhoid, which are taken as criteria, and treatments like naturopathy, ayurvedic, homeopathy, and allopathy are taken as alternatives. This research reveals that, allopathy is identified as the most effective treatment for children suffering from monsoon illnesses. It is concluded that this method is well-suited for addressing multi-criteria decision-making problems. This methodology also yields outcomes for children impacted by various illnesses.The$\mathcal{CCE}$-ELECTRE I technique is the best option for any future attempt after thorough investigation and improvement of$\mathcal{CCE}$-ELECTRE I with AHP and ELECTRE-II.

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Table 1 $\mathcal{CCE}$-fuzzy decision matrix

$\mathcal{D}/\mathcal{T}$	$\mathcal{D}_1$	$\mathcal{D}_2$	$\mathcal{D}_3$
$\mathcal{T}_1$	0.273356	0.349372	0.417852
$\mathcal{T}_2$	0.539245	0.52537	0.370509
$\mathcal{T}_3$	0.486963	0.476773	0.496071
$\mathcal{T}_4$	0.630364	0.612057	0.664858

Table 2: weighted $\mathcal{CCE}$-fuzzy decision matrix

$\mathcal{D}/\mathcal{T}$	$\mathcal{D}_1$	$\mathcal{D}_2$	$\mathcal{D}_3$
$\mathcal{T}_1$	0.131732	0.079444	0.12147
$\mathcal{T}_2$	0.259865	0.119465	0.107707
$\mathcal{T}_3$	0.234671	0.108415	0.144208
$\mathcal{T}_4$	0.303776	0.139177	0.193275

Table 3:$\mathcal{CCE}$-fuzzy ELECTRE I result

Alternatives	$\mathcal{C}_{xy}$	$\mathcal{D}_{xy}$	$\dot{\mathcal{L}}$	$\dot{\mathcal{M}}$	$\dot{\mathcal{N}}$	Outranking Relation
$(\mathcal{T}_1, \mathcal{T}_2)$	0.290701	1	0	0	0	Incomparable
$(\mathcal{T}_1, \mathcal{T}_3)$	0	1	0	0	0	Incomparable
$(\mathcal{T}_1, \mathcal{T}_4)$	0	1	0	0	0	Incomparable
$(\mathcal{T}_2, \mathcal{T}_1)$	0.709299	0.107408	1	1	1	$\mathcal{T}_2 \rightarrow \mathcal{T}_1$
$(\mathcal{T}_2, \mathcal{T}_3)$	0.709299	1	1	0	0	Incomparable
$(\mathcal{T}_2, \mathcal{T}_4)$	0	1	0	0	0	Incomparable
$(\mathcal{T}_3, \mathcal{T}_1)$	1	0	1	1	1	$\mathcal{T}_3 \rightarrow \mathcal{T}_1$

$(\mathcal{T}_3, \mathcal{T}_2)$	0.290701	0.69025	0	0	0	Incomparable
$(\mathcal{T}_3, \mathcal{T}_4)$	0	1	0	0	0	Incomparable
$(\mathcal{T}_4, \mathcal{T}_1)$	1	0	1	1	1	$\mathcal{T}_4 \rightarrow \mathcal{T}_1$
$(\mathcal{T}_4, \mathcal{T}_2)$	1	0	1	1	1	$\mathcal{T}_4 \rightarrow \mathcal{T}_2$
$(\mathcal{T}_4, \mathcal{T}_3)$	1	0	1	1	1	$\mathcal{T}_4 \rightarrow \mathcal{T}_3$

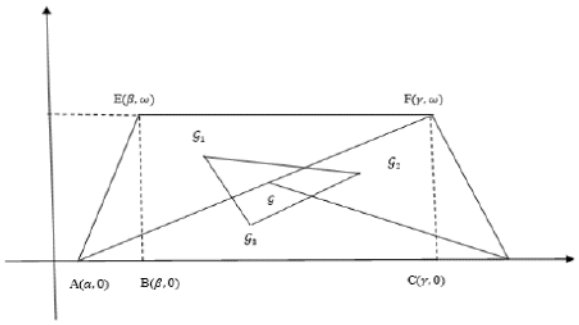


Fig1: Centroid of centroids of trapezoidal fuzzy number

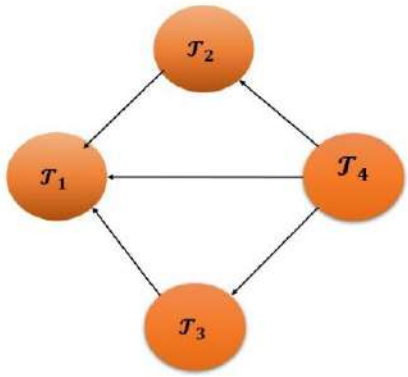


Fig 2: Graph showing alternative outranking.

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RESEARCH ARTICLE

Effectiveness of Static and Dynamic Strengthening along with Kinesio Taping in Scapular Dyskinesis among Collegiate Players

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ABSTRACT

The scapula, or shoulder blade, is integral to the shoulder complex's mobility and stability. Its proper positioning and movement are crucial for efficient shoulder function and injury prevention. Unfortunately, scapular dyskinesis, characterized by abnormal scapular kinematics, is common among overhead athletes and individuals with shoulder issues. To find the effectiveness of static and dynamic strengthening along with kinesio taping in scapular dyskinesis among collegiate players. This study involves 30 participants having scapular dyskinesis were screened based on the selection criteria. And were assigned to two groups: Static strengthening group (n=15) and dynamic strengthening group (n=15) using convenient sampling method. Both groups were received 40 minutes/day intervention for 5 days a week for 4 weeks. The intervention first started with warmup for 5 minutes, exercise protocol (static/dynamic strengthening) for 30 minutes and followed by cool down for 5 minutes. Both the groups were received common warmup and cool down. Both group participants were instructed to avoid playing during the 4 weeks of treatment. After 4 weeks, post-test values were collected, tabulated and analyzed in different statistics. The pre-test and post-test values were analyzed and results suggests that dynamic strengthening group has significant improvement with P value <0.001 The findings of this study provide compelling evidence that both static and dynamic strengthening, along with kinesio taping, effectively improve scapular dyskinesis in collegiate players. While both approaches help with pain, range of motion, and functional abilities of upper limb, dynamic strengthening stands out for delivering more significant results. This suggests that prioritizing dynamic exercises can be a more effective strategy for collegiate players dealing with scapular dyskinesis.

Keywords: Shoulder blades, Overhead athletes, Isometrics, Isotonics, Elastic tape, winging of scapula

INTRODUCTION

Scapular dyskinesis (SD) is characterized by abnormal scapular kinematics and a malpositioned scapula at rest and during motion. Repetitive abduction and external rotation in overhead sports like handball, volleyball, tennis, and swimming can lead to scapula dyskinesis [1].Different overhead sport athletehas altered scapula kinematics may also be at an increased risk of developing shoulder issues[2].Compared to nonoverhead athletes, who have a prevalence of 33%, overhead athletes have a higher reported prevalence of scapular dyskinesis (61%)[3]. The term "shoulder blade" describes the flat, triangular bone known as the scapula, located on the back of the rib cage in the upper thoracic region. The glenohumeral joint, where it joins the humerus, and the acromioclavicular joint, the clavicle, form the shoulder joint[4].The scapula is a crucial component in giving the neck and shoulder region stability and mobility because it serves as a "bridge" connecting the cervical spine and shoulder complex. Healthy overhead sportsmen may also have scapular dyskinesis as a sport-specific adaptation, with an underlying shoulder condition [5]. Four biomechanical functions of the scapula are as follows: it is the humerus's center of rotation; it anchors the humerus to the thoracic wall; it prevents impingement by preventing the acromion from impeding humerus movement in abduction and flexion; and it transfers forces from the arm to the core[6].The trapezius, serratus anterior, and posterior rhomboid muscles play a central role in stabilizing the scapula on the thorax. The primary function of the scapula stabilizers is to maintain and coordinate the shoulder complex[1,7]. The symptoms of scapular dyskinesis include an obvious medial border and inferior angle, early scapular elevation, or inadequate upward and downward rotation during arm motions.There is also alterations in the activity of the scapula stabilizing muscles as well as tightness in the soft tissues[8].Many conditions can cause SD: long thoracic or auxiliary nerve palsy, muscular problems like soft tissue inflexibility, muscle weakness, inhibition, or imbalance, and bone problems like clavicular fractures[9].The scapular assistance test (SAT) is corrective manueuverthat might affect how an injury feels. When patient elevates their arm during SAT, the examiner applies pressure to the inferior medial scapular angle to assist with scapular upward rotation and posterior tilt. With proven interrater reliability, this intervention raises scapular posterior tilt by 7° to 10°, resulting in decreased pain from impingement and increased range of motion[10, 11].

Kinesio Taping (KT) has been employed as a therapeutic intervention for both the prevention and direct treatment. It enhances circulation, reduceedema, and provide proprioception and stability during movement through sensory stimulation. Also relieves painthrough afferent feedback and reducing direct pressure on subcutaneous nociceptors by stimulating CNS sensory pathways[12]. The application of Kinesio tape on the upper and lower trapezius muscles may promote a more balanced state in the scapular muscles, leading to an augmentation in upward scapular rotation[13]. Pectoralis minor length and scapular dyskinesis have improved when rigid or Kinesio tape is applied to the shoulder and scapular region[14]. Isometric contractions maintain muscle length with minimal movement, primarily engaging muscle fibers and elastic components. Isotonic contractions, lifting fixed mass against gravity, define most weight training methods, including machine and free weight exercises[15].Isometric training offers low-impact exercise ideal for those with injuries or arthritis, promoting joint health. It enhances digestion, lowers cholesterol, and boosts bone density, muscle mass, and strength. Isotonic workouts target overall fitness, aiding weight loss, muscle building, and power enhancement[16].During continuous stimulation, Asmussen observed that muscle fibers in isometric contraction show a lower isotonic strength curve compared to isometric strength curve. However, forcefully extending the fiber results in a tension curve significantly above the isometric curve[17]. Isometric and isotonic exercises are recognized for inducing skeletal muscle hypertrophy and strength gains. Yet, uncertainty persists regarding their comparative outcomes. Despite both enhancing muscle size and strength, whether their results are identical remains unresolved[18].

METHODS

Study design and selection criteria

An experimental study was done with the subjects meeting the selection criteria and a preliminary assessment involving NPRS, Goniometer (shoulder flexion and abduction) and DASH questionnaire were recruited among

collegiate players from a university in Chennai, Tamil Nadu, India. This study was conducted following the acquisition of signed consent forms from participants and approval from the Institutional Scientific Review Board (ISRB) number: 03/025/2023/ISRB/SR/SCPT. The study included 30 participants who were divided into two groups by convenient sampling method. Inclusion criteria involves players who play overhead games, players with pain: 4-7, ROM < 150 and <130 for shoulder flexion and abduction respectively, gender- male, age: 18-25 years, positive on observational examination (includes both type I SD: prominence of inferomedial border and type II SD: the whole medial border's prominence),Scapular assistance test result is positive. Exclusion criteria involves subjects with previous shoulder surgery, presence of inflammatory diseases, recent shoulder injury, rheumatologic, neurologic or systemic disorders, allergic to tape. Participants with SD were divided into two groups: static strengthening and dynamic strengthening group, with each group receiving different treatment protocol. The NPRS values were recorded, goniometer measurements were taken for both shoulder flexion and abduction. Testing position for shoulder flexion was patient in supine with knees flexed, palm facing medially and thumb is up. Axis location was middle of humeral head laterally, stationary arms was parallel with the trunk and movement arm was in line with the mid line of humerus. Testing position for shoulder abduction was patient in supine with palm facing upwards and wrist in supination. Axis location was inferior lateral coracoid process, stationary arm was parallel with trunk, and movement arm was in line with the mid line of the humerus. And the values were recorded. DASH questionnaire was given to each participant and asked them to fill the appropriate symptom and the values were calculated and recorded. Each group underwent a 40-minute intervention daily for five days a week over a period of four weeks. The intervention comprised a 5-minute warm-up, a 30-minute exercise protocol involving either static or dynamic strengthening, and a concluding 5-minute cool-down.

Both groups followed common warm-up and cool-down procedures. Throughout the four weeks of treatment, participants were instructed to abstain from engaging in any sports activities. The warm-up exercises were brisk walking for 1 minute (1 rep), jump rope for 1 minute (1 rep), stepping for 1 minute (1 rep), arm circles for 30 seconds (2 reps), and wrist rotation for 30 seconds (2 reps). The cool-down exercises were slow walking for 2 minutes (1 rep) and corpse pose for 3 minutes (1 rep). The Static Strengthening Group received Shoulder flexion, extension, abduction, internal rotation, and external rotation against the wall were the exercises that were performed, as well as knee pushup hold, pushup hold, knee plank, plank, and side plank. Each exercise was performed for 35 seconds with a 25-second rest (1 minute) for 3 reps[19,20].The Dynamic Strengthening Group received shoulder front raise, shoulder lateral raise, shoulder press, Arnold press, shoulder kickbacks, shoulder shrugs, reverse dumbbell flys, upright rows, bent-over rows, and monkey rows. Each exercise was performed for 10 reps/set (35 seconds) with a 25-second rest for 3 sets[21,22,23].Kinesio taping was administered to both groups, involving the cleaning and preparation of the skin to be taped. The subjects were positioned comfortably in a sitting position. Standardized Kinesio taping for therapeutic purposes was utilized, utilizing ordinary 5-cm Kinesio tape. Using paper-off tension, a Y-strip was applied and stretched from the origin to the supraspinatus' insertion. Furthermore, employing downward pressure and a 50–75% stretch, an I-strip was wrapped around the posterior deltoid from the coracoid process. The tape on this I-strip terminated in a Y form. Lastly, a Y-strip was employed from the lower trapezius muscle in the T10–12 region. These taping applications were part of the therapeutic interventions provided during the study[14].

RESULT

When compared the pre-test, the post-test values show that there is a significant improvement on pain, ROM and functional abilities of upper limb in dynamic strengthening group. A statistically analysed quantitative data indicated a statistically significant difference in both the groups.

Table 1: Pre-test and Post-test values of pain using NPRS in Static strengthening Group by Wilcoxon signed rank test. The values for pain: median pre-test (6) and post-test (4), Z value (-3.477) and T value (-120). As a result, the findings are considered statistically significant that the p value is <0.001.Pre-test and Post-test values of pain using NPRS in

Dynamic strengthening Group by Wilcoxon signed rank test. The values for pain: median pre-test (6) and post-test (3), Z value (-3.508) and T value (-120). As a result, the findings are considered statistically significant that the p value is <0.001.Post-test values of pain using NPRS in Static strengthening Group and Dynamic strengthening Group by Mann-Whitney rank sum test. The values for pain: median post-test of Static strengthening group (4) and post-test of dynamic strengthening Group (3), U value (28.000) and T value (317). As a result, the findings are considered statistically significant that the p value is <0.001. **Table 2:** Pre-test and Post-test values of shoulder flexion ROM using goniometer in Static strengthening group by paired t-test. The values for ROM: mean pre-test (139.267) and post-test (142.467), SD pre-test (6.273) and post-test (4.824), T value (-5.967). As a result, the findings are considered statistically significant that the p value is <0.001.Pre-test and Post-test values of shoulder flexion ROM using goniometer in Dynamic strengthening group using by paired t-test. The values for ROM: mean pre-test (139.4) and post-test (150.667), SD pre-test (6.501) and post-test (5.314), T value (-20.581).

As a result, the findings are considered statistically significant that the p value is <0.001.Post-test values of shoulder flexion ROM using goniometer in Static and Dynamic strengthening group by t-test. The values of ROM: mean post-test of static strengthening group (142.467) and post-test of dynamic strengthening group (150.667), SD post-test of static strengthening group (4.824) and dynamic strengthening group (5.314), T value (-4.425). As a result, the findings are considered statistically significant that the p value is <0.001.Pre-test and Post-test values of shoulder abduction ROM using goniometer in Static strengthening group by paired t-test. The values for ROM: mean pre-test (115.733) and post-test (120.4), SD pre-test (4.992) and post-test (7.018), T value (-6.243). As a result, the findings are considered statistically significant that the p value is <0.001.Pre-test and Post-test values of shoulder abduction ROM using goniometer in Dynamic strengthening group by paired t-test. The values for ROM: mean pre-test (120.2) and post-test (131.2), SD pre-test (6.657) and post-test (6.394), T value (-19.621). As a result, the findings are considered statistically significant that the p value is <0.001.Post-test values of shoulder abduction ROM using goniometer in Static and Dynamic strengthening group by t-test. The values of ROM: mean post-test of static strengthening group (120.4) and post-test of dynamic strengthening group (131.200), SD post-test of static strengthening group (7.018) and dynamic strengthening group (6.394), T value (-4.406). As a result, the findings are considered statistically significant that the p value is <0.001. **Table 3:**Pre-test and Post-test values of functional abilities of upper limb using DASH questionnaire in Static strengthening Group by Wilcoxon signed rank test. The values for functional abilities of upper limb: median pre-test (55) and post-test (51.9), Z value (-3.408) and T value (-120).

As a result, the findings are considered statistically significant that the p value is <0.001.Pre-test and Post-test values of functional abilities of upper limb using DASH questionnaire in Dynamic strengthening Group by Wilcoxon signed rank test. The values for functional abilities of upper limb: median pre-test (50) and post-test (41.1), Z value (-3.409) and T value (-120). As a result, the findings are considered statistically significant that the p value is <0.001.Post-test values of functional abilities of upper limb using DASH questionnaire in Static strengthening Group and Dynamic strengthening Group by Mann-Whitney rank sum test. The values for functional abilities of upper limb: median post-test of Static strengthening group (51.9) and post-test of dynamic strengthening Group (41.1), U value (30.000) and T value (315). As a result, the findings are considered statistically significant that the p value is <0.001.

DISCUSSION

This study addressing scapular dyskinesis among collegiate players through static and dynamic strengthening, alongside Kinesio Taping, provides crucial insights for targeted rehabilitation. The study advocates for a comprehensive, biomechanically principled approach, tailoring dynamic strengthening exercises for collegiate athletes to reduce shoulder injury risk. The result of the supporting articles has similar results and supports the result of this study. Sana Tauqeer et al., 2024 conducted a randomized trial found that adding manual therapy to stretching and strengthening exercises significantly improved functional capacity, pain reduction, and scapular range of motion for shoulder impingement syndrome compared to exercises alone. This approach addresses mobility restrictions, muscle imbalances, and altered scapular kinematics. While strengths include scapular range of motion

measurements, limitations such as a small sample size and lack of long-term follow-up affect generalizability. Nonetheless, the trial supports integrating manual therapy and exercise for chronic shoulder impingement. [24]. Lan Tang et al., 2021 conducted a randomized controlled trial is assessing tailored scapular stabilization exercises for different types of scapular dyskinesis in treating shoulder periarthritis. This novel approach targets specific dyskinesis types rather than a generic regimen. The Constant-Murley Score measures primary outcomes, evaluating shoulder function, while secondary outcomes include pain, range of motion, scapular positioning, and patient satisfaction. The study aims to provide insights into the effectiveness of targeted exercises for improving shoulder function and correcting scapular dyskinesis in periarthritis patients. [25]. Paula R. Camargo et al., 2015 stated the exercise-only group even trended toward greater improvement in most outcomes. Wide confidence intervals for certain variables suggested variability in manual therapy benefits. Changes in scapular kinematics were inconclusive, lacking clinical significance. Both groups reported reduced pain and improved function, with the exercise-plus-manual therapy group showing slightly better pain reduction. The study concluded that adding manual therapy didn't offer additional benefits in the short term for SIS individuals[26].

Kumaresan A et al., 2024 investigated the comparative effectiveness of two treatment strategies: strengthening the trapezius muscle versus stretching the pectoralis minor muscle combined with interferential therapy, targeting patients with rounded shoulder posture. The results demonstrated that the combined approach was more successful in reducing pain levels. Specifically, the group receiving the combination therapy exhibited notably lower NPRS scores indicating a significant improvement in pain reduction. This suggests that integrating pectoralis minor stretching, lower trapezius strengthening, and interferential therapy is more effective in addressing the muscle imbalances associated with rounded shoulders. Consequently, this comprehensive intervention aids in maintaining the extended length of the pectoralis minor muscle and enhancing scapular positioning, resulting in superior outcomes compared to solely focusing on trapezius strengthening exercises. These findings emphasize the critical role of addressing muscle imbalances to effectively manage rounded shoulder pain[28]. Kumaresan A et al., 2024 compared the efficacy of isometric training and aerobic exercise programs combined with ultrasound therapy for individuals with knee osteoarthritis. The findings revealed that participants in the isometric training group experienced notably superior outcomes, including reduced pain levels and enhanced functionality, in comparison to those in the aerobic exercise group. The authors attribute this success to the targeted strengthening of specific muscle groups such as the quadriceps, hamstrings, and calf muscles through isometric exercises, which contribute to better knee joint support and pain relief. This study strongly advocates for integrating isometric exercises with conventional therapy as an effective approach to managing knee osteoarthritis. By addressing muscle strength, joint alignment, and postural stability, this holistic method tackles the diverse aspects of knee osteoarthritis management, thereby promoting overall well-being among affected individuals[29]. Sibel Tekeli Ozer et al., 2018 statedscapular dyskinesis and pectoralis minor length were rapidly improved by both taping techniques, and these improvements persisted for 60 to 72 hours after the tape was removed.

However, neither method affected scapular upward rotation, and there were no significant differences between the two techniques. The study suggests that for short term, treating pectoralis minor length and scapular dyskinesis can benefit from both rigid and Kinesio taping among asymptomatic overhead athletes, possibly through mechanical correction or neuromuscular activation facilitation. Further research is needed to evaluate taping's efficacy in preventing shoulder injuries among overhead athletes[14].C. Tooth et al., 2020 stated substantial effects on the serratus anterior but not the upper or lower trapezius muscles. Both techniques influenced scapular kinematics, with KT2 showing a more pronounced impact, especially on upward rotation during flexion and abduction. The authors recommend a tailored approach for strip placement and advise against using KT2 in cases of reduced upper trapezius/lower trapezius ratio. They suggest KT1 may benefit specific positions and strength transfer but emphasize kinesiotaping as a supplementary, not replacement, technique in rehabilitation[27].ValériaMayaly Alves de Oliveira et al., 2013 stated that attribute the pain relief provided by KT to its ability to realign joints, modulate muscle activity, and enhance proprioception. They also observed a significant improvement in scapular dyskinesis following KT application, indicating its role in restoring stability to the scapula.The study's sample size was small, and there was no control group, but despite these drawbacks, the authors recommend KT as an additional therapy strategy for SIS

rehabilitation. They recommend larger studies, more precise scapular assessment methods, inclusion of control groups, and longitudinal investigations to evaluate the lasting effects of KT[12]. The findings of this study provide compelling evidence that both static and dynamic strengthening, along with kinesio taping, effectively improve scapular dyskinesis in collegiate players. Whiledynamic strengthening stands out for delivering more significant results. This suggests that dynamic exercises can be a more effective strategy for collegiate players dealing with scapular dyskinesis.

ABBREVIATIONS

Scapular dyskinesis (SD), Glenohumeral (GH), Scapulothoracic (ST), Scapular Assistance Test (SAT), Scapular retraction test (SRT), Kinesio Taping (KT),Institutional Scientific Review Board (ISRB), Numerical Pain Rating Scale (NPRS), Disabilities of Arm, Shoulder and Hand (DASH). Range Of Motion (ROM).

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Table 1: Pre-Test and Post-Test Values of Both Static and Dynamic Strenghtening Group for NPRS.

Outcome	Group	Values	Median	T-Value	P-Value
NPRS	Static Strengthening Group	PRE-TEST	6	-120	<0.001
		POST-TEST	4		
	Dynamic Strengthening Group	PRE-TEST	6	-120	<0.001
		POST-TEST	3		
	Static Strenthening Group	POST-TEST	4	317	<0.001
	Dynamic Strengthening Group	POST-TEST	3		

Table 2: Pre-Test and Post-Test Values of Both Static and Dynamic Strenghtening Group for Goniometer (Shoulder Flexion & Abduction)

Outcome	Group	Values	Mean	Sd	T-Value	P-Value
Goniometer (Shoulder Flexion)	Static Strengthening Group	PRE-TEST	139.267	6.273	-5.967	<0.001
		POST-TEST	142.467	4.824		
	Dynamic Strengthening Group	PRE-TEST	139.4	6.501	-20.581	<0.001
		POST-TEST	150.667	5.314		
	Static Strengthening Group	POST-TEST	142.467	4.824	-4.425	<0.001
	Dynamic Strengthening Group	POST-TEST	150.667	6.501		
Goniometer (Shoulder Abduction)	Static Strengthening Group	PRE-TEST	115.733	4.992	-6.243	<0.001
		POST-TEST	120.4	7.018		
	Dynamic Strengthening Group	PRE-TEST	120.2	6.657	-19.621	<0.001
		POST-TEST	131.2	6.394		
	Static Strengthening Group	POST-TEST	120.4	7.018	-4.406	<0.001
	Dynamic Strengthening Group	POST-TEST	131.2	6.394		

Table 3: Pre-Test and Post-Test Values of both Static and Dynamic Strengthening Group for Dash Questionnaire

Outcome	Group	Values	Median	T-Value	P-Value
DASH	Static Strengthening Group	PRE-TEST	55	-120	<0.001
		POST-TEST	51.9		
	Dynamic Strengthening Group	PRE-TEST	50	-120	<0.001
		POST-TEST	41.1		
	Static Strenthening Group	POST-TEST	51.9	315	<0.001
	Dynamic Strengthening Group	POST-TEST	41.1		

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RESEARCH ARTICLE

Ayurveda Management of Pama Kustha - A Case Study

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ABSTRACT

In the Classical texts, *Kustharogas*are divided in to two type *Maha kustha* and *Kshudrakustha*. where as the *pamakustha* is considered as the *kshudrakustha*, However, in the *kusthaChikitsa Adhyaya, Acharya Kashyapa* identified *Pama* as one of nine *sadhyaKusthaRoga*. *Pama Kushtalakshanas* can be correlated with Scabies symptoms. *Pama Kushta* is a *Kapha pitta* predominant disease and it is treated with the *sodhana, Shaman* and *bahirparimarjanachikitsa.*

Keywords: *Pama kustha, kustharogas, Chikitsa*, Scabies

INTRODUCTION

In the Ayurvedic texts, *Kustharogas* are divided in to two type *Maha kustha* and *Kshudrakustha*.*Pama* is the eighteen types of *kustharogas*. where the *Acharya Charaka, sushruta* and *vagbhata*consider *pamakustha* under the *Kshudrakustha*. However, in the *kusthaChikitsa Adhyaya*, *Acharya Kashyapa* identified *Pama* as one of nine *sadhyaKusthaRoga*. Which has symptoms like *Paka* (suppuration), *Srava* (discharges), *Aru* (tawny colour), *Usna*(colour), *Toda* (prickling pain), and *Kandu* (itching).(1)Ayurvedic treatment regimens play a major part in the management of skin conditions. *Pama Kushtalakshanas* can be correlated with Scabies symptoms. Scabies is a parasitic skin infestation triggered by the mite Sarcoptes scabiei var. homnis having symptoms like intense itching with s-shaped thread like greyish to the dark line, Erythematous Papules, Papulo-vesicles, Nodules. In terms of scabies, *pamakustha* is known as the "disease of poverty" since it typically affects youngsters from poorer socioeconomic backgrounds and without a gender predominance.It is transmitted through close contact, clothing, and bed linen. requiring a month for the initial infection to develop. Scabies affects people of all ethnicities and hundreds of millions of people globally. For the treatment of *pamakusthasodhana, Shamana* and *BahirparimarjanaChikitsa* are explained.(2)

MATERIALS AND METHODS

PRADHANA VEDANA

- Circular blackish coloured skin lesions all over the body since 2 years.
- Severe itching over the skin lesions since 2 years.

ANUBANDHI VEDANA

- Burning sensation after scratching

AGGRAVATING FACTOR

- On exposure to sun
- Itching increased
- Burning sensation.

VEDANA VRUTTANTA

Patient was apparently normal before 2 years, then gradually developed reddish colored skin lesions all over the body. The patient experience severe itching, she used to scratch these lesions leading them to burst and watery discharge were observed, and after that it started to spread other parts of the body, then they turned into blackish colored lesions. Patient took allopathic treatment 1 year back and got temporary relief but after stopping those medication the symptoms got aggravated. So, patient approached for Ayurvedic line of management.

POORVA VYADHI VRUTTANTA

- No H/O DM.
- No H/O microbial infections, allergic diseases.

POORVA CHIKITSA VRUTTANTA

- She had consulted allopathic hospitals, details of medicaments are not available.

KOUTUMBIKA VRUTTANTA

- No family members are having similar complaints.

VAIYAKTIKA VRUTTANTA

Aaturavruttanta:

Aahara: vegetarian (egg)

- Morning (9:00 am) : Upma, avalikki, idli vada, dosa
- Lunch (1:30-2:00pm) : 2 rotti/2 chappati, curry, rice, samber.
- Dinne (9:00 pm) : 2 rotti/ 2 chappati, rice, sambar.
- Vihara :Alpasramajeevi
- Nidra : Normal (10pm- 6:30am)
- KshudhaPravrutti : Madhyama
- Mutra pravrutti : Prakruta (5 to 6 times /day & once at night)
- Mala Pravrutti : Prakruta (once in a day)

GYNECOLOGY HISTORY

- Menarche - 13 years of age
- Interval - 28 days
- Duration - 5 days
- LMP - 20/01/24

ATURA PARIKSHA

ASHTAVIDHA PARIKSHA

1. Nadi - Pitta vata
2. Mala - Prakruta
3. Mutra - Prakruta
4. Jihwa - Liptata
5. Shabda - Prakruta
6. Sparsha -Anushna sheeta
7. Dhruk - Prakruta
8. Akruti - Madhyama

DASHAVIDHA PARIKSHA

- *Prakruti : Kapha Vata*
- *Vikruti : Tridosha*
- *Sara : Madhyama*
- *Satva : Madhyama*
- *Samhanana : Madhyama*
- *Satmya : Madhyama (Katu,Amla,Lavana)*
- *Pramana : Madhyama*
- *Ahara Shakti*
  - *Abhyavarana Shakti : Madhyama*
  - *Jarana Shakti : Madhyama*
- *Vyayama Shakti : Madhyama*
- *Vaya : Madhyama*

GENERAL EXAMINATION

- Appearance - Well
- Built - Moderately Built
- Speech & Interaction - Good
- Nourishment - Moderately Nourished
- Consciousness - Conscious and well oriented
- Decubitus - Normal Supine position
- Temperature - Normal
- Cyanosis - Absent
- Pallor - Absent
- Oedema -Absent
- Lymphadenopathy - Absent
- Tongue - Coated
- Skin - Blackish colored lesions
- Nails - Normal

PHYSICAL EXAMINATION

- BP - 110/70mm of Hg
- Pulse Rate - 80/min
- *Dehoshmata* - 98.6^{o}F
- *Dehabhara* - 45kg
- Dehadheerghata - 145cm
- B.M.I - 21.4kg/m^{2}

SYSTEMIC EXAMINATIONS

- CNS - Conscious and well oriented
- CVS- S1 S2 heard, No any added Sound
- RS - Air Entry Bilaterally Equal.
- P/A – Soft, Non-tender, No Organomegaly

LOCAL EXAMINATION

Morphology of the skin lesion

Inspection and palpation:

- Primary Morphology - Vesicles
- Site - All over the body (except head and neck)
- Shape - Circular
- Color - Blackish lesion
- Demarcation - Well demarcated
- Visible Sweating - Absent
- Discharge - Absent
- Smooth/ Rough - Smooth
- Thin/ Thick - Thin
- Dry / Moist - Dry
- Sensation - Present
- Tenderness - Absent
- **Distribution**
  - Symmetrical/ Asymmetrical - symmetrical
  - Centrifugal / Centripetal - Centripetal
  - Flexor / Extensor - Extensor
  - Pain - Absent
  - Itching - Present
  - Burning Sensation - Present
  - Candle Grease Test - Absent
  - Auspitz sign - Absent
  - Koebner Phenomenon - Absent

SAMPRAPTI GHATAKA

- *Dosha - Kapha- pitta doshaja*
- *Dusya - Twak,Rakta, Mamsa,Lasika*
- *Agni - Jatharagni,Dhatvagni*
- *Aama -Jatharagni&Dhatvagni mandya janya Aama.*
- *Srotas - Rasavaha, Raktavaha, Mamsavaha*
- *Srotodusti - Sanga, Vimargamana*
- *Udbhavastana - Amashaya*
- *Sancharastana - Sarvarasayani*
- *Adhistana - Twak,lasika, Asrik*
- *Vyaktastana -Twak*
- *Rogamarga -Bahya*
- *Sadhyasadhyat -Kruchra Sadhya*
- *Swabhava - Chirakari*

SAMBHAVYA ROGA

- *Pamakustha*
- *Dadrukustha*

- *Mandala kustha*
- *Vicharchik*

VYADHI VYAVACCHEDAKA NIDANA

Acharya differentiates similar symptoms amnong different types of *kutharogas*, they are *Dadrukustha*, *Pama kustha*, *Vicharchika*, *Mandala Kustha*.

VYADHI VINISCHAYA

According to the different acharyas and as per the Observed symptoms the patient was suffering with the *"PAMA KUSTHA".*

Pathya- Apathya:

Pathya

Ahara : Purana shali, Karavellaka, Mudga, Yava, Godhuma, Plenty water intake.

Vihara: Abhyanga, Snana, Rutu Shodhana, Avoid dust.

Apathya

Ahara: Atilavana, Amla, Ushna, Dadhi, Guda, Tila, Fermented food.

Vihara: Diwaswapna, Aatapa Sevana, Vegadharana, AtiVyayama.

TREATMENT

Patient was treated with the following procedure, First day done the *Deepana pachana* with the *Chitrakadivati*- 1TID then from the next day started with the *Snehapana* for 3days with the *Murchitaghrita*, first day 30ml was given, second day 60ml and Third day 90ml, after the *Snehapana* patient was adviced to *SnehaAbhyanga* with *Nimba Taila* and *Baspa Sweda*. Then last day Virechana was done with the *Trivrutleha*(50gm) given with the *triphala Kashaya*(50ml) as *anupana.*

Number of veg as to patient: 16vegas

Medications Advice on Discharge are: Siddhartaka soap, *Siddhartaka Snana Churna*, *Nalpamruta Taila* for Local application, Tab. *Sarivadivati* 1-1-1 after food, Tab. *Panchtiktaguggulughrita*2-0-0 before food, *Khadirarishta* 2tsp-2tsp-2tsp after food.Bilwadigutika 1-1-1 after food.

DISCUSSION

Pama Kushta is a *Kapha pitta* predominant diseasehave symptoms like *Paka* (suppuration), *Srava*(discharges), *Aru* (tawny colour), *Usna* (colour), *Toda* (prickling pain), and *Kandu* (itching). Ayurveda explain the treatment like *Sodhana, Shamana* and *BahirparimarjanaChikitsa.* Hence *Ayurveda* provides appropriate suggestions to eliminate the illness from the body.

Mode of action of *Deepana* and *pachana*

In the *poorva karmaDeepana* and*pachana*was given with the *Chitrakadivati* which acts as the *agnivardhaka*, At the level of *Dhatvagni* and *AamaPaachana*, in addition to *Jataragni,Chitrakadi Vati* functions as *Agni Vardhaka.Chitrakadivati* includes the ingredients like *Chitraka, Marich, Pippali, Pippali moola, Chavya, Adraka, Hingu, Ajmoda, Yava ksara, Panchlavana.*

Mode of Action of *Snehapana*

*AbhyantaraSnehapana*for *Virechana*was done with the *murchitaghirta* which pacify the *pitta dosha*and for *BahyasnehapanaNimbataila*was used to reduced the symptoms like *kandu, srava.* [3]

Mode of Action of *Sodhana*

Vitiation of the *Pitta* and *Rakta* in this disease *virechana* was planned for the patient. In *charaka Samhita kusthachikitsaadhyayacharya* mentioned as '*Virechanam cha agrey' Trivrutleha* was given for the *virechana* since it is

mrudu in *virechana* and acts as *pitta shamak.* As *AnupanaTriphala Kashaya* was given to facilitate the proper action of drug as *virechanopaga*.

Mode of action of *Saman Aushadhi*

*Nalpamruta Taila*contain the *ksheerivriksha Dravya* which are *Kashaya rasa pradhana*acts as *pittahara* and *kapha hara*. The Nalpamaraditaila for local application acts as physical barrier also. Tab.*Sarivadivadi,* it removes the *kled* from *Rakta* and purify so it acts as *Raktasodhak* and *Raktaprasadak.*(3) Tab,*Panchtiktaguggulughrita* acts as *Deepana, pachana, Srotoshodhaka, Kandughna*, *Kushtaghna*, and *Varnya*. Itpurifies the blood from toxins and also work on the aggrevated *pitta dosha.* Khadirarishta useful in Sarvakustha including pamakustha, it is Tikta, KatuRasatmaka it pacifies the Pitta along with the Kapha and also have antifungal and antioxidant activity.(4) *Siddhartaka Snana Churna* is the combination of the *Ayurvedic* ingredients used for *lepana* which acts as *Tridosha hara, Twachya* and *Varnaprashadana*.(6) Bilwadigutika contains Bilwa, Surasa, Karanja, Natam, Surahwam, Harithaki, Vibeethaki, Amalaki, Shunti, Maricha, Pippali, Haridra, Daruharidra which are processed in goat's urine.It is having antimicrobial immunomodulatory and ant inflammatory activity.(7)

CONCLUSION

A female patient aged 18 years diagnosed with the *pamakustha* as per *Ayurveda* classics was treated with *Virechana* and *Shamanaushadis* effectively. After *Virechana* improvement was observed and after *Virechana, Shamanaushadis* is found to be clinically effective in the management of signs and symptoms of *pamakustha.*

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Table:1

	DadruKustha	***Pama Kustha***	***Vicharchika***	***Mandala kustha***
Acc to *Charak Samhita*	*Kandu,RagaPidaka, Mandalakar*	*Shweta, Aruna, Shyava varna, pidaka, kandu*	*Shyava Pidaka, Kandu, Bahu Srava.*	*Shweta or rakta varna, Sthira, styana, Snigdha,utsanna, Anyona samsaktam*
Acc to *Shushrutasamhita*	*Atasi pushpa varna, Visarpapidakayukta*	*Kandu, Daha, Shyava, Aruna pidakas*	*Kandu Ruja*	----
Acc to *Asthanga Hrudaya*	*Atasi pushpa varna, Ati Kandu, Dheergapayatana*	*Sweta, Aruna Varna Pidakas, kandu*	*Sakandu, Shyava Pidaka*	*Sthira, Styana, Guru, Snigdha, Sweta-rakta, Kandu, Anashugam, Anyonvasaktam, Utsanna, Srava, Krimi, Mandala, Slakshna, peeta.*





Clinical images: Fig:1:Before Treatment:





Fig:2:After treatment

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REVIEW ARTICLE

A Review of Anti-Hypertensive Drugs that are used While Pregnant

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ABSTRACT

Hypertension during pregnancy is a complex and multifaceted medical condition that poses significant risks to both maternal and foetal health. Examining the challenges and issues related to antihypertensive medication use during pregnancy is the goal of this study. Though ensuring the health of the mother is the major focus of therapy, the effects of these drugs on the growth of the baby remain a serious concern. This review article provides an in-depth analysis of severe hypertension, moderate hypertension, and insulin-dependent diabetic pregnancy. We explore the different types of hypertensive disorders, including gestational hypertension, preeclampsia, chronic hypertension, and proteinuria. Various approaches to managing diabetic pregnancy, including lifestyle modifications, and close monitoring, are examined. Overall, this review aims to provide a comprehensive understanding of hypertension during pregnancy, enabling healthcare professionals to make informed decisions for optimal maternal and foetal outcomes.

Keywords: Gestational diabetics, Lactation, Sugar level, Insulin-dependent diabetic pregnancy, Persistent hypertension**.**

INTRODUCTION

Nearly 40% of all maternal fatalities in India are caused by hypertensive illnesses during pregnancy and postpartum haemorrhage. Systolic blood pressure of at least 160 mmHg and diastolic blood pressure of at least 110 mmHg are considered severe hypertension in pregnancy. Moderate and mild hypertension issues can also occur during pregnancy [1]. A BP of 140-159/90-109 mmHg is considered mild hypertension, while a reading of 160-170/110 mmHg is considered moderate hypertension. The nine months of pregnancy are the main focus of therapy due to during this time mild-to-moderate hypertension is unlikely to harm the mother's long-term health. Antihypertensive medicines are primarily used in this situation to prevent and treat severe hypertension, to safely extend pregnancy for as long as possible to increase the infant's gestational age, and to reduce the exposure of the foetus to drugs that might have negative consequences [2]. Antihypertensive medications should be used right away in cases of severe hypertension in pregnancy, according to an agreement. When type 1 diabetes develops during pregnancy, it presents specific difficulties since it is also known as insulin-dependent diabetic mellitus (IDDM). Currently, the first-line anti-hypertensive therapies include intravenous (IV) hydralazine, intravenous labetalol, and oral nifedipine. Several Hypertensionoccurs during pregnancy: Gestational hypertension, chronic hypertension, pre-eclampsia, and proteinuria [3]. (Flowchart 1)

Treatment of specific hypertensive disorders

Chronic hypertension

Chronic hypertension during pregnancy refers to high blood pressure that exists or develops before the 20th week of pregnancy.Problems may arise for the mother and the unborn child, making it a crucial medical condition during pregnancy. To promote a healthy pregnancy, persistent hypertension in pregnant women is frequently treated with a mix of medication and lifestyle changes[4]. During pregnancy, medications that are frequently used to treat persistent hypertension include:

Gestational Hypertension

Pregnancy-induced hypertension (PIH), commonly referred to as gestational hypertension, is a condition marked by high blood pressure that appears in women who had previously had normal blood pressure after the 20th week of pregnancy [5].

Preeclampsia

During pregnancy, preeclampsia, a dangerous medical condition, can develop. The liver and kidneys are often the organs that show indications of damage, as well as elevated blood pressure (hypertension). If preeclampsia is not addressed, it can cause issues for both the mother and the unborn child [6].

Proteinuria

Proteinuria during pregnancy is the term used to describe the presence of unusually high levels of protein in a pregnant woman's urine. It could indicate many underlying diseases, such as preeclampsia, gestational hypertension, or renal issues. To preserve the health of both the mother and the unborn child, proteinuria during pregnancy must be properly assessed and controlled by medical specialists [7].(Table 1)

A general principle of anti-hypertensive during pregnancy

Antihypertensive medication should be customised for each pregnant woman's situation, taking into account things like the degree of hypertension, gestational age, the existence of other medical disorders, and possible dangers to both the mother and the unborn child. Methyldopa and labetalol are regarded as first-line medicines for treating hypertension during pregnancy due to their established safety profiles and shown efficacy in regulating blood pressure [9]. Early Identification and Regular Monitoring: It is critical to identify hypertension early on during prenatal care to start therapy as soon as possible. Throughout pregnancy, it is critical to regularly check the blood pressure and urine protein levels. Antihypertensive treatment may be used to manage blood pressure and avoid

problems in preeclampsia, but careful observation of the health of the mother and foetus is essential. The ideal blood pressure for pregnant women varies depending on the severity of their condition with hypertension, but in general, it should be regulated to avoid problems without endangering the unborn child. Antihypertensive medication usage during pregnancy seeks to ensure optimal blood pressure management with less exposure of the foetus to these medicines [10]. Early birth may be required to safeguard both the mother's and the unborn child's health in situations of severe preeclampsia or when blood pressure cannot be appropriately managed. The use of non-pharmacological therapies as supplements to antihypertensive therapy should also be taken into consideration. To achieve complete treatment, obstetricians, maternal-foetal medicine experts, and other healthcare professionals must work closely together to control hypertension throughout pregnancy [11].

There are several strategies to manage pregnancy-related hypertension, including

Regular prenatal care includes careful monitoring of the mother's blood pressure and other vital indicators throughout the pregnancy. Depending on the kind and severity of your hypertension, your doctor may recommend antihypertensive drugs that are safe to use while pregnant. Methyldopa, labetalol, and nifedipine are some of the drugs that are often utilized Your doctor may advise limited physical activity or bed rest to assist control of blood pressure in some cases of moderate pregnant hypertension or preeclampsia. For intensive monitoring and management of severe preeclampsia or eclampsia, hospitalization may be required. Delivery may be the only viable treatment option in situations of severe hypertension or preeclampsia. If the pregnancy is advanced enough, performing an abortion or inducing labour may be required [12].(Table 2)

Identification of blood pressure levels during pregnancy

Severe hypertension during pregnancy

There is general agreement that severe hypertension should be treated if it lasts the entire pregnancy since it is believed to increase the risk of stroke and other end-organ problems in women, even with pre-eclampsia. Women with non-severe gestational hypertension with proteinuria are more likely than those with severe gestational hypertension to develop major maternal (such as pulmonary oedema, and abruption) and perinatal problems.

It has been suggested that a sBP threshold of 160 mmHg is a better appropriate threshold for detecting severe maternal hypertension based on a case series of 28 women with pre-eclampsia and stroke. 96% of the female patients in this group had a sBP of 160 mmHg shortly before suffering a stroke, whereas only 13% had a dBP [13]

Moderate hypertension during pregnancy

Pregnancy-related moderate hypertension is characterized by blood pressure values that are higher than normal, but not as high as those associated with severe hypertension (Stage 1). It's crucial to remember that hypertension during pregnancy has to be carefully monitored and managed by a healthcare professional since it might endanger both the mother and the growing [4]. For both the mother and the unborn child to experience a safe and healthy pregnancy, regular prenatal care and the right medical procedures are important [14,15].

Insulin Dependent Diabetic Pregnancy (IDDP)

A type 1 diabetic woman who needs insulin to manage her blood sugar levels while pregnant, the condition is referred to as an insulin-dependent diabetic pregnancy, also known as type 1 diabetes mellitus during pregnancy. A shortage of insulin results from type 1 diabetes, an autoimmune illness in which the body's immune system assaults and kills the pancreatic cells that produce insulin. Blood sugar levels might alter due to hormonal changes during pregnancy, making diabetes management even more important for the mothers and growing foetus health. Sugar level monitoring, insulin medication, and changes in diet are the main ways to control an insulin-dependent diabetic pregnancy (type 1 diabetes). There are no specific drugs that can replace insulin in the treatment of type 1 diabetes during pregnancy. In addition to promoting the health of the mother and developing foetus, insulin is critical for blood sugar regulation A kind of diabetes called gestational diabetes develops during pregnancy and frequently disappears after giving birth. High blood sugar levels occur when the body is unable to produce enough insulin to keep up with the expanding demands of pregnancy. While the specific origin of gestational diabetes is not entirely

known, it is believed to be a result of both hormonal alterations and insulin resistance. Pregnant women are at a greater risk of developing type 2 diabetes later in life [16].

Antihypertension during lactation

It's necessary to think about the potential effects of the medicine on both the nursing infant and the lactating mother while using antihypertensive medications during lactation (breastfeeding). A healthcare professional should be consulted before deciding whether to use antihypertensive medication while nursing to assess the risks and benefits depending on the mother's unique situation [17].

Antihypertensive during breastfeeding

The effects of maternally given antihypertensive medications supplied through breast milk on infants have not been well studied. The pharmacokinetic factors that control medication absorption into breast milk and subsequent exposure to the foetus are well known. Milk is a fluid that alveolar cells secrete and has fat globules floating in it. It has a pH lower than maternal plasma. Medication transit into milk is favoured by low plasma protein binding, high lipid solubility, and absence of charge at normal pH. Other favourable factors include a narrow maternal volume. Even when nursing infants take medications, the quantity taken, the interval between taking the medication and nursing, the oral bioavailability, and the baby's ability to excrete the medication all have an impact on how much of the medication is exposed to the body [18].

Epoprostenol during pregnancy

Epoprostenol, often referred to as prostacyclin, is a drug used largely to treat pulmonary arterial hypertension (PAH), a disease characterized by elevated blood pressure in the arteries that feed blood to the lungs. Vascular dilation and an increase in blood flow are how it works. Because there might be hazards to the mother as well as the growing foetus, using drugs during pregnancy needs to be carefully evaluated. The care of PAH during pregnancy necessitates a delicate balancing act between protecting the mother's health and minimizing any dangers to the foetus. PAH can represent considerable concerns to both maternal and foetal health. Unless the possible advantages to the mother outweigh the potential hazards to the foetus, epoprostenol is typically not advised for usage during pregnancy. An expert in PAH treatment and high-risk pregnancies should be consulted before deciding whether to take epoprostenol or any other medication during pregnancy [19].

Recent clinical advances in hypertension during pregnancy

To protect the health of the mother and the unborn child, researchers and doctors have been focusing on developing better diagnostic techniques, treatment plans, and general management of hypertension during pregnancy. Numerous confounders were taken into account, but the relationship between pregnancy-related risk factors and the likelihood of developing hypertension later on remained mostly unchanged. Pregnancy-related risk factors, such as preeclampsia/eclampsia, gestational hypertension, preterm delivery, and pregestational or gestational diabetes mellitus, were linked to a high prevalence of hypertension (28.6%) in the population. The results were more robust when restricted to nulliparous women at baseline with a follow-up period of only the first five years, and similar when restricted to women with a normal prepregnancy body mass index [20].

Customised Treatment Approaches

A move has been made towards customised treatment regimens that are built on the unique qualities of every patient. Factors such the gestational age, the intensity of hypertension, and the existence of additional problems are taken into account in personalised medicine.

Home Blood Pressure Monitoring

It is becoming more common to remotely check your blood pressure at home. This makes it easier for medical professionals to see a patient's blood pressure trends more thoroughly and to act quickly when needed.

Usage of Antihypertensive Medications
Research on the effectiveness and safety of several antihypertensive drugs during pregnancy is still continuing. It is imperative to find medications that efficiently control hypertension without impairing foetal development.

Early detection and monitoring
Improvements in biomarker identification and imaging methods help identify hypertensive problems early in pregnancy. Prompt action has the potential to avert issues and enhance results.

Improved Predictive Models for Preeclampsia
Preeclampsia is a severe kind of hypertension that occurs during pregnancy. Researchers have been focusing on improving these models. Early detection of high-risk individuals makes quick treatments and tighter monitoring possible.

Interventions related to the lifestyle
Dietary changes and physical activity are still crucial parts of controlling hypertension during pregnancy. Understanding the effects of these therapies and implementing them into all-inclusive care plans have been the main goals of research [7,20]

FUTURE DIRECTION AND CONCLUSION

Continuous research is essential to improve diagnostic standards, treatment recommendations, and risk stratification for severe hypertension, moderate, gestational hypertension, and insulin-dependent diabetic pregnancy as our knowledge of hypertension during pregnancy develops. Future studies should focus on management strategies that are optimal while assessing the long-term consequences on both the mother and child. In conclusion, a thorough and multidisciplinary strategy that prioritises maternal and foetal health is necessary for the optimal management of mild hypertension during pregnancy.

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CONFLICT OF INTEREST
The authors declare no conflict of interest.

ABBREVIATIONS
IDDM: Insulin-dependent diabetic mellitus;
IV: Intravenous;
PIH; Pregnancy-induced hypertension;
PAH: Pulmonary Arterial Hypertension

SUMMARY
The goal of antihypertensive drugs during pregnancy is to control high blood pressure and lower related risks. Medications such as nifedipine, labetalol, and methyldopa are frequently administered. Alpha and beta receptor blockage is what labetalol does, whereas methyldopa acts centrally. Calcium channel blockers like nifedipine work. To balance blood pressure control and prevent injury to the foetus, careful monitoring is essential. Preeclampsia, preterm birth, and low birth weight are among the consequences that can result from untreated hypertension during

pregnancy. Given the possible effects on the health of the mother and foetus, customised treatment programmes are crucial. For the best management, close coordination amongst healthcare practitioners is essential.

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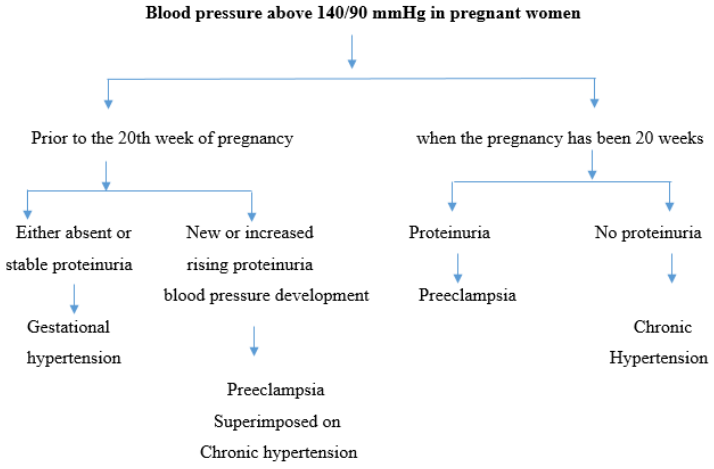
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Table 1: During pregnancy, medications that are frequently used to treat persistent hypertension include[8]:

Labetalol	For pregnant women with persistent hypertension, labetalol is another widely prescribed drug. By blocking certain bodily receptors, this beta-blocker aids in lowering blood pressure. 20 mg intravenously followed by 20-80 mg every 20–30 minutes, up to a maximum of 300 mg, or a steady infusion of 1-2 mg/min.
Methyldopa	One of the first-line medications for managing hypertension during pregnancy is methyldopa. It has been in use for a long time and is typically safe. It lowers blood pressure and relaxes blood arteries, which is how it functions
Nifedipine	Calcium channel blocker nifedipine is occasionally recommended to pregnant women with hypertension. It aids in blood vessel relaxation, which lowers blood pressure. 10-30 mg orally; if necessary, repeat in 45 minutes
Hydralazine	Pregnant women with severe hypertension may benefit from the direct-acting vasodilator hydralazine. Blood arteries are dilated, and blood pressure is reduced. 5 mg, Intravenously or intramuscularly, followed by 5–10 mg every 20–40 minutes; or a continuous infusion of 0.5–10 mg/h.
Prazosin	Alpha-blockers may occasionally be used to treat hypertension during pregnancy
Beta-blockers:	While selective beta-blockers, such as atenolol, are occasionally used in particular circumstances, they are often avoided during pregnancy due to possible dangers to the developing foetus
Diuretics	Not first-line medications, however, if used for essential hypertension before to conception, they are likely safe in modest dosages.

Table 2: Blood pressure level during pregnancy

Normal BP	Pressures in the systole (upper number) and diastole (lower number) must be less than 120 and 80 mm Hg, respectively.
Elevated BP	Less than 80 mm Hg in the diastole and between 120 and 129 mm Hg in the systole.
Hypertension (Stage 1)	Between 80 and 89 mm Hg for diastolic or between 130 and 139 mm Hg for systole.
Hypertension (Stage2):	Diastolic 90 mm Hg or greater, or systolic 140 mm Hg or greater.
Severe Hypertension:	Systolic 160 mm Hg or higher, or diastolic 110 mm Hg or higher.



Flow chart 1: Before and after pregnancy in pregnant women

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RESEARCH ARTICLE

Normal Perhermitian and Conjugate – Normal Per Hermitian Matrices

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ABSTRACT

In this paper, we define some results regarding k-NPM and conjugate k - NPM. Also we discuss some basic concepts and explore characterization of k- NPM and conjugate k- NPM.

Keywords: Hermitian, k-Hermitian, k-Perhermitian, k-normal perhermitian , Conjugate k-normal perhermitian
Mathematics Subject Classification: 15A09, 15B15.

INTRODUCTION

Wiegmann [1] has studied the normal products of matrices. Schneider [2] has characterized normal matrices. Penrose [3] has focused on a generalized inverse for matrices. Ann Lec [4] has studied Secondary skew- symmetric and symmetric orthogonal matrices. Cantoni and Butler [5] have discussed the Eigen values and eigenvectors of centro symmetric matrices. Horn and Johnson [6] have studied matrix analysis. James Weaver [7] has focused on Centrosymmetric (cross-symmetric) matrices, their basic properties, Eigenvalues and Eigenvectors. Bath and Waters [8] have studied On Perhermitian matrices. Feb Bender and Ikramov [9] have introduced Conjugate Normal Matrices: A survey. Krishnamoorthy and Vijayakumar [10] have discussed on s- Normal Matrices. Krishnamoorthy and Subash [11] have studied on k- normal matrices. Krishnamoorthy et.al [12,13] have studied con- k normal matrices and the product of Conjugate k- normal matrices; Elumalai and Rajesh Kannan [14] have discussed k-symmetric circulant, s- symmetric cirulant and s-k symmetric circulant Matrices. Elumalai et.al [15] have studied k-Hermitian Circulant , s-Hermitian Circulant and s-k Hermitian Circulant Matrices, and Hong-ping, Zheng-ke, MIAO, and Jiong- sheng [16] have focused on the Generalized Normal Matrix. Elumalai and Arthi [17] have studied the properties of k- centrosymmetric and k- skew centrosymmetric matrices.

Preliminaries

Let $\mathcal{P}$ be a Perhermitian matrix, $\mathcal{P}^*$ is the conjugate transpose of $\mathcal{P}$ and $\mathcal{P}^\dagger$ is the Moore Penrose inverse of $\mathcal{P}$. Let K Permutation matrix associated with$k$, k be a fixed product of disjoint transposition in S_n. Clearly K satisfies the properties $\overline{K} = K^T = K$, $K^2 = I, KK^T = K^TK = I$. Here k -Normal Perhermitian Matrix is denoted as k-NPM and Moore Penrose Inverse as MPI.

Definition 2.1

Let $\mathcal{P} \in C^{n\times n}$ be any matrix. $\mathcal{P}$ is said to be perhermitian matrix if it satisfies the condition $p_{ij} = \overline{p_{n+1-j,n+1-i}}$ (ie) $\mathcal{P} = \mathcal{P}.^*$

Definition 2.2

Let $\mathcal{P} \in C^{n\times n}$ be any matrix. $\mathcal{P}$ is said to be normal matrix if it satisfies the Condition $\mathcal{P}\mathcal{P}^* = \mathcal{P}^*\mathcal{P}$.

Definition 2.3

Let $\mathcal{P} \in C^{n\times n}$ be a perhermitian matrix. If $\mathcal{P}$ is said to be a k –NPM, then $\mathcal{P}\mathcal{P}^*K = K\mathcal{P}^*\mathcal{P}$.

Some Characterizations of K –Normal Perhermitian Matrix

Theorem 3.1

Let $\mathcal{P}, \mathcal{Q} \in C^{n\times n}$ are k-NPM, then $\mathcal{P} \pm \mathcal{Q}$ is also k-NPM.

Proof

Since $\mathcal{P}, \mathcal{Q}$ are k-NPM, then $\mathcal{P}\mathcal{P}^*K = K\mathcal{P}^*\mathcal{P}$ and $\mathcal{Q}\mathcal{Q}^*K = K\mathcal{Q}^*\mathcal{Q}$.

That is $(\mathcal{P} \pm \mathcal{Q})(\mathcal{P} \pm \mathcal{Q})^*K = K(\mathcal{P} \pm \mathcal{Q})^*(\mathcal{P} \pm \mathcal{Q})$.

Consider $(\mathcal{P} \pm \mathcal{Q})(\mathcal{P} \pm \mathcal{Q})^*K = (\mathcal{P} \pm \mathcal{Q})(\mathcal{P}^* \pm \mathcal{Q}^*)K$

$= (\mathcal{P} \pm \mathcal{Q})(\mathcal{P}^*K + \mathcal{Q}^*K)$

$= \mathcal{P}\mathcal{P}^*K \pm \mathcal{P}\mathcal{Q}^*K \pm \mathcal{Q}\mathcal{P}^*K \pm \mathcal{Q}\mathcal{Q}^*K$

$= K\mathcal{P}^*\mathcal{P} \pm K\mathcal{Q}^*\mathcal{P} \pm K\mathcal{P}^*\mathcal{Q} \pm K\mathcal{Q}^*\mathcal{Q}$

$= K(\mathcal{P}^* \pm \mathcal{Q}^*)\mathcal{P} \pm K(\mathcal{P}^* \pm \mathcal{Q}^*)\mathcal{Q}$

$= K(\mathcal{P}^* \pm \mathcal{Q}^*)(\mathcal{P} \pm \mathcal{Q})$

$= K(\mathcal{P} \pm \mathcal{Q})^*(\mathcal{P} \pm \mathcal{Q})$.

Example 3.1

Let $\mathcal{P} = \begin{pmatrix} 2 & -3i & 2 \\ 3i & 6 & 3i \\ 2 & -3i & 2 \end{pmatrix}$, $\mathcal{Q} = \begin{pmatrix} 4 & 6i & 4 \\ -6i & 7 & -6i \\ 4 & 6i & 4 \end{pmatrix}$

$(\mathcal{P} + \mathcal{Q}) = \begin{pmatrix} 6 & 3i & 6 \\ -3i & 13 & -3i \\ 6 & 3i & 6 \end{pmatrix}$, $(\mathcal{P} + \mathcal{Q})^* = \begin{pmatrix} 6 & 3i & 6 \\ -3i & 13 & -3i \\ 6 & 3i & 6 \end{pmatrix}$

$K = \begin{pmatrix} 0 & 0 & 1 \\ 0 & 1 & 0 \\ 1 & 0 & 0 \end{pmatrix}$ $(\mathcal{P} - \mathcal{Q}) = \begin{pmatrix} -2 & -9i & -2 \\ 9i & -1 & 9i \\ -2 & -9i & -2 \end{pmatrix}$ $(\mathcal{P} - \mathcal{Q})^* = \begin{pmatrix} -2 & -9i & -2 \\ 9i & -1 & 9i \\ -2 & -9i & -2 \end{pmatrix}$

,

(i) $(\mathcal{P} + \mathcal{Q})(\mathcal{P} + \mathcal{Q})^*K = \begin{pmatrix} 81 & 75i & 81 \\ -75i & 187 & -75i \\ 81 & 75i & 81 \end{pmatrix}$

(ii) $K(\mathcal{P} + \mathcal{Q})^*(\mathcal{P} + \mathcal{Q}) = \begin{pmatrix} 81 & 75i & 81 \\ -75i & 187 & -75i \\ 81 & 75i & 81 \end{pmatrix}$

(iii) $(\mathcal{P}-\mathcal{Q})(\mathcal{P}-\mathcal{Q})^*K=\begin{pmatrix}89 & 45i & 89\\ -45i & 163 & -45i\\ 89 & 45i & 89\end{pmatrix}=K(\mathcal{P}-\mathcal{Q})^*(\mathcal{P}-\mathcal{Q}).$

Theorem 3.2

Let $\mathcal{P},\mathcal{Q}\in C^{n\times n}$ are k-NPM. If $\mathcal{PQ}=\mathcal{QP}$, then $\mathcal{PQ}$ and $\mathcal{QP}$ are k-NPM.

Proof:

Since $\mathcal{P},\mathcal{Q}$ are k-NPM, implies that $\mathcal{PP}^*K=K\mathcal{P}^*\mathcal{P}$ and $\mathcal{QQ}^*K=K\mathcal{Q}^*\mathcal{Q}$.

Assume that $\mathcal{PQ}=\mathcal{QP}$ That is $\mathcal{PQ}$ is k-NPM,

Now Consider $(\mathcal{PQ})(\mathcal{PQ})^*K = (\mathcal{PQ})(\mathcal{Q}^*\mathcal{P}^*)K$

$= \mathcal{QPP}^*\mathcal{Q}^*K$

$= \mathcal{QPP}^*\mathcal{Q}^*K$

$= \mathcal{QPP}^*K\mathcal{Q}^*$

$= \mathcal{QKP}^*\mathcal{PQ}^*$

$= K\mathcal{QP}^*\mathcal{PQ}^*$

$= K\mathcal{P}^*\mathcal{QQ}^*\mathcal{P}$

$= K\mathcal{P}^*\mathcal{Q}^*\mathcal{QP}$

$= K(\mathcal{PQ})^*\mathcal{PQ}.$

Theorem 3.3

Let $\mathcal{P},\mathcal{Q}\in C^{n\times n}$ are k-NPM. If $\mathcal{PQ}=\mathcal{QP}$, then $\mathcal{PQ}^*$ is k-NPM.

Proof

Since $\mathcal{P}$ and $\mathcal{Q}$ are k-NPM, then $\mathcal{PP}^*K=K\mathcal{P}^*\mathcal{P}$ and $\mathcal{QQ}^*K=K\mathcal{Q}^*\mathcal{Q}$.

Assume that $\mathcal{PQ}=\mathcal{QP}$. Consider $(\mathcal{PQ}^*)(\mathcal{PQ}^*)^*K = (\mathcal{PQ}^*)((\mathcal{Q}^*)^*\mathcal{P}^*)K$

$= \mathcal{P}(\mathcal{Q}^*)^*\mathcal{Q}^*\mathcal{P}^*K$

$= (\mathcal{Q}^*)^*\mathcal{PQ}^*\mathcal{P}^*K$

$= (\mathcal{Q}^*)^*\mathcal{P}\,\mathcal{P}^*K\mathcal{Q}^*$

$= (\mathcal{Q}^*)^*K\mathcal{P}^*\mathcal{P}\;\mathcal{Q}^*$

$= K\mathcal{P}^*(\mathcal{Q}^*)^*\mathcal{P}\;\mathcal{Q}^*$

$= K(\mathcal{P}^*(\mathcal{Q}^*)^*)\mathcal{PQ}^*$

$= K(\mathcal{PQ}^*)^*\mathcal{PQ}^*.$

Example 3.3

Let $\mathcal{P}=\begin{pmatrix}3 & -5i & 3\\ 5i & 8 & 5i\\ 3 & -5i & 3\end{pmatrix}$, $\mathcal{P}=\begin{pmatrix}3 & -5i & 3\\ 5i & 8 & 5i\\ 3 & -5i & 3\end{pmatrix}$ $K=\begin{pmatrix}0 & 0 & 1\\ 0 & 1 & 0\\ 1 & 0 & 0\end{pmatrix}$ then $\mathcal{PP}^*K=\begin{pmatrix}43 & -70i & 43\\ 70i & 114 & 70i\\ 43 & -70i & 43\end{pmatrix}=K\mathcal{P}^*\mathcal{P}.$

Theorem 3.4

Let $\mathcal{P}\in c^{n\times n}$ be k-NPM, then

$i\mathcal{P}$ is also k-NPM.

$-i\mathcal{P}$ is also k-NPM.

Proof

Let $\mathcal{P}$ be a k-NPM, then $\mathcal{PP}^*K=K\mathcal{P}^*\mathcal{P}$.

Assume that

(i) $i\mathcal{P}$ is also k-NPM.

Show that$(i\mathcal{P})(i\mathcal{P})^*K = K(i\mathcal{P})^*(i\mathcal{P})$.

Consider $\mathcal{PP}^*K=K\mathcal{P}^*\mathcal{P}-i^2\mathcal{PP}^*K=-i^2K\mathcal{P}^*\mathcal{P}(i\mathcal{P})(-i)\mathcal{P}^*K=K(-i)\mathcal{P}^*(i\mathcal{P})$

$(i\mathcal{P})(\bar{i})^T\mathcal{P}^*K=K(\bar{i})^T\mathcal{P}^*(i\mathcal{P})$ Where $(\bar{\imath}=-i)(i\mathcal{P})(i)^*\mathcal{P}^*K=K(i)^*\mathcal{P}^*(i\mathcal{P})$

$(i\mathcal{P})(i\mathcal{P})^*K=K(i\mathcal{P})^*(i\mathcal{P})$Therefore $i\mathcal{P}$ is k-NP.

(ii) $-i\mathcal{P}$ is also k-NPM.

Show that $(-i\mathcal{P})(-i\mathcal{P})^*K = K\,(-i\mathcal{P})^*(-i\mathcal{P})$

Consider $\mathcal{P}\mathcal{P}^*K = K\mathcal{P}^*\mathcal{P} - i^2\mathcal{P}\mathcal{P}^*K = -i^2K\mathcal{P}^*\mathcal{P}$

$(-i)(i)\mathcal{P}\mathcal{P}^*K = K(-i)(i)\mathcal{P}^*\mathcal{P}$ Where - $\bar{\imath} = i(-i)\left(-\bar{\imath}\right)^T\mathcal{P}\mathcal{P}^*K = K(-i)\left(-\bar{\imath}\right)^T\mathcal{P}^*\mathcal{P}$

$(-i)(-i^*)\mathcal{P}\mathcal{P}^*K = K(-i)(-i^*)\mathcal{P}^*\mathcal{P}$ Where $-i^* = (-\bar{\imath})^T(-i)\mathcal{P}(-i^*)\mathcal{P}^*K = K(-i^*)\mathcal{P}^*(-i)\mathcal{P}(-i\mathcal{P})(-i^*\mathcal{P}^*)K = K(-i^*\mathcal{P}^*)(-i\mathcal{P})(-i\mathcal{P})(-i\mathcal{P})^*K = K(-i\mathcal{P})^*(-i\mathcal{P})$. Therefore $-i\mathcal{P}$ is k-NPM.

Example 3.4

Let $\mathcal{P} = \begin{pmatrix} 0 & 0 & 4 \\ 0 & 6i & 0 \\ 4 & 0 & 0 \end{pmatrix}$, $i\mathcal{P} = \begin{pmatrix} 0 & 0 & 4i \\ 0 & -6 & 0 \\ 4i & 0 & 0 \end{pmatrix}$ then $K(i\mathcal{P})^*(i\mathcal{P}) = \begin{pmatrix} 0 & 0 & 16 \\ 0 & 36 & 0 \\ 16 & 0 & 0 \end{pmatrix} = K(i\mathcal{P})^*(i\mathcal{P})$.

Theorem 3.5

Let $\mathcal{P} \in C^{n\times n}$ and $\mathcal{P}^\dagger$ be the MPI of $\mathcal{P}$, then $\mathcal{P}$ is k-NPM, iff $\mathcal{P}^\dagger$ is also k-NPM.

Proof

Let $\mathcal{P}$ be a k-NPM, then $\mathcal{P}\mathcal{P}^*K = K\mathcal{P}^*\mathcal{P}$. Assume that $\mathcal{P}^\dagger$ is k-NPM.

We will show that $\mathcal{P}^\dagger\left(\mathcal{P}^\dagger\right)^*K = K\left(\mathcal{P}^\dagger\right)^*\mathcal{P}^\dagger$.

Now Consider $\mathcal{P}\mathcal{P}^*K = K\,\mathcal{P}^*\mathcal{P}(PP^*K)^\dagger = (KP^*P)^\dagger K^\dagger(\mathcal{P}^*)^\dagger\mathcal{P}^\dagger = \mathcal{P}^\dagger(\mathcal{P}^*)^\dagger K^\dagger K\left(\mathcal{P}^\dagger\right)^*\mathcal{P}^\dagger = \mathcal{P}^\dagger\left(\mathcal{P}^\dagger\right)^*K\mathcal{P}^\dagger\left(\mathcal{P}^\dagger\right)^*K = K\left(\mathcal{P}^\dagger\right)^*\mathcal{P}^\dagger$.

Therefore $\mathcal{P}^\dagger$ is k-NPM.

Assume that $\mathcal{P}$ is k-NPM. We have to show that $\mathcal{P}\mathcal{P}^*K = K\mathcal{P}^*\mathcal{P}$.

Now $\mathcal{P}^\dagger\left(\mathcal{P}^\dagger\right)^*K = K\left(\mathcal{P}^\dagger\right)^*\mathcal{P}^\dagger\left(\mathcal{P}^\dagger\left(\mathcal{P}^\dagger\right)^*K\right)^\dagger = \left(K\left(\mathcal{P}^\dagger\right)^*\mathcal{P}^\dagger\right)^\dagger K^\dagger\left(\left(\mathcal{P}^\dagger\right)^*\right)^\dagger\left(\mathcal{P}^\dagger\right)^\dagger = \left(\mathcal{P}^\dagger\right)^\dagger\left(\left(\mathcal{P}^\dagger\right)^*\right)^\dagger K^\dagger$

$K\left(\left(\mathcal{P}^\dagger\right)^\dagger\right)^*\left(\mathcal{P}^\dagger\right)^\dagger = \left(\mathcal{P}^\dagger\right)^\dagger\left(\left(\mathcal{P}^\dagger\right)^\dagger\right)^*KK\mathcal{P}^*\mathcal{P} = \mathcal{P}\mathcal{P}^*K$ Where $\left(\mathcal{P}^\dagger\right)^\dagger = \mathcal{P}$

Therefore $\mathcal{P}$ is k-NPM.

Theorem 3.6

Let $\mathcal{P} \in C^{n\times n}$ and $\mathcal{P}^{-1}$ be an inverse of $\mathcal{P}$ then $\mathcal{P}$ is k-NPM, iff $\mathcal{P}^{-1}$ is also k-NPM.

Proof:

Let $\mathcal{P}$ be a k-NPM and then $\mathcal{P}\mathcal{P}^*K = K\mathcal{P}^*\mathcal{P}$. assume that $\mathcal{P}^{-1}$ is k-NPM. We will show that $\mathcal{P}^{-1}(\mathcal{P}^{-1})^*K = K(\mathcal{P}^{-1})^*\mathcal{P}^{-1}$.Now Consider $\mathcal{P}\mathcal{P}^*K = K\,\mathcal{P}^*(\mathcal{P}\mathcal{P}^*K)^{-1} = (K\mathcal{P}^*\mathcal{P})^{-1}K^{-1}(\mathcal{P}^*)^{-1}\mathcal{P}^{-1} = \mathcal{P}^{-1}(\mathcal{P}^*)^{-1}K^{-1}K(\mathcal{P}^{-1})^*\mathcal{P}^{-1} = \mathcal{P}^{-1}(\mathcal{P}^{-1})^*K\mathcal{P}^{-1}(\mathcal{P}^{-1})^*K = K\,(\mathcal{P}^{-1})^*\mathcal{P}^{-1}$.

Therefore $\mathcal{P}^{-1}$ is k-NPM.

Assume that $\mathcal{P}$ is k-NPM. We will show that $\mathcal{P}\mathcal{P}^*K = K\mathcal{P}^*\mathcal{P}$.

Now $\mathcal{P}^{-1}(\mathcal{P}^{-1})^*K = K(\mathcal{P}^{-1})^*\mathcal{P}^{-1}$

$$(\mathcal{P}^{-1}(\mathcal{P}^{-1})^*K)^{-1} = (K(\mathcal{P}^{-1})^*\mathcal{P}^{-1})^{-1}$$
$$K^{-1}((\mathcal{P}^{-1})^*)^{-1}(\mathcal{P}^{-1})^{-1} = (\mathcal{P})^{-1}((\mathcal{P}^{-1})^*)^{-1}K^{-1}$$
$$K((\mathcal{P}^{-1})^{-1})^*(\mathcal{P}^{-1})^{-1} = (\mathcal{P}^{-1})^{-1}((\mathcal{P}^{-1})^{-1})^*K$$

$K\mathcal{P}^*\mathcal{P} = \mathcal{P}\mathcal{P}^*K$. Where $(\mathcal{P}^{-1})^{-1} = \mathcal{P}$

Therefore $\mathcal{P}$ is k-NPM.

Theorem 3.7

Let $\mathcal{P} \in C^{n\times n}$ is k-NPM, then

(i) $\mathcal{P}^T$is also k-NPM.

(ii) $\overline{\mathcal{P}}$ is also k-NPM.

(iii) $\mathcal{P}^*$ is also$k$-NPM.

Some Characterization of Conjugate K −NPM

Definition 4
A Perhermitian matrix $\mathcal{P} \in C^{n\times n}$ is said to be Conjugate k-NPM, if $\mathcal{P}\mathcal{P}^*K = K\mathcal{P}^T\overline{\mathcal{P}}$.

Theorem 4.1
Let $\mathcal{P}, \mathcal{Q} \in C^{n\times n}$ are Conjugate k-NPM and then $\mathcal{P} \pm \mathcal{Q}$ is also Conjugate k-NPM.

Proof
Let $\mathcal{P}, \mathcal{Q}$ are Conjugate k-NPM, then $\mathcal{P}\mathcal{P}^*K = KP^T\bar{P}$ and $\mathcal{Q}\mathcal{Q}^*K = K\mathcal{Q}^T\bar{\mathcal{Q}}$.
Assume that $P \pm \mathcal{Q}$ Conjugate k-NPM.
We have to show that $(\mathcal{P} \pm \mathcal{Q})(\mathcal{P} \pm \mathcal{Q})^*K = K(\mathcal{P} \pm \mathcal{Q})^T(\overline{\mathcal{P} \pm \mathcal{Q}})$
Consider $(\mathcal{P} \pm \mathcal{Q})(\mathcal{P} \pm \mathcal{Q})^*K = (\mathcal{P} \pm \mathcal{Q})(\mathcal{P} \pm \mathcal{Q})^*K$
$= (\mathcal{P} \pm \mathcal{Q})(\mathcal{P}^* \pm \mathcal{Q}^*)K$
$= (\mathcal{P} \pm \mathcal{Q})(\mathcal{P}^*K \pm \mathcal{Q}^*K)$
$= \mathcal{P}\mathcal{P}^*K \pm \mathcal{P}\mathcal{Q}^*K \pm \mathcal{Q}\mathcal{P}^*K \pm \mathcal{Q}\mathcal{Q}^*K$
$= K\mathcal{P}^T\bar{\mathcal{P}} \pm K\mathcal{Q}^T\overline{\mathcal{P}} \pm K\mathcal{P}^T\bar{\mathcal{Q}} \pm K\mathcal{Q}^T\bar{\mathcal{Q}}$
$= K(\mathcal{P}^T \pm \mathcal{Q}^T)\overline{\mathcal{P}} \pm K(\mathcal{P}^T \pm \mathcal{Q}^T)\bar{\mathcal{Q}}$
$= K(\mathcal{P}^T \pm \mathcal{Q}^T)(\bar{\mathcal{P}} \pm \bar{\mathcal{Q}})$.

Theorem 4.2
Let $\mathcal{P}, \mathcal{Q} \in C^{n\times n}$ are Conjugate k-NPM. If $\mathcal{P}\mathcal{Q} = \mathcal{Q}\mathcal{P}$, then $\mathcal{P}\mathcal{Q}$ and $\mathcal{Q}\mathcal{P}$ are Conjugate k-NPM.

Proof
Let $\mathcal{P}, \mathcal{Q}$ are Conjugate k-NPM, then $\mathcal{P}\mathcal{P}^*K = K\mathcal{P}^T\bar{\mathcal{P}}$ and $\mathcal{Q}\mathcal{Q}^*K = K\mathcal{Q}^T\bar{\mathcal{Q}}$.
Assume that $\mathcal{P}\mathcal{Q}$ is Conjugate k-NPM.
Consider $(\mathcal{P}\mathcal{Q})(\mathcal{P}\mathcal{Q})^*K = \mathcal{P}\mathcal{Q}\mathcal{Q}^*\mathcal{P}^*K = \mathcal{P}\mathcal{Q}^*\mathcal{Q}\mathcal{P}^*K$
$= \mathcal{P}\mathcal{Q}^*(K\mathcal{Q}^T\bar{\mathcal{P}})$
$= (\mathcal{P}\mathcal{Q}^*K)\mathcal{Q}^T\bar{\mathcal{P}} = K\mathcal{P}^T\bar{\mathcal{Q}}\mathcal{Q}^T\bar{\mathcal{P}}$
$= K(\mathcal{P}^T\mathcal{Q}^T)(\overline{\mathcal{P}\mathcal{Q}})$.

Theorem 4.3
Let $\mathcal{P} \in C^{n\times n}$ be Conjugate k-NPM, then
(i) $i\mathcal{P}$ is also Conjugate k-NPM.

(ii) $-i\mathcal{P}$ is also Conjugate k-NPM.

Proof
Let $\mathcal{P}$ is Conjugate k-NPM, then $\mathcal{P}\mathcal{P}^*K = K\mathcal{P}^T\bar{\mathcal{P}}$
(i) $i\mathcal{P}$ also Conjugate k-NPM.

Show that $(i\mathcal{P})(i\mathcal{P})^*K = K(i\mathcal{P})^T(\overline{i\mathcal{P}})$
Consider $\mathcal{P}\mathcal{P}^*K = K\mathcal{P}^T\bar{\mathcal{P}}$
$(-i^2)\mathcal{P}\mathcal{P}^*K = K(-i^2)\mathcal{P}^T\bar{\mathcal{P}}$
$(i\mathcal{P})(-i\mathcal{P})^*K = K(i)(-i)\mathcal{P}^T\bar{\mathcal{P}}$
$(i\mathcal{P})(i\mathcal{P})^*K = K(i\mathcal{P})^T\bar{\mathcal{P}}$
Therefore $i\mathcal{P}$ Conjugate k-NPM.
(ii) $-i\mathcal{P}$ also Conjugate k-NPM.
(iii) Show that $(-i\mathcal{P})(-i\mathcal{P})^*K = K(-i\mathcal{P})^T(-\overline{i\mathcal{P}})$

Consider $\mathcal{P}\mathcal{P}^*K = K\mathcal{P}^T\bar{\mathcal{P}}(-i^2)\mathcal{P}\mathcal{P}^*K = K(-i^2)\mathcal{P}^T\bar{\mathcal{P}}$

$(-)(-)\mathcal{P}\mathcal{P}^*K = K(-)(-)\mathcal{P}^T\bar{\mathcal{P}}$

(illegible)

(illegible)

Therefore – is Conjugate NPM.

Theorem 4.4

Let $\mathcal{P} \in C^{n\times n}$ be Conjugate k-NPM, then

(i) $\bar{\mathcal{P}}$ is also Conjugate k-NPM.

(ii) $\mathcal{P}^T$ is also Conjugate k-NPM.

(iii) $\lambda\mathcal{P}$ Conjugate k-NPM, (where λ is a non real no)

Theorem 4.5

If $\mathcal{P} \in C^{n\times n}$ and $\mathcal{P}^{-1}$ be an inverse of $\mathcal{P}$ then $\mathcal{P}$ is Conjugate k-NPM, iff $\mathcal{P}^{-1}$ is also Conjugate k-NPM. (Similarly we can prove this by using Theorem 3.6)

Theorem 4.6

Let $\mathcal{P} \in C^{n\times n}$ and $\mathcal{P}^{\dagger}$ be the MPI of $\mathcal{P}$, then $\mathcal{P}$ is Conjugate k-NPM iff $\mathcal{P}^{\dagger}$ is also Conjugate k-NPM.

Proof:

Since $\mathcal{P}$ be a Conjugate k-NPM, then $\mathcal{P}\mathcal{P}^*K = K\mathcal{P}^T\overline{\mathcal{P}}$.

To prove $\mathcal{P}^{\dagger}$ is Conjugate k-NPM.

Show that $\mathcal{P}^{\dagger}(\mathcal{P}^{\dagger})^*K = K(\mathcal{P}^{\dagger})^T\overline{\mathcal{P}^{\dagger}}$.

Consider $\mathcal{P}\mathcal{P}^*K = K\mathcal{P}^T\bar{\mathcal{P}}$

$(\mathcal{P}\mathcal{P}^*K)^{\dagger} = (K\mathcal{P}^T\bar{\mathcal{P}})^{\dagger}$

$K^{\dagger}(\mathcal{P}^*)^{\dagger}\mathcal{P}^{\dagger} = \bar{\mathcal{P}}^{\dagger}(\mathcal{P}^T)^{\dagger}K^{\dagger}$

$\mathcal{P}^{\dagger}(\mathcal{P}^{\dagger})^*K = K(\mathcal{P}^{\dagger})^T(\overline{\mathcal{P}^{\dagger}})$.

Therefore $\mathcal{P}^{\dagger}$ is Conjugate k-NPM. Assume that $\mathcal{P}^{\dagger}$ is Conjugate k-NPM.

To prove that $\mathcal{P}$ is Conjugate k-NPM. Show that $\mathcal{P}\mathcal{P}^*K = K\mathcal{P}^T\bar{\mathcal{P}}$

Consider $\mathcal{P}^{\dagger}(\mathcal{P}^{\dagger})^*K = K(\mathcal{P}^{\dagger})^T(\overline{\mathcal{P}^{\dagger}})$

$\left(\mathcal{P}^{\dagger}(\mathcal{P}^{\dagger})^*K\right)^{\dagger} = \left(K(\mathcal{P}^{\dagger})^T(\overline{\mathcal{P}^{\dagger}})\right)^{\dagger}$

$K^{\dagger}\left((\mathcal{P}^{\dagger})^*\right)^{\dagger}(\mathcal{P}^{\dagger})^{\dagger} = (\overline{\mathcal{P}^{\dagger}})^{\dagger}\left((\mathcal{P}^{\dagger})^T\right)^{\dagger}K^{\dagger}$

$K\left((\mathcal{P}^{\dagger})^{\dagger}\right)^*(\mathcal{P}^{\dagger})^{\dagger} = \overline{((\mathcal{P})^{\dagger})^{\dagger}}((\mathcal{P}^{\dagger})^{\dagger})^TK$

$\mathcal{P}\mathcal{P}^*K = K\mathcal{P}^T\bar{\mathcal{P}}$. Where $(\mathcal{P}^{\dagger})^{\dagger} = \mathcal{P}$

Therefore $\mathcal{P}$ is Conjugate k-NPM.

Example 4.1

Let $\mathcal{P} = \begin{pmatrix} 0 & 0 & -4i \\ 0 & 9 & 0 \\ 4i & 0 & 0 \end{pmatrix}$, $\mathcal{Q} = \begin{pmatrix} 0 & 0 & 9i \\ 0 & 6 & 0 \\ -9i & 0 & 0 \end{pmatrix}$, $(\mathcal{P}+\mathcal{Q}) = \begin{pmatrix} 0 & 0 & 5i \\ 0 & 15 & 0 \\ -5i & 0 & 0 \end{pmatrix}$

$(\mathcal{P}-\mathcal{Q}) = \begin{pmatrix} 0 & 0 & -13i \\ 0 & 3 & 0 \\ 13i & 0 & 0 \end{pmatrix}$, $(\mathcal{P}+\mathcal{Q})^* = \begin{pmatrix} 0 & 0 & 5i \\ 0 & 15 & 0 \\ -5i & 0 & 0 \end{pmatrix}$

$(\mathcal{P}-\mathcal{Q})^* = \begin{pmatrix} 0 & 0 & -13i \\ 0 & 3 & 0 \\ 13i & 0 & 0 \end{pmatrix}$, $\overline{(\mathcal{P}+\mathcal{Q})} = \begin{pmatrix} 0 & 0 & -5i \\ 0 & 15 & 0 \\ 5i & 0 & 0 \end{pmatrix}$,

$(\mathcal{P}+\mathcal{Q})^T = \begin{pmatrix} 0 & 0 & -5i \\ 0 & 15 & 0 \\ 5i & 0 & 0 \end{pmatrix}$, $(\mathcal{P}-\mathcal{Q})^T = \begin{pmatrix} 0 & 0 & 13i \\ 0 & -1 & 0 \\ -13i & 0 & 0 \end{pmatrix}$

$\overline{(\mathcal{P}-\mathcal{Q})} = \begin{pmatrix} 0 & 0 & 13i \\ 0 & 3 & 0 \\ -13i & 0 & 0 \end{pmatrix}$.

CONCLUSION

We discuss some characterizations of *k*-NPM and Conjugate *k*-NPM and illustrating with suitable examples.

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RESEARCH ARTICLE

Regulatory Requirements for Approval of Medical Devices in the EU

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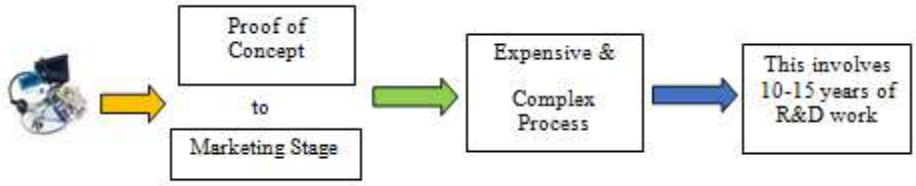
ABSTRACT

Medical devices based on human tissue and cells are a relatively new class of technology. As a result, no information is available regarding the classification and assessment of human cells and tissue products before their sale in the US, EU, or Japan. This study looked at legal frameworks, approval procedures, and definitions of important terminology. The regulations controlling the marketing of medical devices were changed following the French Poly Implant Prothèse (PIP) scandal. The recently developed Medical Device Regulation (MDR [EU]) 2017/745 went into effect on May 25, 2017. Following a three-year transition period, all members of the European Union and the European Economic Area must ratify the law. Numerous changes, including software and mobile applications, have been made to the manufacturing and marketing of medical equipment since the enactment of this Act. Medical device producers have to manage a challenging process with several regulatory constraints during the product's research and marketing phases. This study provides a general overview and analysis & approval of the medical device software and app the market should be aware of. It primarily focuses on the new MDR, harmonized standards related to it, and European Commission advising papers.

Keywords: EMA, MDR, Regulations, Medical Devices, PIP, USFDA,

INTRODUCTION

Medical Devices are any tools, supplies, machinery, appliances, equipment, or other items that the manufacturer intends to employ on humans, either separately or in combination. In addition to replacing or altering anatomy or physiological processes, they can be used in the diagnosis, prevention, monitoring, treatment, or relief of diseases, injuries, or impairments are goods or devices intended for use in medicine.[1] Due to safety concerns, the Medical Device Directive (MDD) 93/42/EEC was modified. Then, in 2017/745, the new Medical Device Regulation (MDR [EU]) was introduced. This was especially valid in the context of the French Poly Implant Prothèse (PIP) event. The European Union (EU) and the European Economic Area must ratify the Mutual Défense Treaty (MDR) by May 25, 2017[1].



The healthcare industry accounts for a significant portion of government spending in developed nations with aging populations. As a result, the GDP's proportion of healthcare rises. Considerable emphasis is given to this development in terms of specific sectors and demographic trends. Moreover, the role of medical devices (MDs) in the provision of healthcare is growing and crucial [2]. To guarantee their safety and proper operation, the European Union (EU) will conduct an assessment of their compliance, which they must pass. EU Member States regulate them at the state level; however, the European Medicines Agency (EMA) is involved in the regulation process.[3]

Examples


Fig:2


Fig:3


Fig:4


Fig:5

OBJECTIVES

- To understand the **Overview – Medical Devices** in the EU
- To provide updated **Regulations/Directives for Medical Devices** in the EU
- To understand the **classification, approval process & Timeline** for medical device
  - s in the EU

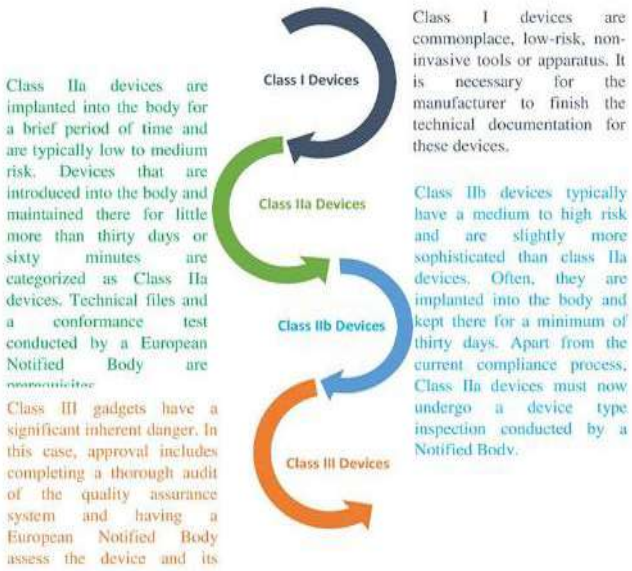
REGULATIONS

Sl No.	Directives / Regulations
1.	EU MDR 2017/745 – Medical Devices
2.	EU IVDR 2017/746 _ Invitro Diagnostic

GUIDANCE DOCUMENTS

Sl. No	Guidance Documents	URL Website
01	Basic Information about the European Directive 93/42/EEC on Medical Devices	https://www.mdcce.de/fileadmin/userupl1/Downloads/mdcDokumente/Broschueren/040100 basic info 93-42-EEC 06 e.pdf
02	Guidelines relating to the application of the Council Directive 93/42/EEC on medical devices	http://economie.fgov.be/nl/binaries/02classificatiegids COM 24 1 rev 9classification en tcm325-45934.pdf
03	Guidelines relating to the application of the council directive 90/385/EEC on active implantable medical devices the Council Directive 93/42/EEC on medical devices	https://eurlex.europa.eu/legalcontent/EN/ALL/?uri=uriserv:OJL_2017.117.01 0001.01.ENG
04	Regulation (EU) 2017/745 of the European Parliament and of the Council of 5 April 2017 on medical devices, amending Directive 2001/83/EC, Regulation (EC) No 178/2002 and Regulation (EC) No 1223/2009 and repealing Council Directives 90/385/EEC and 93/42/EEC (Text with EEA relevance.)	https://ema.europa.eu/en/news/medical-device-regulation-comes- application
05	Regulation (EU) 2017/745 on medical devices becomes applicable in the European Union today, 26 May 2021	https://ema.europa.eu/en/news/medical-device-regulation-comes- application
06	Regulation (EU) 2017/746 of the European Parliament and of the Council of 5 April 2017 on in vitro diagnostic medical devices and repealing Directive 98/79/EC and Commission Decision 2010/227/EU (Text with EEA relevance.)	https://eurlex.europa.eu/legalcontent/EN/TXT/?uriCELEX%3A32017R0746

RESULTS & DISCUSSIONS



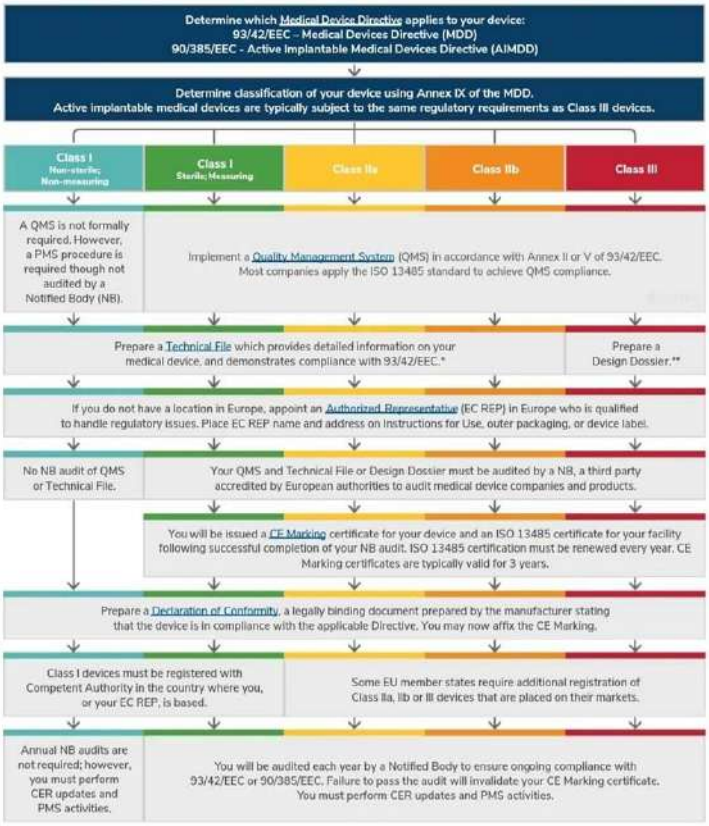
According to the classification rules, medical devices are divided into four risk groups: I, IIa, IIb, and III, depending on the possible risks connected to their use.[4] The particular classification principles are contained in EU Directive

93/42/EEC Annexe IX. The classification criteria are determined by the intended use of the goods and are the responsibility of the producers.[4]

CLASSIFICATION OF MEDICALDEVICES

Sl No.	Class	Risk Level	Examples
1.	Class I	Low-risk devices	bandages, stethoscopes
2.	Class IIa	Moderate-risk devices	hearing aids, contact lenses
3.	Class IIb	Higher-risk devices	infusion pumps, X-ray machines
4.	Class III	Highest-risk devices	implantable defibrillators, heart valves

APPROVAL PROCESS – MEDICAL DEVICES IN EU



Step:1

Organize your equipment according to the MDR's classification guidelines, and designate a Person Responsible for Regulatory Compliance for your company who has received MDR training.

Step:2
Make sure that the MDR is followed by your QMS. Most companies adhere to the EN ISO 13485 standard when it comes to compliance. The three primary cornerstones of your quality management system are clinical evaluation, post-market surveillance, and clinical follow-up plans (PMCF, PMS, and PMS).
Step:3
Prepare the CE Technical Documentation in accordance with MDR Annex II and III.

Step:4
To acquire an SRN from the pertinent authorities, use EUDAMED and choose an EU Authorized Representative (EC REP).

Step:5
In Europe, national authorities designate Notified Bodies as unbiased third-party conformity assessment bodies to audit medical device manufacturers and products to ensure they comply with relevant EU regulations. Every device, excluding Class I (self-certified) devices, needs to have its QMS and Technical Documentation audited.
Class I (self-certified) devices do not require notification bodies.

Step:6
You will receive an ISO 13485 certificate for your facility and a CE marking certificate for your device after your Notified Body audit is successfully finished (the CE marking certificate is not applicable for Class I (self-certified) models).

Step:7
The manufacturer is required by Annex IV of the MDR to prepare a formal Declaration of Compliance (DoC) attesting to the device's compliance with all applicable European standards. The CE marking can now be applied.[5]

TIMELINES
The marketing authorization application for a new drug must be reviewed in 210 "active" days. The duration of "active evaluation time" is required for EMA specialists to examine the supporting documents that the applicant encloses with their MLM.[3]

SUMMARY & CONCLUSION

Medical devices have to abide by strict standards meant to limit health hazards and safeguard patients from the usage of often extremely complex technologies. Devices that pose a higher danger are anticipated to be subject to stricter rules, while those that pose a lesser risk should only be subject to reasonable controls. The threats are classified based on the intended use and function of the device. Manufacturers of gadgets must nevertheless categorize them into the proper risk category, even though regulatory bodies may interpret the laws for a specific product. Potential global ramifications stem from our findings. Notified entities are independent establishments that permit the selling of gadgets inside the European Union. It might be difficult to connect publicly available data with material that has been examined by experts in the field because the information they assess isn't always mandated to be accessible to the public.The manufacturer can identify medical devices, create corporate policies and plans, and prepare for any future legal or compliance requirements by classifying medical devices based on their risk level. All of this will enhance the design and development process and put the company in a better position to grow in the marketplace and economy. Using the right methodology, it is possible to estimate the financial impact of introducing a medical device early on in the design and development process.

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RESEARCH ARTICLE

Assessment of Antimicrobial Efficacy of Phytochemical (Quercetin) on Periodontal Pathogens - An *In vitro* Study

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ABSTRACT

Antibiotics have widely been employed in the treatment of periodontal disease but has led to resistant strains. Phytochemicals have been recently identified to have antibacterial activity, one such being a bioflavonoid Quercetin. Investigations into quercetin's potential as an antibacterial agent for the treatment of periodontal diseases could lead to the creation of useful treatment strategies. Assessment and comparison of the antimicrobial efficacy of different concentrations of quercetin with 0.2% chlorhexidine gluconate on cell culture of Porphyromonas gingivalis, Fusobacterium nucleatum, Prevotella intermedia and Tanerella forsythia. Quercetin solution was prepared by dissolving quercetin powder in Dimethyl Sulphoxide (DMSO) solution then diluted into concentrations of 1-5mg/ml. Antibacterial activity of different concentrations of quercetin was assessed using the agar disc diffusion assay. Quercetin solution in different concentrations was added to wells created in blood agar plates. Chlorhexidine (0.2%) as positive control was added in one well. The culture plates were incubated at 37°C in anaerobic atmosphere for 48 hours. The area surrounding the well without bacterial growth was measured to determine the zone of inhibition which denoted the amount of antibacterial activity.

Quercetin was able to inhibit the growth of tested pathogens at all the concentrations (1-5 mg/ml) in a dose dependent manner whereas the growth of Prevotella intermedia was inhibited only at 4mg/ml and 5 mg/ml. For the zone of inhibition for Fusobacterium nucleatum, no statistically significant difference was seen between the 5 mg/ml quercetin and 0.2% chlorhexidine. Quercetin is an effective antimicrobial agent against the periodontal pathogens as it was able to inhibit the growth of all tested pathogens.

Keywords: phytochemical, bioflavonoid, antibacterial, periodontal disease, disc diffusion

INTRODUCTION

Periodontal disease is a chronic inflammatory, infectious disease characterized by destruction of bone and connective tissue caused by dental plaque, bacteria and bacterial products.It is triggered by the bacterial biofilm of dental plaque, resulting in loss of tooth supporting tissues [1]. It is a serious public health issue affecting 10–15% of the world adult population [2].It is also the most common cause of tooth loss in adults [3]. The dental plaque biofilm that accumulates on the tooth surfaces is a complex ecosystem consisting of about 700 different reported bacterial species [4]. However, initiation and causation of periodontitis is associated with a few pathogenic species. Significant evidence has implicated *P. gingivalis* [5]in the development of periodontitis. Additionally, *Bacteroides forsythu[6]*, *P. intermedia* [7], and *Fusobacterium nucleatum* [7]have been strongly associated with the progression of periodontitis. Antibiotics have widely been used to treat oral infections caused by these bacteria but has been accompanied by the rapid appearance of resistant strains [8].Hence alternative therapeutic and preventive measures which are safe, effective and free of side effects, are highly desirable, one such modality being the use of herbal drugs. Plant-based chemicals or phytochemicals have become a focus of interest in recent times [9]. Polyphenols is one such type of chemical produced by plants as a secondary metabolite. There are about more than 8000 identified compounds described to date [10]. Some authors have classified polyphenols into five main groups: hydrolysable tannins, phenolic acids, polyphenolic amides, flavonoids, and other, with their corresponding subgroups based on chemical composition [11]. Flavonoids, being the most abundant group of polyphenols. Quercetin (3,5,7,3′,4′-pentahydroxyflavone) is an important phytochemical, belonging to the flavonoid group of polyphenols. It is present abundantly in vegetables and fruits like apples, onions, berries, red grapes, kales, broccoli, cherriesas well as in tea [12] Quercetin possesses many pharmacological activities such as antioxidant[13], anti tumour[14], antiviral[15], anti-inflammatory[16] along with cardio protective properties[17]. It is also found to have antimicrobial[18 19]property. However, its antimicrobial activity against periodontal pathogens and other oral bacteria has not been thoroughly investigated. If it is found to be effective against periodontal pathogens, it can be used as one of the treatment modalities for treatment of periodontal disease.This study was therefore planned to assess the antimicrobial efficacy of different concentrations of quercetin on cell cultures of Porphyromonas gingivalis, Fusobacterium nucleatum, Prevotella intermedia, Tanerella forsythia and compare this efficacy with that of 0.2% Chlorhexidine."

Aim

"To assess the antimicrobial efficacy of different concentrations of quercetin on cell cultures of various periodontal pathogens and compare its efficacy to 0.2% chlorhexidine"

Objectives

1. To assess and compare the antimicrobial efficacy of different concentrations of quercetin with 0.2% chlorhexidine on cell culture of Porphyromonas gingivalis.
2. To assess and compare the antimicrobial efficacy of different concentrations of quercetin with 0.2% chlorhexidine on cell culture of Fusobacterium nucleatum.
3. To assess and compare the antimicrobial efficacy of different concentrations of quercetin with 0.2% chlorhexidine on cell culture of Prevotella intermedia.

4. To assess and compare the antimicrobial efficacy of different concentrations of quercetin with 0.2% chlorhexidine on cell culture of Tanerella forsythia.

MATERIALS AND METHODS

The study was carried out at Maratha Mandal Dental College and Hospital, Belagavi.

Preparation of Quercetin Solution

Quercetin solution in various dilutions was prepared by weighing 10 g of quercetin powder and dissolving it in 1 ml of Dimethyl Sulphoxide (DMSO) solution. It was then serially diluted into various concentrations of 1mg/ml, 2mg/ml, 3 mg/ml, 4mg/ml and 5 mg/ml. Antimicrobial susceptibility testing protocol (given by Schwalbe et al in 2007[20]) was followed for this study. This method consists of inoculating the isolated bacteria onto a Blood agar plate, followed by placing anti-microbial agent on the surface of the agar. By incubating this plate, the agent diffused into the agar in a gradient. Susceptibility was determined by measuring the diameter of the zones of bacterial inhibition around the antimicrobial agent and comparing the diameters with the standard. Disk diffusion is relatively inexpensive, easy to use and flexible agar-based method which provides qualitative results for rapidly growing bacteria.

METHODOLOGY

Bacterial Sample(Inoculum) was obtained and its turbidity was visually adjusted to that of a 0.5 McFarland turbidity standard which has been vortexed. Within 15 min of adjusting the inoculum to a McFarland 0.5 turbidity standard, a sterile cotton swab was dipped into the inoculum and rotated against the wall of the tube (above the liquid) to remove excess inoculum.Cell cultures of periodontal pathogens (Porphyromonasgingivalis, Fusobacterium nucleatum, Prevotella inter media and Tanerella forsythia) were used in this study. They were cultured on different blood agar plates. The agar plates were brought to room temperature before inoculation.The entire surface of agar plate was swabbed three times by rotating plates approximately 60º between streaking to ensure even distribution. Care was taken toavoid hitting sides of petridish and creating aerosols. The inoculated plate was allowed to restfor atleast 3 minutes but not longer than 15 min. Wells were drilled in the agar plates using sterile punch at regular intervals. 10 µl of Quercetin solution in different concentrations was then added to the wells. Chlorhexidine (0.2%) was used as positive control and was also added in one of the wells. The plates were then incubated within 15 min of quercetin application. They were incubated for a period of 24 hrs at 37 ºC in the incubator. The plates were then incubated in an anaerobic jar and keptat 37 ºC. After 24 hours, the antimicrobial activity was assessed by measuring the diameter of inhibition zone using vernier callipers.

Statistical Analysis

Data was recorded and statistical analysis was then carried out.Descriptive statistics were expressed as means and standard deviation. For each organism, the comparison of zone of inhibition achieved from different concentrations of quercetin and chlorhexidine was done using Kruskal Walis ANOVA test. In the above tests, p values less than or equal to 0.05 was considered statistically significant. All the analyses were performed using SPSS version 25.

RESULTS

Based on the data given in Figure 1; phytochemical quercetin was able to inhibit the growth of Porphyromonas gingivalis, Fusobacterium nucleatum and Tanerella forsythia at all the concentrations (1-5 mg/ml) in a dose dependent manner whereas the growth of Prevotella intermedia was inhibited only at 4mg/ml and 5 mg/ml. Based on the data given in table 1,2,3,4, statistically significant difference was observed in the inhibitory effect of 5mg/ml quercetin when compared to lower concentrations (1-4mg/ml) ($p<0.05$) of quercetin against all the tested pathogens.

The Zone of inhibition for Fusobacterium nucleatum was of a larger diameter than that of 0.2% Chlorhexidine (Table 2). However, when statistically analyzed, there was no significant difference between the two and therefore can be considered equally effective. There was statistically significant difference observed in the inhibitory effect of 5mg/ml quercetin and 0.2% Chlorhexidine on Porphyromonas gingivalis (Table 1) and Tanerella forsythia (Table 4). There was more inhibition in the growth of the test pathogens by quercetin as compared to that of 0.2% Chlorhexidine.

DISCUSSION

The widespread nature of periodontal disease is mostly attributed to biofilm formation. In most environments, bacteria exist mainly in the form of biofilms(21). Developing biofilm communities is an adaptive strategy for the survival of bacteria in host environments(22). The biofilm phenotype is physiologically and functionally distinct from the planktonic bacteria. Bacteria enclosed in the biofilm structure can tolerate antibiotics and antibacterial agents more than 100–1000 times higher than planktonic bacteria and protect bacteria from attack by the host immune system, which enables persistent infection(22) (23). *P. gingivalis* has the ability to form biofilm, matrix-enclosed structure in subgingival plaque. He et al in the year 2020(24)assessed theanti-biofilm properties of quercetin against bacterial pathogens by observing the structure and thickness of the biofilmwith the help of confocal laser scanning microscopy. They found that quercetin strongly inhibited biofilm formation by P. gingivalis by altering the bacterial cell surface hydrophobicity and bacterial aggregation. Cell surface hydrophobicity is considered an important attribute of bacteria that contributes to adhesion and biofilm formation. The study also showed that quercetin increased cell surface hydrophobicity which may lead to the inhibition of biofilm which strongly indicates the effectiveness of polyphenol quercetin. Taking this into consideration, this study was planned to understand the exact concentration which may be useful against periodontal pathogens. Also we wanted to evaluate the antibacterial potential of quercetin against the red and orange complex bacteria rather than just P. gingivalis.

These two complexes are comprised of the species that are major etiologic agents of periodontal diseases(25). The orange complex consisting of anaerobic gram-negative species such as Prevotella intermedia and Fusobacterium nucleatum (25). They cause periodontal destruction. Tanerella forsythia and Porphyromonas gingivalis are highly virulent and they also cause further progression of the disease(25).The present study highlights the effectiveness of quercetinat all concentrations (1-5 mg/ml) against all the four periodontal pathogens (Porphyromonas gingivalis, Fusobacterium nucleatum, Prevotella intermedia and Tanerella forsythia).However,only 4 mg/ml and 5 mg/ml were effective against Prevotella intermedia. Similarly, same concentration (4mg/ml) showed inhibition of growth of Prevotella intermedia by Shu et al (2011)(26). However, the same concentration was ineffective against Fusobacterium nucleatum and Porphyromonas gingivalis which is contradictory to the findings of the present study. Studies in the literature have mentioned about its efficacy at further lower concentrations (<1mg/ml) against different periodontal pathogens. Study conducted by Cushnie and Lamb in 2005(27), found quercetin to be effective against P. gingivalis at a concentration of 200μM (0.06 mg/ml). According to them the antimicrobial effectof flavonoids like quercetin was due to inhibition of nucleic acid synthesis, inhibition of cytoplasmic membrane function and inhibition of energy metabolism.Shazad at al (2015)(28)outlined the potency of quercetin amongst 48 polyphenols againsttest strains of *P. gingivalis* & *F.* nucleatum at concentration of 0.0625 mg/ml and 0.5 mg/mlrespectively**.** Also, study conducted by Aithal et al (2018)(29)found nano emulsion gel of quercetin to be effective against Tanerella forsythia and Porphyromonas gingivalis. They found that the two bacteria were sensitive to quercetin at a concentration of 100μg/ml (0.1mg/ml). Quercetin can thus be considered as one of the potential polyphenolic extracts having antibacterial property against periodontal pathogens which play a fundamental role in progression of periodontal disease.

CONCLUSION

Taking into consideration the role of vast aggregation of putative pathogens in causing periodontal disease, it is of vital importance to search for a safer and reliable option which can help in taking care of the harmful bacteria.

Amongst the herbal products, polyphenols have gained importance in many pharmacologically significant fields. Apart from having various protective functions, quercetin appears to have promising antibacterial property. It can be concluded from the present study that quercetin with lowest concentration of 1 mg/ml to highest concentration of 5 mg/ml is a rational antibacterial option against deleterious periodontal pathogens such as Porphyromonas gingivalis, Fusobacterium nucleatum, Prevotella intermedia and Tanerella forsythia. This study can provide a base for formulation of quercetin to be used for human intervention. Additionally, further research is essential to better understand the mechanisms of quercetin's antimicrobial action and its potential role in combating drug-resistant pathogens.

Limitations of the study

Although in the present study, quercetin has been proven to be an effective antimicrobial agent, the study carries some limitations. Quercetin solutions at lower concentration range could have been tested based on the literature. The effect of quercetin could also have been studied on other bacteria associated with periodontal disease. Also, the effect was seen on bacterial cultures. Studies can be conducted on bacteria isolated from human plaque samples.

Future perspective

Studies need to be carried out to find out its cytotoxic property before employing it in humans. Also, quercetin can be combined with other plant derived chemicals to see if there can be any additive effect which can pave the way for developing different modalities for treating periodontal disease.

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Table 1: Comparison of antimicrobial efficacy of different concentration of quercetin and 0.2% chlorhexidine on cell culture of Porphyromonas gingivalis

(I)	*(J)*	Mean Difference*(I-J)*	p value
Group 1 **(0.2% CHX)** 18	Group 2 (5mg/ml quercetin) 13	05	0.04*
	Group 3 (4mg/ml quercetin) 12	06	0.04*
	Group 4 (3mg/ml quercetin) 11	05	0.03*
	Group 5 (2mg/ml quercetin) 10	08	0.00*
	Group 6 (1mg/ml quercetin) 09	09	0.00*
Group 2 (**5mg/ml quercetin) 13**	Group 1 (0.2% CHX) 18	-5	0.10
	Group 3 (4mg/ml quercetin) 12	01	0.09
	Group 4 (3mg/ml quercetin) 11	02	0.12
	Group 5 (2mg/ml quercetin) 10	03	0.05
	Group 6 (1mg/ml quercetin) 09	04	0.04*
Group 3 (**4mg/ml quercetin)** 12	Group 1 (0.2% CHX) 18	-6	0.11
	Group 2 (5mg/ml quercetin) 13	-1	0.09
	Group 4 (3mg/ml quercetin) 11	1	0.18
	Group 5 (2mg/ml quercetin) 10	2	0.04*
	Group 6 (1mg/ml quercetin) 09	3	0.04*
Group 4 (3**mg/ml quercetin)** 11	Group 1 (0.2% CHX) 18	-7	0.21
	Group 2 (5mg/ml quercetin) 13	-2	0.19
	Group 3 (4mg/ml quercetin) 12	-1	0.07
	Group 5 (2mg/ml quercetin) 10	1	0.06
	Group 6 (1mg/ml quercetin) 09	2	0.05
Group 5 **(2mg/ml quercetin)** 10	Group 1 (0.2% CHX) 18	-8	0.21
	Group 2 (5mg/ml quercetin) 13	-3	0.19
	Group 3 (4mg/ml quercetin) 12	-2	0.07
	Group 4 (3mg/ml quercetin) 11	-1	0.06
	Group 6 (1mg/ml quercetin) 09	1	0.06
Group 6 **(1mg/ml quercetin)** 09	Group 1 (0.2% CHX) 18	-9	0.10
	Group 2 (5mg/ml quercetin) 13	-4	0.09
	Group 3 (4mg/ml quercetin) 12	-3	0.08
	Group 4 (3mg/ml quercetin) 11	-2	0.06
	Group 5 (2mg/ml quercetin) 09	0	0.05

Table2: Comparison of antimicrobial efficacy of different concentration of quercetin and 0.2% chlorhexidine on cell culture of Fusobacterium nucleatum

(I)	*(J)*	Mean Difference*(I-J)*	p value
Group 1 **(0.2% CHX)** 14	Group 2 (5mg/ml quercetin) 15	-1	0.10
	Group 3 (4mg/ml quercetin) 13	1	0.11
	Group 4 (3mg/ml quercetin) 11	3	0.02
	Group 5 (2mg/ml quercetin) 11	3	0.02
	Group 6 (1mg/ml quercetin) 10	4	0.00*
Group 2 (**5mg/ml quercetin)** 15	Group 1 (0.2% CHX) 14	1	0.10
	Group 3 (4mg/ml quercetin) 13	2	0.09
	Group 4 (3mg/ml quercetin) 11	4	0.05
	Group 5 (2mg/ml quercetin) 11	4	0.05
	Group 6 (1mg/ml quercetin) 10	5	0.04*

Group 3 (**4mg/ml quercetin)** 13	Group 1 (0.2% CHX) 14	-1	0.11
	Group 2 (5mg/ml quercetin) 15	-2	0.09
	Group 4 (3mg/ml quercetin) 11	2	0.18
	Group 5 (2mg/ml quercetin) 11	2	0.03*
	Group 6 (1mg/ml quercetin) 10	3	0.04*
Group 4 (**3mg/ml quercetin)** 11	Group 1 (0.2% CHX) 14	-3	0.21
	Group 2 (5mg/ml quercetin) 15	-4	0.19
	Group 3 (4mg/ml quercetin) 13	-2	0.07
	Group 5 (2mg/ml quercetin) 11	0	0.06
	Group 6 (1mg/ml quercetin) 10	1	0.05
Group 5 (**2mg/ml quercetin)** 11	Group 1 (0.2% CHX) 14	-3	0.21
	Group 2 (5mg/ml quercetin) 15	-4	0.19
	Group 3 (4mg/ml quercetin) 13	-2	0.07
	Group 4 (3mg/ml quercetin) 11	0	0.06
	Group 6 (1mg/ml quercetin) 10	1	0.06
Group 6 **(1mg/ml quercetin)** 10	Group 1 (0.2% CHX) 14	-4	0.10
	Group 2 (5mg/ml quercetin) 15	-5	0.09
	Group 3 (4mg/ml quercetin) 13	3	0.08
	Group 4 (3mg/ml quercetin) 11	-1	0.06
	Group 5 (2mg/ml quercetin) 11	-1	0.05

Table 3: Comparison of antimicrobial efficacy of different concentration of quercetin and 0.2% chlorhexidine on cell culture of Prevotella intermedia

(I)	***(J)***	**Mean Difference*(I-J)***	**p value**
Group 1 **(0.2% CHX)** 16	Group 2 (5mg/ml quercetin) 13	03	0.05
	Group 3 (4mg/ml quercetin) 09	07	0.04*
	Group 4 (3mg/ml quercetin) 00	16	0.03*
	Group 5 (2mg/ml quercetin) 00	16	0.00*
	Group 6 (1mg/ml quercetin) 00	16	0.00*
Group 2 (**5mg/ml quercetin) 13**	Group 1 (0.2% CHX) 16	-3	0.10
	Group 3 (4mg/ml quercetin) 09	04	0.04*
	Group 4 (3mg/ml quercetin) 00	13	0.00*
	Group 5 (2mg/ml quercetin) 00	13	0.00*
	Group 6 (1mg/ml quercetin) 00	13	0.00*
Group 3 (**4mg/ml quercetin)** 09	Group 1 (0.2% CHX) 16	-7	0.11
	Group 2 (5mg/ml quercetin) 13	-4	0.09
	Group 4 (3mg/ml quercetin) 00	09	0.00
	Group 5 (2mg/ml quercetin) 00	09	0.00*
	Group 6 (1mg/ml quercetin) 00	09	0.00*
Group 4 (**3mg/ml quercetin)** 00	Group 1 (0.2% CHX) 16	-16	0.17
	Group 2 (5mg/ml quercetin) 13	-13	0.12
	Group 3 (4mg/ml quercetin) 09	-09	0.07
	Group 5 (2mg/ml quercetin) 00	00	0.06
	Group 6 (1mg/ml quercetin) 00	00	0.06
Group 5	Group 1 (0.2% CHX) 16	-16	0.23
	Group 2 (5mg/ml quercetin) 13	-13	0.21
	Group 3 (4mg/ml quercetin) 09	-09	0.09

(2**mg/ml quercetin)** 00	Group 4 (3mg/ml quercetin) 00	00	0.08
	Group 6 (1mg/ml quercetin) 00	00	0.08
Group 6 **(1mg/ml quercetin)** 00	Group 1 (0.2% CHX) 16	-16	0.13
	Group 2 (5mg/ml quercetin) 13	-13	0.09
	Group 3 (4mg/ml quercetin) 09	-09	0.08
	Group 4 (3mg/ml quercetin) 00	00	0.06
	Group 5 (2mg/ml quercetin) 00	00	0.06

Table 4: Comparison of antimicrobial efficacy of different concentration of quercetin and 0.2% chlorhexidine on cell culture of Tanerella forsythia

(I)	*(J)*	**Mean Difference*(I-J)***	**p value**
Group 1 **(0.2% CHX)** 18	Group 2 (5mg/ml quercetin) 14	04	0.04*
	Group 3 (4mg/ml quercetin) 12	06	0.04*
	Group 4 (3mg/ml quercetin) 11	07	0.03*
	Group 5 (2mg/ml quercetin) 10	08	0.00*
	Group 6 (1mg/ml quercetin) 09	09	0.00*
Group 2 (**5mg/ml quercetin) 14**	Group 1 (0.2% CHX) 18	-4	0.10
	Group 3 (4mg/ml quercetin) 12	02	0.09
	Group 4 (3mg/ml quercetin) 11	03	0.12
	Group 5 (2mg/ml quercetin) 10	04	0.05
	Group 6 (1mg/ml quercetin) 09	05	0.04*
Group 3 (4**mg/ml quercetin)** 12	Group 1 (0.2% CHX) 18	-6	0.11
	Group 2 (5mg/ml quercetin) 14	-2	0.09
	Group 4 (3mg/ml quercetin) 11	1	0.18
	Group 5 (2mg/ml quercetin) 10	2	0.04*
	Group 6 (1mg/ml quercetin) 09	3	0.04*
Group 4 (3**mg/ml quercetin)** 11	Group 1 (0.2% CHX) 18	-7	0.21
	Group 2 (5mg/ml quercetin) 14	-3	0.19
	Group 3 (4mg/ml quercetin) 12	-1	0.07
	Group 5 (2mg/ml quercetin) 10	1	0.06
	Group 6 (1mg/ml quercetin) 09	2	0.05
Group 5 (2**mg/ml quercetin)** 10	Group 1 (0.2% CHX) 18	-8	0.21
	Group 2 (5mg/ml quercetin) 14	-4	0.19
	Group 3 (4mg/ml quercetin) 12	-2	0.07
	Group 4 (3mg/ml quercetin) 11	-1	0.06
	Group 6 (1mg/ml quercetin) 09	1	0.06
Group 6 **(1mg/ml quercetin)** 09	Group 1 (0.2% CHX) 18	-9	0.10
	Group 2 (5mg/ml quercetin) 14	-5	0.09
	Group 3 (4mg/ml quercetin) 12	-3	0.08
	Group 4 (3mg/ml quercetin) 11	-2	0.06
	Group 5 (2mg/ml quercetin) 10	-1	0.05

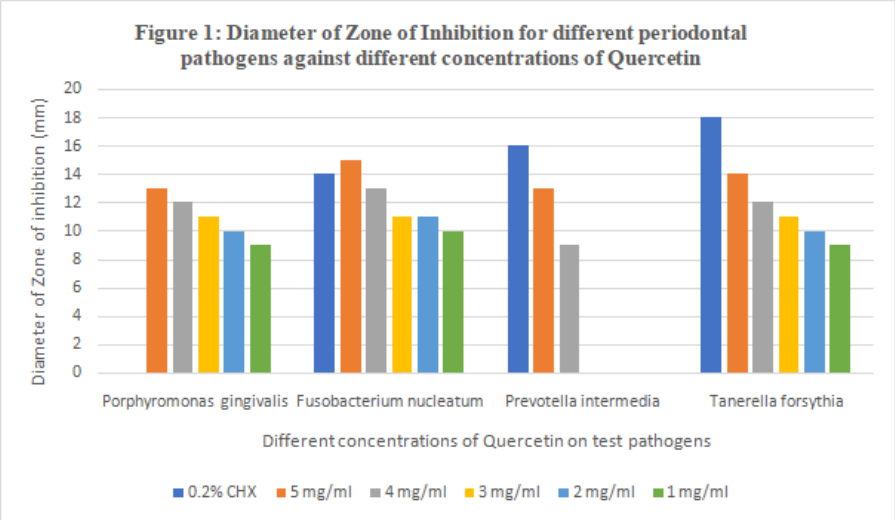


Figure 1: Diameter of Zone of Inhibition for different periodontal pathogens against different concentrations of Quercetin

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REVIEW ARTICLE

The Management of Breast Cancer using Medicinal Plants

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ABSTRACT

The fact that they are the main cause of death in women with breast cancer makes it even more important to find new and effective cancer drugs right away. Drugs for healing cancer that come from compounds found in plants have shown promise. Compared to hormone-targeted anti-cancer drugs, they work better because tolerance doesn't build up as quickly, they're safer, and they're less harmful when used. PubMed, Embase, Web of Science, and the Cochrane Library were all used in the study. The search strategy used words and phrases like breast cancer, clinical trials, botanicals, physiologically active components with anti-cancer properties," and "chemotherapeutic medicines. Scientists have written about how different herbs can help prevent and treat cancer. These herbs include ginseng, garlic (*Allium sativum*), black cumin (*Nigella sativa*), black cohosh (*Actaea racemose*), turmeric (*Curcuma longa*), echinacea, Arctium (burdock), and *Camellia sinensis* (green tea). The plants have anti-cancer properties that stop new blood vessels from growing, start cell death, limit cell growth, and manage important biological processes. To give strong proof of the healing benefits of these treatments, more clinical trials and cohort studies with human subjects are needed.

Keywords: Management, Breast Cancer and Medicinal Plants.

INTRODUCTION

Each minuscule cell that comprises our body is an independent, living entity. Growth and division in a normal somatic cell undergo a period of activity before coming to a halt. Subsequently, they engage in reproduction just in instances where it is necessary for the restoration of impaired or deceased cells. Cancer occurs when the process of cellular reproduction becomes uncontrolled. The abnormal development and division of cancer cells may be attributed to the damage inflicted on their DNA, which is the genetic material responsible for determining their biological characteristics and functioning. Cellular DNA can undergo several forms of malfunction and damage. For example, being exposed to tobacco smoke or other environmental factors can trigger a sequence of events that lead to cellular DNA abnormalities and ultimately result in the development of cancer. Conversely, it is possible for you to inherit flawed DNA from your parents. Tumours are aggregations of cancer cells that originate from the proliferation and duplication of cancer cells (1). Tumours exert a substantial impact on the symptoms of cancer by compressing, crushing, and causing the demise of the adjacent non-cancerous cells and tissues.

Cancer is distinct from infectious and environmental diseases caused by antigens that are not present in human body, as well as diseases associated with microorganisms and parasites. Human malignancies can develop due to several circumstances, such as genetic or epigenetic influences that lead to mutations in normal cells. Epigenetics is the scientific field that investigates how changes in the way genes are expressed can lead to the abnormal growth of cells. The causes of cancer include dysregulation of apoptosis, abnormal gene function, changes in gene expression patterns, disruption of normal cell growth, development, and control, initiation of angiogenesis, and metastasis to healthy tissues or organs. Metastasis refers to the process by which cancer cells migrate from their primary site to a distinct, healthy region inside a tissue or organ. The ancient Greeks defined cancer as a manifestation of melancholy and the presence of black bile (2, 3). Prioritizing early cancer detection, prevention, and therapy is of utmost importance for several cancer research groups. According to GLOBOCAN estimates, there is an anticipated global increase of 47% in the number of new cancer cases, reaching 28.4 million in 2040 compared to the average number of cases in 2020. Anticipated demographic shifts are projected to lead to a significant surge in the rate of transitioning, with estimates ranging from 32 to 56 percent to 65 to 95 percent. Furthermore, this rate may further escalate due to rapid economic expansion and Globalisation. Cancer patients commonly endure worry and pessimism as a result of the prevailing notion that the cancer is untreatable. Additionally, they may encounter discomfort and unfavourable consequences stemming from chemotherapy. Hence, scientific investigation in the field of cancer is of utmost significance in order to advance a more effective and enduring healthcare system and therapy to fulfil the medical needs of individuals afflicted with the ailment and prolong their lifespan (4, 5).

Breast Cancer

Worldwide, invasive breast cancer was the most common cancer in women in 2020, with over 11.7 percent of new cases. In the United States, 1 in 8 women and 1 in 10 men will get breast cancer at some point in their lives. Among women aged 40 and up, 95% of all new cases of breast cancer are detected. In women aged 75–79, the incidence rate of breast cancer reaches a maximum of 421.3 cases per 100,000. This rate increases with age. The median age of a woman's breast cancer diagnosis is 61 years old. The incidence of breast cancer rose sharply up to the year 2000, after which it began to decline. Declines are more pronounced for women younger than 50. The mortality rate from breast cancer has decreased in North America and several parts of Europe during the last quarter of a century as a result of better detection methods and more effective treatments. Between 1980 and 2020, there was a 43% decline in the breast cancer death rate in the United States. Despite this, breast cancer is becoming more common and is killing more people in a number of African and Asian countries (6). Even inside the US, there is a discernible racial and socioeconomic disparity in the rates of detection and survival. Death rates among African Americans are significantly higher than those among non-Hispanic whites, even though the incidence is highest among this group. Of all cancers, 23% are breast cancers, and 14% of cancer-related fatalities occur each year due to this disease. among addition to being the most prevalent cancer diagnosis among women, it is also the top cause of cancer-related mortality in this population. Reports indicate that the incidence of breast cancer in Uganda is 22 cases per 100,000 people, with a 5-year survival rate of 56%. By 2030, the burden of breast cancer is projected to double due to changes in risk factors

and population rise. Surgery, radiation therapy, and chemotherapy are the mainstays of breast cancer treatment. Tragically, just 25% of breast cancer patients in Uganda have access to radiation treatment, and survival rates are worse than average because to subpar nursing care, surgery, and a lack of both advanced and basic systemic medicines. Most patients present with clinical stages IV and III, and there is a median delay of 13 months before patients in Uganda seek treatment for breast cancer. Many breast cancer patients, particularly those residing in rural Uganda, may not be able to travel to the one public health facility in the country that provides specialist cancer treatment, which might be contributing to the delay. In addition, patients are still required to pay for their own medication as the Uganda Cancer Institute is sometimes out of stock, even though the government of Uganda covers 92.7% of the cost. Because of financial concerns, patients who cannot afford these drugs discontinue therapy. Herbal therapies, whether prepared at home or prescribed by traditional medical practitioners, are commonly used by breast cancer patients and other cancer patients as well (7, 8).

Advantages of herbal drugs over allopathic drugs

Many people worldwide depend on medicinal plants for healing. Plants' medicinal and economic benefits are being recognised and developed in poor and developed nations. A botanical, or herb, is a plant or plant component used for its aroma, flavour, or therapeutic properties. Botanical supplements, botanicals, and phytomedicines are used to maintain or improve health. Pharmacological therapy has traditionally employed natural remedies to treat chronic conditions or enhance health. About 25% of the pharmacopoeia is plant-derived, estimates say. Local and regional healing traditions use raw or slightly processed plant-based medicines to treat ailments. Herbal drugs are used to promote health, prevent diseases, when conventional treatments have limited options or poor outcomes for a serious illness, when conventional therapies have been exhausted, when conventional therapies are dissatisfactory or ineffective, when conventional medicine has significant side effects or risks, and when herbal and natural products are believed to be safer. Allopathic medications have several severe side effects. Sleeplessness, nausea, diarrhoea, constipation, dizziness, suicidal thoughts, anger, depression, mania, seizures, coma, anaemia, alopecia, hyperglycemia, kleptomania, edoema, impotence, panic attacks, disorientation, syncope, and death are adverse effects. Seniors sometimes struggle to manage many medicines, which may increase the risk of allopathic side effects. Allopathic medicine usually treats health issues with medications or surgery. Drugs conceal the problem since they restrict and change physiological function rather than treat it. Sometimes this helps, especially in severe pain. However, there may be few or no disease-enhancing therapies. Patients who qualify for alternative therapy are denied it. Pharmaceuticals, surgeries, hospital stays, and other medical procedures may cause adverse reactions including death (9,10).

Medicinal Plants effective against Breast Cancer

Plant-derived chemicals show promise as anti-tumor and anti-cancer drugs. Their effectiveness also reduces toxicity and hormone-targeting anti-cancer medication resistance. These chemicals affect the immune system, inhibit cancer cell proliferation, and inhibit apoptosis due to their antioxidant and anti-inflammatory properties. This is done in a chemo-preventive fashion that may be used as a preventative and therapeutic approach and is safe for long-term use. Additionally, existing anti-breast cancer drugs are toxic and must be used long-term. While plants are important reservoirs of modern anti-cancer medications like Paclitaxel, Vincristine, and Vinblastine, as well as plant-based remedies used by breast cancer patients, including those claiming to cure, the traditional treatment methods and specific plants used by communities in India and other developing nations for breast cancer treatment, along with the theories that support their continued use, are unclear. The bioactive components that fight breast cancer in these plants are unknown. Thus, untested therapies may harm people. This has slowed the development of cancer-fighting pharmaceuticals from medicinal plants. Traditional health practitioners' knowledge and practices concerning breast cancer detection and treatment using medicinal herbs were examined (11-13).

Moringa oleifera

Moringa oleifera is a tree that grows quickly and can survive in dry conditions. It is widely used in South and Southeast Asia, but it comes from the Indian subcontinent. A person that is in the *Moringaceae* family. In coastal or archipelagic parts of Asia, this plant is also known as the horseradish tree, the moringa tree, the drumstick tree, and

the malunggay tree. This is because the roots of this plant taste a lot like horseradish. In every part of its range, *M. oleifera* is used in a lot of different ways in cooking. Whole leaves, leaflets, stalks, and stems; raw, green fruits or seed pods; fragrant flowers; young seeds; and roots are all parts of the plant that can be eaten (14).

Pimenta dioica

The tropical tree Pimenta dioica comes from the Caribbean and is used for many things, like food, perfume, traditional medicine, and natural bug spray. The full, dried Pimenta dioica fruit that Christopher Columbus found on his trips were found in Jamaica. It helps with symptoms like nausea, diarrhea, vomiting, and even constipation because it has a lot of eugenol in it. The vitamins in pimento may help with cramps and stomach because they reduce inflammation. Although pimento doesn't actually numb or relieve pain, it does help muscles relax and ease pain. In Central America and the Caribbean, pimento has been used a lot in traditional healing. It can help with colds, ease menstrual cramps, and settle an upset stomach when made as tea. Some of the conditions that all-spice salves can help with are bruises, muscle pain, and stiff joints (15,16).

Achyranthes aspera

Achyranthes aspera, "an Amaranthaceae weed, grows on Indian roadsides. Methanol preparations of stem bark include saponin fractions alkaloid and non-alkaloid that prevent EBV. In vitro, non-alkaloid fractions with nonpolar chemicals have the best inhibitory efficacy, whereas in vivo, the complete methanol extract inhibits mouse skin carcinogenesis in two stages. The Achyranthes aspera leaf DMSO extract inhibits cell proliferation 100%. The extract's cytotoxicity impact is assessed by direct cell count analysis, revealing a 24.9 ± 0.3 percent decrease in proliferation following 72 h and 24 h of medium replacement therapy at 200 μg/mL (17).

Andrographis paniculate

The aerial plant part's ethanol extraction yielded fourteen phytochemically recognised components. Labdane diterpenoids and flavonoids were abundant. The isolate may decrease tumour development in different cell lines. Three cytotoxic and immune-stimulating components make up the dichloromethane fraction. It causes headaches, weariness, gastrointestinal discomfort, bitter taste, and liver dysfunction if ingested in large doses. A. paniculata leaf ethanol extract inhibits IMR-32 and HT-29 cell lines at 200 μg/mL, whereas other extracts yield 50% inhibition at 250 μg/mL. Water, ethanol, and acetone extracts of A. paniculata leaves inhibited HT-29 cancer cell lines by 50% at 200 μg/mL concentration (18).

Annona muricata

Graviola contains medicinal acetogenins that inhibit human cell ATP generation and will help eliminate cancer medications. Annona muricata is derived from seeds, bark, fruit, and leaves. Multiple drug-resistant tumours can be treated with acetogenin. Several acetogenins are toxic to cancer cell lines, including carcinoma tumours, prostatic adenocarcinoma, lung solid human breast cancer, human lymphoma, pancreatic carcinoma, multiple-drug-resistant human breast cancer, liver cancer, and colonic cancer. A. muricata ethanolic extract was investigated for anticancer efficacy against MDA and SKBR3 breast cancer cell lines using MTT assay (19-21).

Bidens Pilosa

Contains terpenoids, polyacetylenes, phenylpropanoids, flavonoids, etc. Phenyl-1,3,5-heptatriyne, which is harmful to normal blood, is extracted, fractionated, isolated, and characterized from the plant. Though hexane extract has a significant anticancer impact, methanol, chloroform, and plant extract and fractionation all show excellent results. Bidens Pilosa petroleum ether extract inhibited proliferation in human epithelial cancer cell line, hepatoma cancer cell line, human nasopharyngeal carcinoma cell line (CNE-2), and murine tumour. IC50 = 49.11 ± 2.72 μg/mL. Petroleum ether extract of Bidens Pilosa contains triterpenes, which have anticancer action in vivo and in vitro (22,23). India is sometimes called the "Botanical Garden of the World" because it is a global leader in producing medicinal botanicals. medical plants possess intrinsic medical capabilities that can effectively treat many disorders. Additionally, these plants provide extraordinary nutrition and serve as valuable resources for commercial uses.

Extensive research has been carried out on these plants with the aim of fighting cancer. Some plant-derived chemicals have been promoted as anticancer drugs, drawing on both traditional uses and scientific evidence (Table 1). These plants can improve the host's immune system by supporting the equilibrium and health of physiological tissues, therefore reducing the risk of infection. Multiple studies affirm that the antioxidants included in medicinal plants have the ability to treat cancer on their own. Therapeutic botanicals are really more easily accessible, cheaper, and devoid of harmful ingredients compared to modern (allopathic) pharmaceuticals. Once the plants have been separated and identified, it becomes feasible to generate different combinations of the isolated and identified active constituents. Nevertheless, more research is necessary to ascertain their potential synergy. Uniform delivery timings and doses are crucial for the effective treatment of cancer. Both human and animal health require urgent and strong measures in response to the fast spread of cancer. Although medicinal plants show promise in the production of powerful anticancer drugs, further study is necessary.

Major Anticancer Agents Obtained from Medicinal Plants

Nearly 10 million deaths are expected in 2020 from cancer, according to WHO.Many phytocompounds bioactivities for health benefits have been explored for decades. Phytocompounds are replacing synthetic drugs because they affect a wide range of target cells with lower cell cytotoxicity and side effects than synthetic anticancer compounds, which prevent and treat carcinoma. Anticancer properties of Murraya koenigii leaf extract ZnO nanoparticles and other medicinal plants. 50% of contemporary cancer medications come from medicinal herbs. Over 80% of people in underdeveloped nations utilise traditional medicinal herbs, and 60% of cancer patients use herbal treatment. High-risk breast cancer patients receive tamoxifen and similar drugs like raloxifene. Most cancer research studies have examined curcumin, polyphenols, Withaferin A (WFA), a triterpenoid, celastrol, and berry bioactives for anti-proliferative action. Vinca alkaloids, podophyllotoxin, taxanes, campothecin, homoharringtonine, saponin, isoquinoline, shatavarine IV, stigamsterola, calotropin, and shikonin phytocompounds are discussed" (47).

Vinca Alkaloids

On December 8, 2016, the WHO Model List of Essential Medicines declared Vinca alkaloids the first plant-based antimitotic substance used in pharmaceuticals and therapeutics and extremely successful in treating and using them. First-generation cancer treatments included vinblastine, vinca alkaloids, and leurocristine from Catharanthus roseus. In an attempt to produce oral hypoglycemic medications, these chemicals were isolated from the Catharanthus roseus plant species, however they reduced white blood cell count and lowered bone marrow in rats. This plant extract extends the lifespan of transplantable lymphocytic leukaemia mice. Vindesine (VDS) and vinorelbine (VRLB), semi-synthetic vinca alkaloids, can be used with other chemotherapy medicines to treat certain malignancies. Vinblastine treats Kaposi's sarcoma, breast, leukaemia, testicular, lung, and lymphoma. Childhood acute lymphocytic leukaemia is treated with vincristine (48).

Podophyllotoxin Derivatives

Anticancer treatment uses podophyllotoxin (PTOX) compounds etoposide, teniposide, and etoposide phosphate from Podophyllum peltatum L. (Berberidaceae) and Podophyllum emodi Wall. The aryltetralin-lignan PTOX is very cytotoxic. In germ cell tumours and small cell and non-small cell lung malignancies, podophyllotoxin derivatives inhibit proliferation. TOP-53, a derivative of podophyllotoxin, has antitumor and anticancer properties against lung cancer and lung metastasis. TOP-53 exhibited cytotoxicity activity (IC50 = 0.016-0.37 μg/mL) against mouse tumours and 0.26-8.9 μg/mL against human NSCLC cell lines. The TOP-53 podophyllotoxin derivative is also effective against lung localized and metastatic tumours (48,49).

Taxanes

Taxol or Paclitaxel was the first Taxus brevifolia Nutt. (Taxaceae) bark chemical isolated. Taxus species including T. canadensis Marshall, T. baccata L., and T. brevifolia have been utilised to cure ovarian and breast malignancies. This has increased demand. T. baccata leaves were used to cure cancer in Ayurveda. Taxanes from T. wallichiana plants are anti-inflammatory, analgesic, antipyretic, antiallergic, immunomodulatory, anticonvulsant, anti-conceptive, anti-osteoporotic, antiplatelet, antifungal, antibacterial, and antispasmodic. Taxus leaves contain paclitaxel. Baccatins are

abundant and converted to paclitaxel and active paclitaxel analogues like docetaxel or Taxotere, which treat Kaposi sarcoma, lung, ovarian, and breast cancer. Paclitaxel may treat non-cancerous disorders such rheumatoid arthritis, psoriasis, and MS. Breast cancer is mainly treated with semisynthetic docetaxel. The efficacy of docetaxel was statistically analysed by establishing a clinical study with over a dozen taxanes analogues (47,48).

Camptothecin Derivatives

Camptothecin, a phytochemical derived from the Chinese ornamental tree Camptotheca acuminata Decne (Nyssaceae), was initially utilised as an anticancer drug in the early 1960s. This displays anticancer medication development progress. Camptothecin from Camptotheca acuminata species has strong anti-tumor and anticancer effectiveness among 1000 plant extracts examined. The Camptotheca acuminata plant has this unusual trait. The active compounds extracted from it were identified as camptothecin, which the NCI considered for clinical studies in the 1970s. However, its bladder toxicity problem made it obsolete. Glaxo SmithKline produces Topotecan (Hycamtin) and effective camptothecin derivatives, while Yakult Honsha, a Japanese business, develops Irinotecan, which is more effective. Colorectal cancers are treated with irinotecan, whereas lung and ovarian tumours with topotecan (47-49).

Homoharringtonine

Semi-synthetic cephataxine homoharringtonine was first produced and used therapeutically from the Chinese tree Cephalo taxus harringtonia var drupacea. Elliptinium comes from the Apocynaceae family, which includes Fijian anticancer herb Bleekeri avitensis. Chinese chronic myelogenous leukaemia therapy uses HHT and harringtonine. Due to medication resistance, pure homoharringtonine is utilised to treat leukemias. Elliptinium treats breast cancer in France. HHT fights cancer. HHT 25 mg/kg suppresses tumour development like cisplatin. Cisplatin also reduces weight, unlike HHT. In a lung cancer xenograft mouse model, 10 mg/kg cisplatin and 15 mg/kg and 25 mg/kg HHT reduced tumours by 69.6%, 40.5%, and 74.6%. We may infer that HHT treats lung cancer well. Omacetaxine mepesuccinate generally treats breast cancer and leukaemia. This medication causes cell death by preventing peptidyl transferase centre production (48,49).

SUMMARY AND CONCLUSION

This review fully proved these nine herbs' breast cancer chemopreventive and chemotherapeutic properties. The results show that these herbs have anti-cancer properties in vitro and in vivo. The effects include preventing cell proliferation, cancer formation, metastasis, angiogenesis, apoptosis, and cell survival modifications. The herbs' active components control intracellular signalling, including vascular endothelial growth factor, nuclear factor-κB, and Bcl-2. Breast cancer development and progression depend on these regulators. However, limited bioavailability and pharmacokinetic characteristics limit the therapeutic efficacy of several physiologically active compounds in herbs, such as curcumin and thymoquinone. In lab and clinical studies, Echinacea inhibits cytochrome P450 enzymes (50). Oral administration using nanotechnology-based formulations and liposome carriers can overcome these limits. Some herbs' active compounds can boost the anti-cancer effects of chemotherapy drugs as tamoxifen, doxorubicin, 5-fluorouracil, and paclitaxel. Additionally, chemotherapy drugs became more effective and less harmful. The focus is on administering chemotherapeutic drugs and nano-formulated curcumin to boost its preventive and therapeutic effects. To assess the risks and benefits of combining the nano-formulation of the active chemical with standard chemotherapy, more clinical trials are needed. These herbs primarily inhibit cancer in a variety of human cancer cell lines and, to a lesser extent, in animal tumour models. Thus, while the statistics imply that these herbs have several anti-cancer properties, clinical study is needed to confirm them. Furthermore, greater study on existing and new biologically active compounds obtained from these herbs should include rigorous quality control, toxicological, safety, and pharmacodynamic and pharmacokinetic studies. To learn about these plants' therapeutic properties, further clinical trials and cohort human studies are needed (51).

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Table 1:Anti-cancer activities of commonly studied herbs (24-46)

Sr. No.	Title of the paper	Journal name	Plant used	Reference
1	Ginsenoside Rh2 epigenetically regulates cell-mediated immune pathway to inhibit proliferation of MCF-7 breast cancer cells	J. Ginseng Res.	Ginseng	Lee et al., (2018)
2	Chemo-preventive effects of heat-processed Panax quinquefolius root on human breast cancer cells	Anticancer Res.	Ginseng	Wang et al., (2010)
3	Diallyl disulfide (DADS) retards the growth of breast cancer cells in vitro and in vivo through apoptosis induction	Biomed. Pharmacol. J.	Garlic	Sujatha et al., (2017)
4	Curcumin inhibits cell proliferation of MDA-MB-231 and BT-483 breast cancer cells mediated by down-regulation of NFkappaB, cyclin D and MMP-1 transcription.	Phytomedicine.	*Curcuma longa*	Liu et al., (2010)
5	Potent growth suppressive activity of curcumin in human breast cancer cells: Modulation of Wnt/β-catenin signalling	Chem. Biol. Interact.	*Curcuma longa*	Prasad et al., (2010)
6	The anti-prolific effect of Echinacea Pallida on BT-549 cancer cell line.	Cancer Res.	*Echinacea*	Driggins et al., (2014)

7	Arctigenin, a dietary phytoestrogen, induces apoptosis of Estrogen receptor-negative breast cancer cells through the ROS/p38 MAPK pathway and epigenetic regulation.	Free Radic. Biol. Med.	*Arctium lappa (greater burdock)*	Hsieh et al., (2013)
8	The anti-metastatic effects of the phytoestrogen Arctigenin on human breast cancer cell lines regardless of the status of ER expression.	Int. J. Oncol.	*Arctium lappa (greater burdock)*	Maxwell et al., (2017)
9	Flaxseed and pure secoisolariciresinol diglucoside, but not flaxseed hull, reduce human breast tumor growth (MCF-7) in athymic mice.	J. Nutr.	*Flaxseed (dietary)*	Chen et al., (2010)
10	Molecular targeting of Akt by thymoquinone promotes G (1) arrest through translation inhibition of cyclin D1 and induces apoptosis in breast cancer cells.	Life Sci.	*Nigella sativa*	Rajput et al., (2013)
11	Effect of thymoquinone on P53 gene expression and consequence apoptosis in breast cancer cell line.	Int. J. Prev. Med.	*Nigella sativa*	Dastjerdi et al., (2016)
12	Thymoquinone inhibits bone metastasis of breast cancer cells through abrogation of the CXCR4 signalling axis	Front Pharmacol.	*Nigella sativa*	Shanmugam et al., (2018)
13	Mangifera indica (Mango): A promising medicinal plant for breast cancer therapy and understanding its potential mechanisms of action	Breast Cancer: Targets and Therapy.	*Mangifera indica*	Yap et al., (2021)
14	Medicinal plants: their use in anticancer treatment.	International journal of pharmaceutical sciences and research	Naturally-derived compounds from medicinal plants	Greenwell et al., (2015)
15	Natural products for the management and prevention of breast cancer.	Evidence-Based Complementary and Alternative Medicine.	*Nigella sativa*	Mitra et al., (2018)
16	Medicinal plants commonly used against cancer in traditional medicine formulae in Sri Lanka.	Saudi Pharmaceutical Journal.	Ginseng	Kuruppu et al., (2019)
17	Effective medicinal plant in cancer treatment, part 2: review study.	Journal of evidence-based complementary & alternative medicine.	*Achillea wilhelmsii*	Kooti et al., (2017)
18	Current perspectives in the application of medicinal plants against cancer: novel therapeutic agents.	Anti-Cancer Agents in Medicinal Chemistry (Formerly Current Medicinal Chemistry-Anti-Cancer Agents).	Naturally-derived compounds from medicinal plants	Gezici et al., (2019)
19	Anti-cancer effect of Annona Muricata Linn Leaves Crude Extract (AMCE) on breast cancer cell line.	BMC complementary and alternative medicine	*Annona MuricataLinn* Leaves Crude Extract	Syed et al., (2016)

20	Rajeshkumar S. Anticancer activity of silver nanoparticles synthesized using aqueous fruit shell extract of Tamarindus indica on MCF-7 human breast cancer cell line.	Journal of drug delivery science and technology	*Tamarindus indica*	Gomathi et al., (2020)
21	Mangifera indica (Mango): A promising medicinal plant for breast cancer therapy and understanding its potential mechanisms of action.	Breast Cancer: Targets and Therapy.	*Mangifera indica (Mango)*	Yap et al., (2021)



Figure 1: ***Moringa oleifera***



Figure 2: ***Pimenta dioica***



Figure 3: ***Achyranthes aspera***



Figure 4:*Andrographis paniculate*



Figure 5:*Annona muricata*



Figure 6:*Bidens Pilosa*

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RESEARCH ARTICLE

GC-MS Analysis and Antioxidant Activity of Bio-Active Compounds from the Ethanolic Extract of the Charred form of Dried Rhizome of *Acorus calamus* (L.)

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ABSTRACT

Acute diarrhea stands out as one of the most prevalent illnesses among children. Rotavirus emerges as the leading cause of acute diarrhea in children under five years old, ranking as the sixth most common cause of mortality globally. Traditional methods have proven effective in treating diarrhea, with medicinal plants playing a significant role due to the multitude of active components stored in their roots and root modifications. *Acorus calamus* (L.), a member of the Acoraceae family, is a commonly used plant in traditional medicines like Siddha, particularly in charred form, for managing diarrheal diseases in children. This formulation, derived from the charred rhizome of *Acorus calamus* (L.), plays a pivotal role in controlling diarrhea, especially among pediatric populations. This study aimed to explore the chemical composition and antioxidant activity of ethanol extracts obtained from charred rhizomes. The phytochemicals present in the ethanolic extracts were analyzed using GC-MS, while the antioxidant activity of the test samples was assessed through the DPPH assay. The phytochemical analysis of the plant extracts

revealed the presence of 9 significant compounds, including D-Allose,Phenol, 3,5-bis(1,1-dimethylethyl)-,Galacto-heptulose, Asarone, Hexadecanoic acid, methyl ester,Cyclic octaatomic sulfur etc. These compounds had significant pharmacological activity andthese compounds exhibited moderate antioxidant activity in the DPPH assay. This study contributes to society's comprehension of the importance of plant-based traditional medicine, offering scientific evidence regarding the potential phytochemical constituents and their antioxidant activity in the charred form of *Acorus calamus* (L.) rhizome.

Keywords: *Acorus calamus*,anti-oxidant, charred form, DPPH assay, GC-MS

INTRODUCTION

Acute diarrhea is a common occurrence among pediatric patients in primary care settings. Among children under five years old, therota virus stands out as the leading cause, contributing significantly to global mortality rates. Typically, laboratory tests are not required for diagnosing diarrhea, as it can usually be diagnosed based on clinical presentation alone[1]. Failure to assess dehydration levels in a child with diarrhea can lead to severe complications such as electrolyte imbalances, renal failure, and even death. Therefore, it's crucial for physicians to accurately evaluate dehydration status, with oral rehydration therapy being the primary treatment for mild-to-moderate dehydration in children[2]. In Siddha pediatrics, diarrhea is termed as "*Kazhichal*" and is commonly observed in children aged 1 to 12 years. Traditional methods in Siddha medicine have demonstrated efficacy in managing diarrhea[3]. Roots and their modifications, particularly rhizomes, are rich sources of active compounds utilized in medicinal treatments[4]. Rhizomes from the *Zingiberaceae*[5]and *Acoraceae*[6]*f*amilies are extensively utilized in Indian medicine. The utilization of medicinal plants in traditional medicine has garnered recognition from the scientific community. Plant-based pharmaceuticals have gained popularity due to their effectiveness, affordability, and minimal side effects[7]. Plants offer a plethora of bio active compounds with diverse applications, serving as medicines, nutraceuticals, cosmetics, and functional foods. Calamus root, known by various names such as sweet cane, sweet flag, and flag root, is a semi-aquatic herb commonly found in tropical and temperate regions, particularly in moist areas of India[8]. *Acorus calamus* (L.), known by regional names such as *Pillai marunthu* and *Vacha*, is primarily used in charred form in Siddha medicine. It possesses various therapeutic properties including carminative, antiperiodic, and stomachic actions. The charring process is crucial for purifying *Acorus calamus* (L.) in Siddha medicine, ensuring the elimination of toxic elements[9]. Historically, dried rhizomes of *Acorus calamus* (L.) have been used to treat conditions such as dysentery, diarrhea, and asthma, among others. However, it's important to note that *Acorus calamus* (L.) dried rhizomes contain β-asarone, a compound associated with potential health risks, including carcinogenicity. Despite its therapeutic effects, caution should be exercised in its use[10,11]. The objective of this study was to investigate the efficacy of charred *Acorus calamus* (L.) rhizome in treating pediatric diarrhea. To the best of our knowledge, this study represents the first pre-clinical investigation specifically targeting the pediatric population.

MATERIALS AND METHODS

The dried rhizome of *Acorus calamus* (L.) was acquired from Trivandrum, Kerala, India, and its authenticity was confirmed by the Department of *Gunapadam Marunthiyal* (Pharmacology) at Santhigiri Siddha Medical College, Thiruvananathapuram. The rhizome underwent a process of charring in an earthen vessel until it reached a red-hot state, followed by placement under sand to eliminate oxygen. Subsequently, the charred rhizome was ground into powder, weighed, and stored in an airtight container.

Sample extraction for GC-MS analaysis and DPPH assay

An amount of 500 milliliters of ethanol was utilized to extract a 100-gram sample of powdered and burned rhizome in an orbital shaker for a period of 72 hours. The extraction process was repeated with the same solvent until a

transparent, colorless solution was obtained. The extracted material was then dried by complete evaporation and stored in an airtight container at 4°C for future use.

Method of Gas Chromotography-Mass Spectroscopy analysis

The GC-MS analysis of the Vasambu ethanol extract was conducted using a GCMS-QP2010 Shimadzu instrument with specific parameters. A Rtx - 5MS cross band 5% phenyl 95% dimethylpolysiloxane fused silica capillary column (30m x 0.25mmID x 0.25µm film thickness) was employed, with an injection volume of 1.0 µl. The injector temperature was set to 280 ºC, and the ion-source temperature was maintained at 250 ºC. Helium served as the carrier gas at a constant flow rate of 1 ml/min. The temperature program of the oven commenced at 50°C, held for one minute, then ramped up at a rate of 6 °C per minute until reaching 220 °C for five minutes, and finally increased to 280 °C for an additional five minutes. Electron ionization technique was utilized to obtain mass spectra, scanning fragments from 40 to 600 Da at a scan interval of 0.4 seconds. Comparison was made between the spectrum from the NIST20 library database and those of the isolated chemicals.

Evaluation of radical scavenging activity by the DPPH method

A DPPH test was employed to assess the antioxidant activity of the sample extract (Brand Williams, 2005). To 3.9 ml of DPPH solution (0.025 g/l in methanol), aliquots (0.1 ml) containing various concentrations of vasambu ethanol extract (5.0, 2.5, 1.25, 0.62, 0.3125, and 0.1563) were added. The absorbance was measured at 515 nm using a UV-visible spectrophotometer after a 30-minute incubation period at room temperature. Quercetin served as the standard for the DPPH assay. The DPPH scavenging activity was determined using the following formula:

% Inhibition = (A0 - A1) / A0 x 100

Where: A0 = Absorbance of the control in nm. A1 = Absorbance of the sample in nm.

Observations

The GC-MS graphs presented in Figure 1 illustrate the charred form of dried rhizome derived from Acorus calamus (L.), showcasing distinctive peaks and corresponding retention periods. Figure 4 and Table 1 provide insights into the GC-MS profile of the dried, charred rhizome of Acorus calamus (L.), revealing a diverse array of bioactive components. Identification of secondary metabolites within the profile was accomplished by analyzing fragmentation patterns and retention times utilizing mass spectra available in the NIST (National Institute of Standards and Technology) spectral library (version 1.10 beta, Shimadzu). To ascertain the potential medicinal applications of each active ingredient, additional resources were consulted, including Dr. Duke's phytochemical and ethnobotanical database from the National Agriculture Library in the United States, as detailed in Table 1.Table 2 and Figure 2 depict the findings of the DPPH assay conducted to evaluate the antioxidant activity of the standard, while Table 3 and Figure 3 illustrate the results for the trial sample. Through the DPPH assessment, the antioxidant activity was examined, revealing an IC50 value of 2.44 mg/ml for DPPH activity. This finding underscores the sample's efficacy in scavenging free radicals.

RESULTS AND DISCUSSION

According to Siddha literature, consumption of milk, ghee, fruit, coconut, groundnut, and jaggery in large quantities induces heat and flatus in the gut of the pediatric age group, which consumes only mother milk. This increased gas accumulation leads to indigestion, characterized by diarrheal disease in children. It is also induced by the improper food habits of breastfeeding mothers [3]. For all types of digestive problems, the charred form of dried rhizome from *Acorus calamus* (L.)is used as a single drug, or it is one of the ingredients in compound formulations like *Jathikkai ennai* for 21 types of *mantham, seriya mantha kiyazham,manthathirkku veppa ennai thylam, pal mantha kudineer, mantha kuligai,* and *manthathukku kuligai*[3] because of its pungent taste and hot potency, which lowers the air accumulation in the gut and cures the diarrhea. The main site of action of the charred form of dried rhizome from *Acorus calamus* (L.) is the gastrointestinal tract. It acts as a carminative, stomachic, and stimulant and cures the diarrhea induced by improper food habits in the pediatric community [12]. These bioactive compounds that have been identified have

antibacterial, antioxidant, antimicrobial, analgesic, anti-inflammatory, and anti-diarrheal activities. In addition, they are antioxidants that inhibit oxidation, a chemical process that could contribute to the production of free radicals [13]. It is important to check reliable Siddha books, practitioners, or academic research on Siddha medicine concerning this aspect—the charred form of dried rhizome of *Acorus calamus* (L.). Furthermore, individual responses may differ, just as with any herbal therapy, so it's essential that you consult with a Siddha practitioner or other healthcare provider before utilizing it for certain medical issues.

CONCLUSION

The molecules identified through GC-MS and DPPH analyses suggest various medicinal properties that could enhance the effectiveness of charred dried rhizome of *Acorus calamus (L.)* in treating a range of diseases. However, further research is imperative to substantiate its therapeutic efficacy.

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Table 1: GC-MS analysis of charred form of Rhizome of *Acorus calamus*(L.):

S.No	Run time(Min)	Area	Peak Area%	Similarity	Name of the compound	Pharamcological actions [13]
1.	19.001	160298	1.98	90	D-Allose	Anti-cancer, anti-oxidant,coagulant,demulcent, anti-diabetic, neuroprotective
2.	19.493	15218	0.19	70	Phenol, 3,5-bis(1,1-dimethylethyl)-	Antimicrobial, anti-cancer, anti-oxidant, neuroprotective
3.	20.083	13769	0.17	75	Galacto-heptulose	Nutritional, anti-diabetic, probiotic, beta-galactosidase-inhibitor
4.	21.560	27106	0.33	75	Asarone	Antiproliferative, immunosuppressive, anticonvulsant, CNS depressant, anxiolytic, anti-fatigue,anti-parkinson, neuroprotective, sedative, and anti-pyretic
5.	26.253	69582	0.86	71	2-Amino-5-hydroxy-6-3-[3,4,5-trimethoxy benzamido]pyrimidine pyrimidines derivatives	Anti-inflammatory, analgesic ,antioxidant, antiplatelet
6.	27.193	52814	0.65	83	Hexadecanoic acid, methyl ester	Anti-inflammatory
7.	29.414	20833	0.26	70	Cyclic octaatomic sulfur	Chelationtheraphy,vasodilation, antioxidant,anti-inflammatory,antimicrobial
8.	30.473	39268	0.49	74	Methyl stearate	Anti-inflammatory,antimicrobial activity
9.	39.015	57579	0.71	77	Hexadecanoic acid, 2-hydroxy-1-(hydroxymethyl) ethyl ester	Anti-inflammatory

Table 2: Anti-oxidant Activity of Standard – Quercetin

Standard - Quercetin Concentration (mg/ml)	% inhibition
0.001	45.72
0.002	46.61
0.004	57.75
0.0161	69.64
0.0642	70.6
IC50	0.003mg/ml

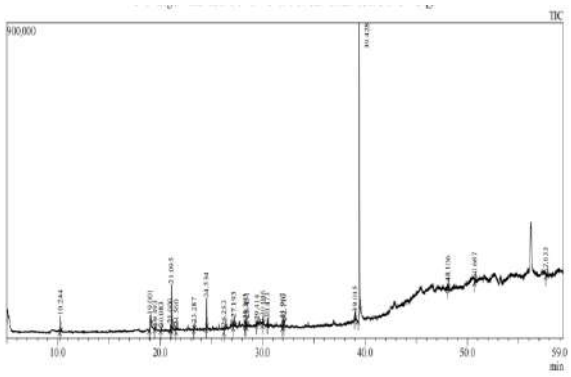


Figure 1: GC-MSChromatogram of charred form of Rhizome of *Acorus calamus*

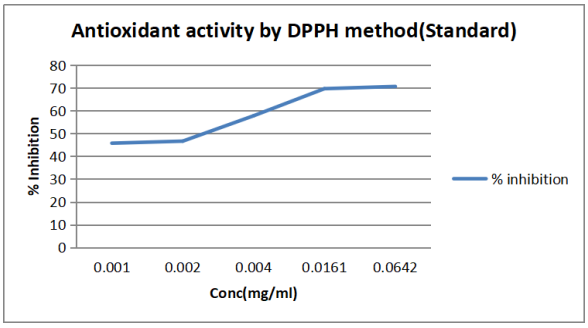


Figure 2: Anti-oxidant Activity of Standard - Quercetin

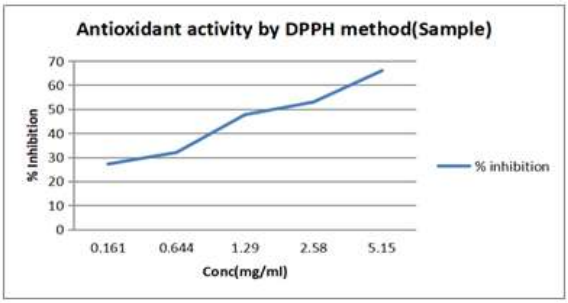
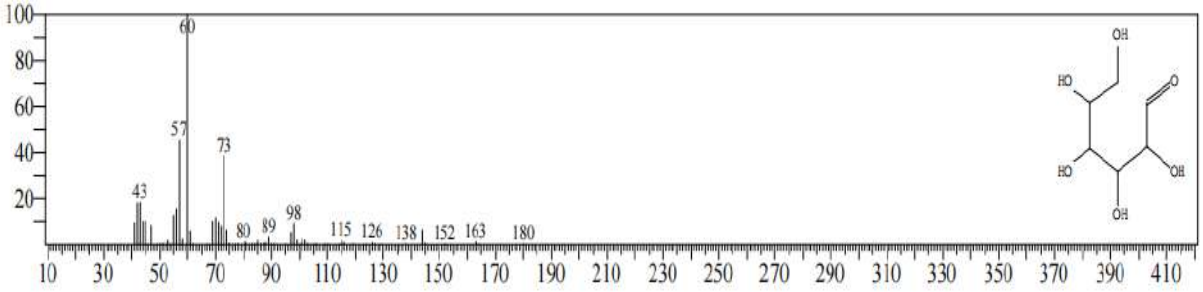
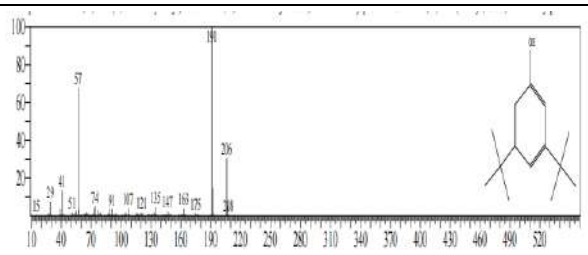


Figure 3: Anti-oxidant Activity of Sample

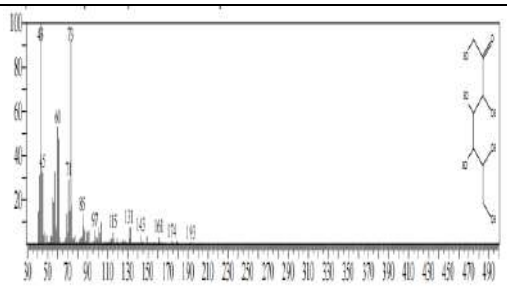
1) **D-Allose**



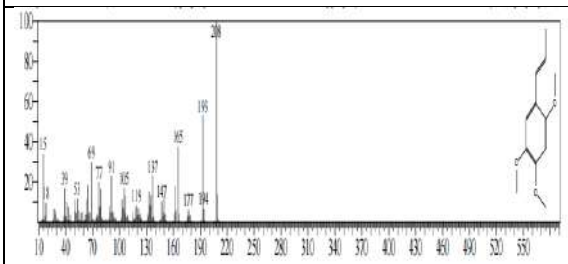
2) **Phenol, 3,5-bis(1,1-dimethylethyl)-**



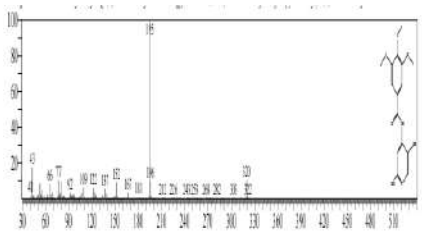
3) **Galacto-heptulose**



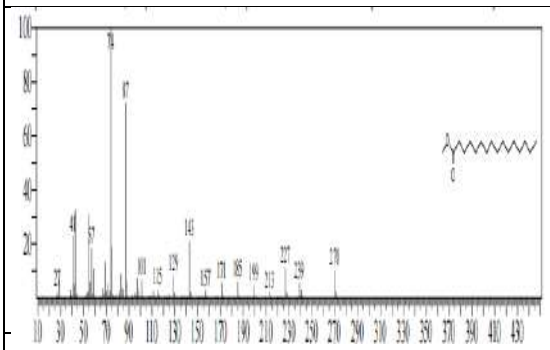
4) **Asarone**



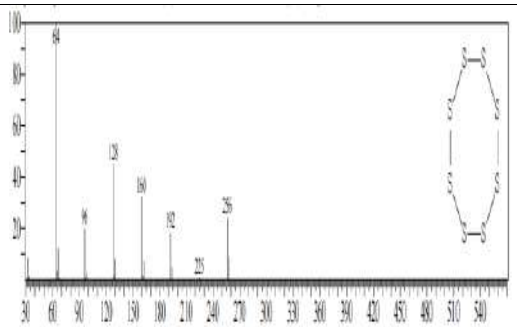
5) **2-Amino-5-hydroxy-6-[3,4,5-trimethoxybenzamido]pyrimidine**



6) **Hexadecanoic acid, methyl ester**

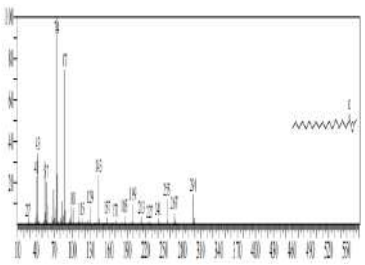


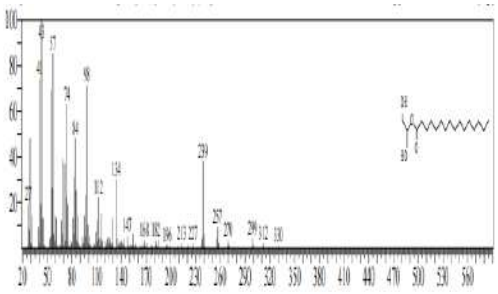
7) **Cyclic octaatomic sulfur**



8) **Methyl stearate**

9) **Hexadecanoic acid, 2-hydroxy-1-(hydroxymethyl)ethyl ester**





RESEARCH ARTICLE

Nano (1,2)⋆-gg⋆-Closed Sets

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ABSTRACT

In this paper, we introduce a new class of sets namely nano (1,2)*-g*-closed sets in nano bitopological spaces. This class lies between the class of nano (1,2)*-closed sets and the class of nano (1,2)*-g-closed sets. Also, we have studied the properties, applications of (1,2)*-g*-clodsed sets and compared with other related sets.

Keywords: nano closed sets, nano g-closed sets, nano (1,2)*-g*-closed sets and nano (1,2)*-g-closed sets.
Classification: 54C05, 54C08, 54C10.

INTRODUCTION

Lellis Thivagar et al.,[7] over took all these theory by bringing out a new topology to study the imperfect data in mathematics. The new topology is named as Nano Topology because of its size. Whatever may be the size of the universe, it is reduced to at most five open sets by defining the lower and upper approximations and boundary region of a subsets of a universe. The elements of the nano topology are called the nano open sets. Lellis Thivagar et al., [8] further established the weak forms of nano topology, nano topology in Čech rough closure space so on. Buvaneshwari et al., [2] investigated the concept nano (1,2)*-g-closed sets. They also amended the concept by imposing nano (1,2)*-g-semi open sets and nano (1,2)*-g-pre open sets in nano bitopological space. Recently, several nano bitopologiest introduce and investigated the novel concepts of generalized closed sets and maps (res. [5, 3, 5,

9]). In this paper, we introduce a new class of sets namely nano $(1,2)^{\star}$-$g^{\star}$-closed sets in nano bitopological spaces. This class lies between the class of nano $(1,2)^{\star}$-closed sets and the class of nano $(1,2)^{\star}$-g-closed sets.

Definition 1.1 [10] Let U be a non-empty finite set of objects called the universe and R be an equivalence relation on U named as the indiscernibility relation. Elements belonging to the same equivalence class are said to be indiscernible with one another. The pair (U, R) is said to be the approximation space. Let $X \subseteq U$.

1. The lower approximation of X with respect to R is the set of all objects, which can be for certain classified as X with respect to R and it is denoted by $L_R(X)$. That is, $L_R(X) = \cup_{x \in U} \{R(x): R(x) \subseteq X\}$, where R(x) denotes the equivalence class determined by x.
2. The upper approximation of X with respect to R is the set of all objects, which can be possibly classified as X with respect to R and it is denoted by $U_R(X)$. That is, $U_R(X) = \cup_{x \in U} \{R(x): R(x) \cap X \neq \phi\}$.
3. The boundary region of X with respect to R is the set of all objects, which can be classified neither as X nor as not - X with respect to R and it is denoted by $B_R(X)$. That is, $B_R(X) = U_R(X) - L_R(X)$.

Definition 1.2 [7] Let U be the universe, R be an equivalence relation on U and $\tau_R(X) = \{U, \phi, L_R(X), U_R(X), B_R(X)\}$ where $X \subseteq U$. Then $\tau_R(X)$ satisfies the following axioms:

1. U and $\phi \in \tau_R(X)$,
2. The union of the elements of any sub collection of $\tau_R(X)$ is in $\tau_R(X)$,
3. The intersection of the elements of any finite subcollection of $\tau_R(X)$ is in $\tau_R(X)$.

Thus $\tau_R(X)$ is a topology on U called the nano topology with respect to X and $(U, \tau_R(X))$ is called the nano topological space. The elements of $\tau_R(X)$ are called nano-open sets (briefly n-open sets). The complement of a n-open set is called n-closed.

Definition 1.3 [4] Let U be the universe, R be an equivalence relation on U and $\tau_{R_{1,2}}(X) = \cup \quad \{\tau_{R_1}(X), \tau_{R_2}(X)\}$ where $X \subseteq U$. Then it is satisfies the following axioms:

1. U and $\phi \in \tau_{R_{1,2}}(X)$.
2. The union of the elements of any sub collection of $\tau_{R_{1,2}}(X)$ is in $\tau_{R_{1,2}}(X)$.
3. The intersection of the elements of any finite sub collection of $\tau_{R_{1,2}}(X)$ is in $\tau_{R_{1,2}}(X)$.

Then $\tau_{R_{1,2}}(X)$ is a topology on U called the Nano bitopology on U with respect to X. $(U, \tau_{R_{1,2}}(X))$ is called the Nano bitopological space. Elements of the Nano bitopology are known as Nano $\tau_{1,2}$-open sets in U. Elements of $(\tau_{R_{1,2}}(X))^c$ are called Nano $\tau_{1,2}$-closed sets in $\tau_{R_{1,2}}(X)$.

Definition 1.4 [4] If $(U, \tau_{R_{1,2}}(X))$ is a nano bitopological space with respect to X where $X \subseteq U$ and if $A \subseteq U$, then

1. The Nano $(1,2)^{\star}$ closure of A is defined as the intersection of all Nano $(1,2)^{\star}$ closed sets containing A and it is denoted by $N_{\tau_{1,2}}$-$cl(A)$.
2. The Nano $(1,2)^{\star}$ interior of A is defined as the union of all Nano $(1,2)^{\star}$ open subsets of A contained in A and it is denoted by $N_{\tau_{1,2}}$-$int(A)$.

Definition 1.5 [2] Let G be a subset of a nano bitopological space $(U, \tau_{R_{1,2}}(X))$. Then G is called nano $(1,2)^{\star}$-g-closed set if $N_{\tau_{1,2}}$-$cl(G) \subseteq V$ where $G \subseteq V$ and V is nano $\tau_{1,2}$-open.

Definition 1.6 Let $(U, \tau_{R_{1,2}}(X))$ be a nano bitopological space and $A \subseteq U$. Then A is said to be

1. Nano $(1,2)^{\star}$-pre open [6] if $A \subseteq N_{\tau_{1,2}}$-$int(N_{\tau_{1,2}}$-$cl(A))$.
2. Nano $(1,2)^{\star}$-semi open [4] if $A \subseteq N_{\tau_{1,2}}$-$cl(N_{\tau_{1,2}}$-$int(A))$.

Definition 1.7 Let $(U, \tau_{R_{1,2}}(X))$ be a nano bitopological space and $A \subseteq U$. Then A is said to be

1. Nano $(1,2)^{\star}$-sg-closed set [4] if $N_{(1,2)^{\star}}$-$scl(A) \subseteq H$ whenever $A \subseteq H$ and H is nano $(1,2)^{\star}$-semi-open in U.

2. Nano $(1,2)^{\star}$-gs-closed set [4] if $N_{(1,2)^{\star}}$-$scl(A) \subseteq H$ whenever $A \subseteq H$ and H is nano $\tau_{1,2}$-open in U.
3. Nano $(1,2)^{\star}$-gp-closed set [6] if $N_{(1,2)^{\star}}$-$pcl(A) \subseteq H$ whenever $A \subseteq H$ and H is nano $\tau_{1,2}$-open in U.

Definition 1.8 [3] Let $(U, \tau_{R_{1,2}}(X))$ be a nano bitopological space and $A \subseteq U$. Then A is said to be a Nano $(1,2)^{\star}$-α-open if $A \subseteq N_{\tau_{1,2}}$-$int(N_{\tau_{1,2}}$-$cl(N_{\tau_{1,2}}$-$int(A)))$.

Definition 1.9 [3] Let $(U, \tau_{R_{1,2}}(X))$ is called a nano $(1,2)^{\star}$-αg-closed set if $N_{(1,2)^{\star}}$-$\alpha cl(A) \subseteq V$ whenever $A \subseteq V$ and V is nano $\tau_{1,2}$-open in V.

Definition 1.10 [5] A subset A of $(U, \tau_{R_{1,2}}(X))$ is called a nano $(1,2)^{\star}$-regular open set if $A \subseteq N_{\tau_{1,2}}$-$int(N_{\tau_{1,2}}$-$cl(A))$.

Definition 1.11 [5] A subset A of $(U, \tau_{R_{1,2}}(X))$ is called a nano $(1,2)^{\star}$-regular-generalized closed set if $N_{(1,2)^{\star}}$-$rcl(A) \subseteq V$ whenever $A \subseteq V$ and V is nano $(1,2)^{\star}$-regular open.

NANO $(1,2)^{\star}$-$g^{\star}$-CLOSED SETS

Definition 2.1 Let G be a subset of a nano bitopological space $(U, \tau_{R_{1,2}}(X))$. Then G is called
1. nano $(1,2)^{\star}$-$g^{\star}$-closed set if $N_{\tau_{1,2}}$-$cl(G) \subseteq H$ whenever $G \subseteq H$ and H is nano $(1,2)^{\star}$-g-open in U. The complement of nano $(1,2)^{\star}$-g *-closed set is called nano $(1,2)^{\star}$-g *-open.
The family of all nano $(1,2)^{\star}$-$g^{\star}$-closed sets in U is denoted by $N(1,2)^{\star}$-G $^{\star}C(U)$.
2. nano $(1,2)^{\star}$-$g^{\star}_{\alpha}$-closed set if $N_{(1,2)^{\star}}$-$\alpha cl(G) \subseteq H$ whenever $G \subseteq H$ and H is nano $(1,2)^{\star}$-g-open in U. The family of all nano $(1,2)^{\star}$-$g^{\star}_{\alpha}$-closed sets in U is denoted by $N(1,2)^{\star}$-G $^{\star}_{\alpha}C(U)$.

Proposition 2.2 Every nano $\tau_{1,2}$-closed set is nano $(1,2)^{\star}$-$g^{\star}$-closed.
Proof. If G is any nano $\tau_{1,2}$-closed set in U and F is any nano $(1,2)^{\star}$-g-open set containing G, then $F \supseteq G = N_{\tau_{1,2}}$-$cl(G)$. Hence G is nano $(1,2)^{\star}$-$g^{\star}$-closed.
The converse of Proposition 2.2 need not be true as seen from the following example.

Example 2.3 Let $U = \{a, b, c\}$ with $U/R_1 = \{\{a\}, \{b, c\}\}$ and $X = \{a\}$, $\tau_{R_1}(X) = \{\phi, \{a\}, U\}$. Then $U/R_2 = \{\{a, c\}, \{b\}\}$ and $X = \{c\}$, $\tau_{R_2}(X) = \{\phi, \{a, c\}, U\}$. Then the sets in $\{\phi, \{a\}, \{a, c\}, U\}$ are called nano $\tau_{1,2}$-open and the sets in $\{\phi, \{b\}, \{b, c\}, U\}$ are called nano $\tau_{1,2}$-closed. Then $\{a, b\}$ is nano $(1,2)^{\star}$-$g^{\star}$-closed set but not nano $\tau_{1,2}$-closed.
Proposition 2.4 Every nano $(1,2)^{\star}$-$g^{\star}$-closed set is nano $(1,2)^{\star}$-$g^{\star}_{\alpha}$-closed.

Proof. If G is a nano $(1,2)^{\star}$-$g^{\star}$-closed subset of U and F is any nano $(1,2)^{\star}$-g-open set containing G, then $F \supseteq N_{\tau_{1,2}}$-$cl(G) \supseteq N_{(1,2)^{\star}}$-$\alpha cl(G)$. Hence G is nano $(1,2)^{\star}$-$g^{\star}_{\alpha}$-closed.
The converse of Proposition 2.4 need not be true as seen from the following example.

Example 2.5 Let $U = \{a, b, c\}$ with $U/R_1 = \{\{a\}, \{b\}, \{c\}\}$ and $X = \{b\}$, $\tau_{R_1}(X) = \{\phi, \{b\}, U\}$. Then $U/R_2 = \{\{a, b\}, \{c\}\}$ and $X = \{b\}$, $\tau_{R_2}(X) = \{\phi, \{a, b\}, U\}$. Then the sets in $\{\phi, \{b\}, \{a, b\}, U\}$ are called nano $\tau_{1,2}$-open and the sets in $\{\phi, \{c\}, \{a, c\}, U\}$ are called nano $\tau_{1,2}$-closed. Then $\{a\}$ is nano $(1,2)^{\star}$-$g^{\star}_{\alpha}$-closed but not nano $(1,2)^{\star}$-$g^{\star}$-closed in U.

Remark 2.6 The following examples show that nano $(1,2)^{\star}$-$g^{\star}$-closed sets are independent of nano $(1,2)^{\star}$-α-closed sets.

Example 2.7 In Example 2.5, $\{b, c\}$ is nano $(1,2)^{\star}$-$g^{\star}$-closed but not nano $(1,2)^{\star}$-αclosed and $\{b\}$ is nano $(1,2)^{\star}$-αclosed but not nano $(1,2)^{\star}$-$g^{\star}$closed in U

Remark 2.8 The following examples show that nano (*1,2*)*-*g*closed sets are independent of nano (*1,2*)*-semi-closed sets.

Example 2.9 In Example 2.5, {*a*} is nano (*1,2*)*-*g*closed but not nano (*1,2*)*-semi-closed and {*b*} is nano (*1,2*)*-semi-closed but not nano (*1,2*)*-*g*closed in *U*

Remark 2.10 The following examples show that nano (*1,2*)*-*g*closed sets are independent of nano (*1,2*)*-pre-closed sets.

Example 2.11 In Example 2.5, {*a*} is nano (*1,2*)*-*g*closed but not nano (*1,2*)*-pre-closed and {*b*} is nano (*1,2*)*-pre-closed but not nano (*1,2*)*-*g*closed in U.

Remark 2.12 The following examples show that nano (1,2)*-g^*-closed sets are independent of nano (1,2)*-β-closed sets.

Example 2.13 In Example 2.5, $\{b, c\}$ is nano (1,2)*-g^*-closed but not nano (1,2)*-β-closed and $\{a\}$ is nano (1,2)*-β-closed but not nano (1,2)*-g^*-closed in U.

Remark 2.14 The following examples show that nano (1,2)*-g^*-closed sets are independent of nano (1,2)*-$g\alpha$-closed sets.

Example 2.15 In Example 2.5, $\{b, c\}$ is nano (1,2)*-g^*-closed but not nano (1,2)*-$g\alpha$-closed and $\{a\}$ is nano (1,2)*-$g\alpha$-closed but not nano (1,2)*-g^*-closed in U.

Remark 2.16 The following examples show that nano (1,2)*-g^*-closed sets are independent of nano (1,2)*-sg-closed sets.

Example 2.17 In Example 2.5, $\{b, c\}$ is nano (1,2)*-g^*-closed but not nano (1,2)*-sg-closed and $\{a\}$ is nano (1,2)*-sg-closed but not nano (1,2)*-g^*-closed in U.

Proposition 2.18 Every nano (1,2)*-g^*-closed set is nano (1,2)*-g-closed.

Proof. If G is a nano (1,2)*-g^*-closed subset of U and F is any nano $\tau_{1,2}$-open set containing G, since every nano $\tau_{1,2}$-open set is (1,2)*-g-open, we have $F \supseteq N_{\tau_{1,2}}\text{-}cl(G)$. Hence G is nano (1,2)*-g-closed in U.

The converse of Proposition 2.18 need not be true as seen from the following example.

Example 2.19 Let $U = \{a, b, c\}$ with $U/R_1 = \{\{a\}, \{b\}, \{c\}\}$ and $X = \{c\}$, $\tau_{R_1}(X) = \{\phi, \{c\}, U\}$. Then $U/R_2 = \{\{a, b\}, \{c\}\}$ and $X = \{c\}$, $\tau_{R_2}(X) = \{\phi, \{c\}, U\}$. Then the sets in $\{\phi, \{c\}, U\}$ are called nano $\tau_{1,2}$-open and the sets in $\{\phi, \{a, b\}, U\}$ are called $\tau_{1,2}$-closed. Then $\{a\}$ is nano (1,2)*-g-closed but not nano (1,2)*-g^*-closed set in U.

Proposition 2.20 Every nano (1,2)*-g^*-closed set is nano (1,2)*-gs-closed.

Proof. If G is a nano (1,2)*-g^*-closed subset of U and F is any nano $\tau_{1,2}$-open set containing G, since every nano $\tau_{1,2}$-open set is nano (1,2)*-g-open, we have $F \supseteq N_{\tau_{1,2}}\text{-}cl(G) \supseteq N_{(1,2)^*}\text{-}scl(G)$. Hence G is nano (1,2)*-gs-closed in U.

The converse of Proposition 2.20 need not be true as seen from the following example.

Example 2.21 In Example 2.19, $\{a\}$ is nano (1,2)*-gs-closed but not nano (1,2)*-g^*-closed set in U.

Remark 2.22 Any nano (1,2)*-g^*-closed set is nano (1,2)*-r-g-closed. The converse of Remark 2.22 need not be true as seen from the following example.

Example 2.23 In Example 2.5, $\{a\}$ is nano $(1,2)^{\star}$-r-g-closed but not nano $(1,2)^{\star}$-$g^{\star}$-closed set in U.

Proposition 2.24 Every nano $(1,2)^{\star}$-$g^{\star}$-closed set is nano $(1,2)^{\star}$-αg-closed.

Proof. If G is a nano $(1,2)^{\star}$-$g^{\star}$-closed subset of U and F is any nano $\tau_{1,2}$-open set containing G, since every nano $\tau_{1,2}$-open set is nano $(1,2)^{\star}$-g-open, we have $F \supseteq N_{\tau_{1,2}}\text{-}cl(G) \supseteq N_{(1,2)^{\star}}\text{-}\alpha cl(G)$. Hence G is nano $(1,2)^{\star}$-αg-closed in U.
The converse of Proposition 2.24 need not be true as seen from the following example.

Example 2.25 Let $U = \{a, b, c\}$ with $U/R_1 = \{\{a, b\}, \{c\}\}$ and $X = \{c\}$, $\tau_{R_1}(X) = \{\phi, \{c\}, U\}$. Then $U/R_2 = \{\{a, b\}, \{c\}\}$ and $X = \{a, b\}$, $\tau_{R_2}(X) = \{\phi, \{a, b\}, U\}$. Then the sets in $\{\phi, \{c\}, \{a, b\}, U\}$ are called nano $\tau_{1,2}$-open and nano $\tau_{1,2}$-closed. Then $\{a, c\}$ is nano $(1,2)^{\star}$-αg-closed but not nano $(1,2)^{\star}$-$g^{\star}$-closed set in U.

Proposition 2.26 Every nano $(1,2)^{\star}$-$g^{\star}$-closed set is nano $(1,2)^{\star}$-gsp-closed.

Proof. If G is a nano $(1,2)^{\star}$-$g^{\star}$-closed subset of U and F is any nano $(1,2)^{\star}$-regular open set containing G, since every nano $(1,2)^{\star}$-regular set is nano $(1,2)^{\star}$-g-open, we have $F \supseteq N_{\tau_{1,2}}\text{-}cl(G) \supseteq N_{(1,2)^{\star}}\text{-}\beta cl(G)$. Hence G is nano $(1,2)^{\star}$-gsp-closed in U.
The converse of Proposition 2.26 need not be true as seen from the following example.

Example 2.27 Let $U = \{a, b, c\}$ with $U/R_1 = \{\{a\}, \{b\}, \{c\}\}$ and $X = \{b\}$, $\tau_{R_1}(X) = \{\phi, \{b\}, U\}$. Then $U/R_2 = \{\{a, c\}, \{b\}\}$ and $X = \{b\}$ $\tau_{R_2}(X) = \{\phi, \{b\}, U\}$. Then the sets in $\{\phi, \{b\}, U\}$ are called nano $\tau_{1,2}$-open and the sets in $\{\phi, \{a, c\}, U\}$ are called nano $\tau_{1,2}$-closed. Then $\{c\}$ is nano $(1,2)^{\star}$-gsp-closed but not nano $(1,2)^{\star}$-$g^{\star}$-closed set in U.

Proposition 2.28 Every nano $(1,2)^{\star}$-$g^{\star}$-closed set is nano $(1,2)^{\star}$-gp-closed.

Proof. If G is a nano $(1,2)^{\star}$-$g^{\star}$-closed subset of U and F is any nano $\tau_{1,2}$-open set containing G, since every nano $\tau_{1,2}$-open set is nano $(1,2)^{\star}$-g-open, we have $F \supseteq N_{\tau_{1,2}}\text{-}cl(G) \supseteq N_{(1,2)^{\star}}\text{-}pcl(G)$. Hence G is nano $(1,2)^{\star}$-gp-closed in U.
The converse of Proposition 2.28 need not be true as seen from the following example.

Example 2.29 Let $U = \{a, b, c\}$ with $U/R_1 = \{\{a\}, \{b\}, \{c\}\}$ and $X = \{b\}$, $\tau_{R_1}(X) = \{\phi, \{b\}, U\}$. Then $U/R_2 = \{\{a, b\}, \{c\}\}$ and $X = \{a, b\}$, $\tau_{R_2}(X) = \{\phi, \{a, b\}, U\}$. Then the sets in $\{\phi, \{b\}, \{a, b\}, U\}$ are called nano $\tau_{1,2}$-open and the sets in $\{\phi, \{c\}, \{a, c\}, U\}$ are called nano $\tau_{1,2}$-closed. Then $\{a\}$ is nano $(1,2)^{\star}$-gp-closed but not nano $(1,2)^{\star}$-$g^{\star}$-closed in U.

Proposition 2.30 Every nano $(1,2)^{\star}$-$g^{\star}$-closed set is nano $(1,2)^{\star}$-gpr-closed.
Proof. If G is a nano $(1,2)^{\star}$-$g^{\star}$-closed subset of U and F is any nano $(1,2)^{\star}$-regular open set containing G, since every nano $(1,2)^{\star}$-regular open set is nano $(1,2)^{\star}$-g-open, we have $F \supseteq N_{\tau_{1,2}}\text{-}cl(G) \supseteq N_{(1,2)^{\star}}\text{-}pcl(G)$. Hence G is nano $(1,2)^{\star}$-gpr-closed in X.
The converse of Proposition 2.30 need not be true as seen from the following example.

Example 2.31 Let $U = \{a, b, c\}$ with $U/R_1 = \{\{a\}, \{b\}, \{c\}\}$ and $X = \{b\}$, $\tau_{R_1}(X) = \{\phi, \{b\}, U\}$. Then $U/R_2 = \{\{a, b\}, \{c\}\}$ and $X = \{a, b\}$, $\tau_{R_2}(X) = \{\phi, \{a, b\}, U\}$. Then the sets in $\{\phi, \{b\}, \{a, b\}, U\}$ are called nano $\tau_{1,2}$-open and the sets in $\{\phi, \{c\}, \{a, c\}, U\}$ are called nano $\tau_{1,2}$-closed. Then $\{a\}$ is nano $(1,2)^{\star}$-gpr-closed but not nano $(1,2)^{\star}$-$g^{\star}$-closed in U.

Proposition 2.32 Every nano $(1,2)^{\star}$-$g^{\star}$-closed set is nano $(1,2)^{\star}$-$\alpha^{\star\star}g$-closed.

Proof. If G is a nano $(1,2)^{\star}$-$g^{\star}$-closed subset of U and F is any nano $\tau_{1,2}$-open set containing G, since every nano $\tau_{1,2}$-open set is nano $(1,2)^{\star}$-g-open, we have $F \supseteq N_{\tau_{1,2}}\text{-}cl(G) \supseteq N_{\tau_{1,2}}\text{-}int(N_{\tau_{1,2}}\text{-}cl(G))$. Hence G is nano $(1,2)^{\star}$-$\alpha^{\star\star}g$-closed in U. The converse of Proposition 2.32 need not be true as seen from the following example.

Example 2.33 In Example 2.31, $\{a\}$ is nano (1,2)*-$\alpha^{\star\star}g$-closed but not nano (1,2)*-$g^\star$-closed in U.

PROPERTIES OF NANO $(1,2)^\star$-$g^\star$-CLOSED SETS

Definition 3.1 The intersection of all nano (1,2)*-g-open subsets of U containing G is called the nano (1,2)*-g-kernel of G and denoted by $N_{(1,2)^\star}$-g-$ker(G)$.

Lemma 3.2 A subset G of a nano bitopological space U is nano (1,2)*-$g^\star$-closed if and only if $N_{\tau_{1,2}}$-$cl(G) \subseteq N_{(1,2)^\star}$-$g$-$ker(G)$.

Proof. Suppose that G is nano (1,2)*-$g^\star$-closed. Then $N_{\tau_{1,2}}$-$cl(G) \subseteq H$ whenever $G \subseteq H$ and H is nano (1,2)*-g-open. Let $a \in N_{\tau_{1,2}}$-$cl(G)$. If $a \notin N_{(1,2)^\star}$-g-$ker(G)$, then there is a nano (1,2)*-g-open set H containing G such that $a \notin H$. Since H is a nano (1,2)*-g-open set containing G, we have $a \notin N_{\tau_{1,2}}$-$cl(G)$ and this is a contradiction. Conversely, let $N_{\tau_{1,2}}$-$cl(G) \subseteq N_{(1,2)^\star}$-$g$-$ker(G)$. If H is any nano (1,2)*-g-open set containing G, then $N_{\tau_{1,2}}$-$cl(G) \subseteq N_{(1,2)^\star}$-$g$-$ker(G) \subseteq H$. Therefore, G is nano (1,2)*-$g^\star$-closed.

Proposition 3.3 If a set G is nano (1,2)*-$g^\star$-closed in U, then $N_{\tau_{1,2}}$-$cl(G) - G$ contains no nonempty nano (1,2)*-g-closed set in U.

Proof. Suppose that G is nano (1,2)*-$g^\star$-closed. Let K be a nano (1,2)*-g-closed subset of $N_{\tau_{1,2}}$-$cl(G) - G$. Then $G \subseteq K^c$. But G is nano (1,2)*-$g^\star$-closed, therefore $N_{\tau_{1,2}}$-$cl(G) \subseteq K^c$. Consequently, $K \subseteq (N_{\tau_{1,2}}$-$cl(G))^c$. We already have $K \subseteq N_{\tau_{1,2}}$-$cl(G)$. Thus $K \subseteq N_{\tau_{1,2}}$-$cl(G) \cap (N_{\tau_{1,2}}$-$cl(G))^c$ and hence K is empty.

Proposition 3.4 If G is nano (1,2)*-$g^\star$-closed in U and $G \subseteq H \subseteq N_{\tau_{1,2}}$-$cl(G)$, then H is nano (1,2)*-$g^\star$-closed in U.

Proof. Let J be nano (1,2)*-g-open set in U such that $K \subseteq J$. Since G is nano (1,2)*-$g^\star$-closed, $N_{\tau_{1,2}}$-$cl(G) \subseteq J$. Since $N_{\tau_{1,2}}$-$cl(H) \subseteq N_{\tau_{1,2}}$-$cl(G)$, we have $N_{\tau_{1,2}}$-$cl(H) \subseteq J$. Hence H is nano (1,2)*-$g^\star$-closed set.

Proposition 3.5 If G is both nano (1,2)*-g-open and nano (1,2)*-$g^\star$-closed in U, then G is nano $\tau_{1,2}$-closed in U.

Proof. Since G is nano (1,2)*-g-open and nano (1,2)*-$g^\star$-closed, $N_{\tau_{1,2}}$-$cl(G) \subseteq G$ and hence G is nano $\tau_{1,2}$-closed in U.

Proposition 3.6 For each $a \in U$, either $\{a\}$ is nano (1,2)*-g-closed or $\{a\}^c$ is nano (1,2)*-$g^\star$-closed in U.

Proof. Suppose that $\{a\}$ is not nano (1,2)*-g-closed in U. Then $\{a\}^c$ is not nano (1,2)*-g-open and the only nano (1,2)*-g-open set containing $\{a\}^c$ is the space U itself. Therefore $N_{\tau_{1,2}}$-$cl(\{a\}^c) \subseteq U$ and so $\{a\}^c$ is nano (1,2)*-$g^\star$-closed in U.

Theorem 3.7 Let G be a nano (1,2)*-$g^\star$-closed set of a nano bitopological space U. Then,

1. If G is nano (1,2)*-regular open, then $N_{(1,2)^\star}$-$pint(G)$ and $N_{(1,2)^\star}$-$scl(G)$ are also nano (1,2)*-$g^\star$-closed sets
2. If G is nano (1,2)*-regular closed, then $N_{(1,2)^\star}$-$pcl(G)$ is also nano (1,2)*-$g^\star$-closed set.

Proof. (1) Since G is nano (1,2)*-regular open in U, $G = N_{\tau_{1,2}}$-$int(N_{\tau_{1,2}}$-$cl(G))$. Then $N_{(1,2)^\star}$-$scl(G) = G \cup N_{\tau_{1,2}}$-$int(N_{\tau_{1,2}}$-$cl(G)) = G$. Thus, $N_{(1,2)^\star}$-$scl(G)$ is nano (1,2)*-$g^\star$-closed in U. Since $N_{(1,2)^\star}$-$pint(G) = G \cap N_{\tau_{1,2}}$-$int(N_{\tau_{1,2}}$-$cl(G)) = G$, $N_{(1,2)^\star}$-$pint(G)$ is nano (1,2)*-$g^\star$-closed.

(2) Since G is nano (1,2)*-regular closed in U, $G = N_{\tau_{1,2}}$-$cl(N_{\tau_{1,2}}$-$int(G))$. Then $N_{(1,2)^\star}$-$pcl(G) = G \cup N_{\tau_{1,2}}$-$cl(N_{\tau_{1,2}}$-$int(G)) = G$. Thus, $N_{(1,2)^\star}$-$pcl(G)$ is nano (1,2)*-$g^\star$-closed in U.

NANO* $(\mathbf{1},\mathbf{2})^{\star}$*-$g^{\star}$-CLOSURE

Definition 4.1 For every set $G \subseteq U$, we define the nano $(1,2)^{\star}$-$g^{\star}$-closure of G to be the intersection of all nano $(1,2)^{\star}$-$g^{\star}$-closed sets containing G.
i.e., $N_{(1,2)^{\star}}$-$g^{\star}$-$cl(G) = \cap \{K: G \subseteq K \in N(1,2)^{\star}$-$G^{\star}C(U)\}$.

Lemma 4.2 For any $G \subseteq U$, $G \subseteq N_{(1,2)^{\star}}$-$g^{\star}$-$cl(G) \subseteq N_{\tau_{1,2}}$-$cl(G)$.

Remark 4.3 Both containment relations in Lemma 4.2 may be proper as seen from the following example.

Example 4.4 Let $U = \{a, b, c\}$ with $U/R_1 = \{\{a\}, \{b\}, \{c\}\}$ and $X = \{a, b\}$, $\tau_{R_1}(X) = \{\phi, \{a, b\}, U\}$. Then $U/R_2 = \{\{a, b\}, \{c\}\}$ and $X = \{a\}$, $\tau_{R_2}(X) = \{\phi, \{a, b\}, U\}$. Then the sets in $\{\phi, \{a, b\}, U\}$ are called nano $\tau_{1,2}$-open and the sets in $\{\phi, \{c\}, U\}$ are called $\tau_{1,2}$-closed. Let $G = \{a\}$. Then $N_{(1,2)^{\star}}$-$g^{\star}$-$cl(G) = \{a, c\}$ and so $G \subseteq N_{(1,2)^{\star}}$-$g^{\star}$-$cl(G) \subseteq N_{\tau_{1,2}}$-$cl(G)$.
The following two Propositions are easy consequences from definitions.

Proposition 4.5 For any $G \subseteq U$, the following hold:
1. $N_{(1,2)^{\star}}$-$g^{\star}$-$cl(G)$ is the smallest nano $(1,2)^{\star}$-$g^{\star}$-closed set containing G.
2. G is nano $(1,2)^{\star}$-$g^{\star}$-closed if and only if $N_{(1,2)^{\star}}$-$g^{\star}$-$cl(G) = G$.

Proposition 4.6 For any two subsets G and H of U, the following hold:
1. If $G \subseteq H$, then $N_{(1,2)^{\star}}$-$g^{\star}$-$cl(G) \subseteq N_{(1,2)^{\star}}$-$g^{\star}$-$cl(H)$.
2. $N_{(1,2)^{\star}}$-$g^{\star}$-$cl(G \cap H) \subseteq N_{(1,2)^{\star}}$-$g^{\star}$-$cl(G) \cap (1,2)^{\star}$-$g^{\star}$-$cl(H)$.

NANO $(\mathbf{1},\mathbf{2})^{\star}$-$g^{\star}$-OPEN SETS

Definition 5.1 Let G be a subset of a nano bitopological space U. Then G is called nano $(1,2)^{\star}$-$g^{\star}$-open in U if G^c is nano $(1,2)^{\star}$-$g^{\star}$-closed in U. The collection of all nano $(1,2)^{\star}$-$g^{\star}$-open sets in U is denoted by $N_{(1,2)^{\star}}$-$G^{\star}O(U)$.

Proposition 5.2 For any nano bitopological space U, the following assertions hold:
1. Every nano $\tau_{1,2}$-open set is nano $(1,2)^{\star}$-$g^{\star}$-open but not conversely.
2. Every nano $(1,2)^{\star}$-$g^{\star}$-open set is nano $(1,2)^{\star}$-$g^{\star}_{\alpha}$-open but not conversely.
3. Every nano $(1,2)^{\star}$-$g^{\star}$-open set is nano $(1,2)^{\star}$-g-open but not conversely.
4. Every nano $(1,2)^{\star}$-$g^{\star}$-open set is nano $(1,2)^{\star}$-sg-open but not conversely.
5. Every nano $(1,2)^{\star}$-$g^{\star}$-open set is nano $(1,2)^{\star}$-αg-open but not conversely.
6. Every nano $(1,2)^{\star}$-$g^{\star}$-open set is nano $(1,2)^{\star}$-gs-open but not conversely.
7. Every nano $(1,2)^{\star}$-$g^{\star}$-open set is nano $(1,2)^{\star}$-gsp-open but not conversely.

Theorem 5.3 A subset G of U is nano $(1,2)^{\star}$-$g^{\star}$-open if and only if $H \subseteq N_{\tau_{1,2}}$-$int(G)$ whenever H is nano $(1,2)^{\star}$-g-closed and $H \subseteq G$.

Proof. Suppose that $H \subseteq N_{\tau_{1,2}}$-$int(G)$ such that H is nano $(1,2)^{\star}$-g-closed and $H \subseteq G$. Let $G^c \subseteq K$ where K is nano $(1,2)^{\star}$-g-open. Then $K^c \subseteq G$ and K^c is nano $(1,2)^{\star}$-g-closed. Therefore $K^c \subseteq N_{\tau_{1,2}}$-$int(G)$ by hypothesis. Since $K^c \subseteq N_{\tau_{1,2}}$-$int(G)$, we have $(N_{\tau_{1,2}}$-$int(G))^c \subseteq K$. i.e., $N_{\tau_{1,2}}$-$cl(G^c) \subseteq K$, since $N_{\tau_{1,2}}$-$cl(G^c) = (N_{\tau_{1,2}}$-$int(G))^c$. Thus G^c is nano $(1,2)^{\star}$-$g^{\star}$-closed. i.e., G is nano $(1,2)^{\star}$-$g^{\star}$-open.
Conversely, suppose that G is nano $(1,2)^{\star}$-$g^{\star}$-open such that $H \subseteq G$ and H is nano $(1,2)^{\star}$-g-closed. Then H^c is nano $(1,2)^{\star}$-g-open and $G^c \subseteq H^c$. Therefore, $N_{\tau_{1,2}}$-$cl(G^c) \subseteq H^c$ by definition of nano $(1,2)^{\star}$-$g^{\star}$-closedness and so $H \subseteq N_{\tau_{1,2}}$-$int(G)$, since $N_{\tau_{1,2}}$-$cl(G^c) = (N_{\tau_{1,2}}$-$int(G))^c$.
We introduce the following definition.

Definition 5.4 For any $G \subseteq U$, $N_{(1,2)^\star}$-$g^\star$-$int(G)$ is defined as the union of all nano (1,2)*-$g^\star$-open sets contained in G. i.e., $N_{(1,2)^\star}$-$g^\star$-$int(G)$ =$\cup$ $\{D: D \subseteq G$ and D is nano (1,2)*-$g^\star$-open$\}$.

Lemma 5.5 For any $G \subseteq U$, $N_{\tau_{1,2}}$-$int(G) \subseteq N_{(1,2)^\star}$-$g^\star$-$int(G) \subseteq G$.
Proof. It is obvious.
The following two Propositions are easy consequences from definitions.

Proposition 5.6 For any $G \subseteq U$, the following hold:
1. $N_{(1,2)^\star}$-$g^\star$-$int(G)$ is the largest nano (1,2)*-$g^\star$-open set contained in G.
2. G is nano (1,2)*-$g^\star$-open if and only if $N_{(1,2)^\star}$-$g^\star$-$int(G) = G$.

Proposition 5.7 For any subsets G and H of U, the following hold:
1. $N_{(1,2)^\star}$-$g^\star$-$int(G \cap H) \subseteq N_{(1,2)^\star}$-$g^\star$-$int(G) \cap N_{(1,2)^\star}$-$g^\star$-$int(H)$.
2. $N_{(1,2)^\star}$-$g^\star$-$int(G \cup H) \supseteq N_{(1,2)^\star}$-$g^\star$-$int(G) \cup N_{(1,2)^\star}$-$g^\star$-$int(H)$.
3. If $G \subseteq H$, then $N_{(1,2)^\star}$-$g^\star$-$int(G) \subseteq N_{(1,2)^\star}$-$g^\star$-$int(H)$.
4. $N_{(1,2)^\star}$-$g^\star$-$int(U) = U$ and $N_{(1,2)^\star}$-$g^\star$-$int(\phi) = \phi$.

APPLICATIONS
As applications of nano (1,2)*-$g^\star$-closed sets, we introduce the notions called nano (1,2)*-$T_g^\star$-spaces and nano (1,2)*-${}_gT_g^\star$-spaces and obtain their properties and characterizations.

Definition 6.1 A space U is called a nano (1,2)*-$T_g^\star$-space if every nano (1,2)*-$g^\star$-closed set in it is nano $\tau_{1,2}$-closed.

Example 6.2 Let $U = \{a, b, c\}$ with $U/R = \{\{a\}, \{b\}, \{c\}\}$ and $X = \{b\}$, $\tau_{R_1}(X) = \{\phi, \{b\}, U\}$, Then $U/R = \{\{a, c\}, \{b\}\}$ and $X = \{b\}$, $\tau_{R_2}(X) = \{\phi, \{b\}, U\}$. Then the sets in $\{\phi, \{b\}, U\}$ are called nano $\tau_{1,2}$-open and the sets in $\{\phi, \{a, c\}, U\}$ are called nano $\tau_{1,2}$-closed. Then $N_{(1,2)^\star}$-$G^\star C(U) = \{\phi, \{a, c\}, U\}$. Thus U is a nano (1,2)*-$T_g^\star$-space.

Example 6.3 Let $U = \{a, b, c\}$ with $U/R = \{\{a\}, \{b\}, \{c\}\}$ and $X = \{a, c\}$, $\tau_{R_1}(X) = \{\phi, \{a, c\}, U\}$. Then $U/R = \{\{a, c\}, \{b\}\}$ and $X = \{a, c\}$, $\tau_{R_2}(X) = \{\phi, \{a, c\}, U\}$. Then the sets in $\{\phi, \{a, c\}, U\}$ are called nano $\tau_{1,2}$-open and the sets in $\{\phi, \{b\}, U\}$ are called nano $\tau_{1,2}$-closed. Then $N_{(1,2)^\star}$-$G^\star C(U) = \{\phi, \{b\}, \{a, b\}, \{b, c\}, U\}$. Thus U is not a nano (1,2)*-$T_g^\star$-space.

Proposition 6.4 Every nano (1,2)*-$T_{1/2}$-space is nano (1,2)*-$T_g^\star$-space but not conversely.
Proof. Follows from Proposition 2.18.
The converse of Proposition 6.4 need not be true as seen from the following example.

Example 6.5 In Example 6.2. Then we have $N_{(1,2)^\star}$-$GC(U) = \{\phi, \{a\}, \{c\}, \{a, b\}, \{a, c\}, \{b, c\}, U\}$. Thus U is not a nano (1,2)*-$T_{1/2}$-space.

Proposition 6.6 Every nano (1,2)*-T_b-space is nano (1,2)*-$T_g^\star$-space but not conversely.
Proof. Follows from Proposition 2.20.
The converse of Proposition 6.6 need not be true as seen from the following example.

Example 6.7 In Example 6.2. Then we have $N_{(1,2)^\star}$-$GSC(U) = \{\phi, \{a\}, \{c\}, \{a, b\}, \{a, c\}, \{b, c\}, U\}$. Thus U is not a nano (1,2)*-T_b-space.

Remark 6.8 We conclude from the next two examples that nano (1,2)*-$T_g^\star$-spaces and nano (1,2)*-α-spaces are independent.

Example 6.9 In Example 6.2. Then we have $N_{(1,2)^\star}$-$\alpha C(U) = \{\phi, \{a\}, \{c\}, \{a, c\}, U\}$. Thus U is a nano $(1,2)^\star$-$T_g^\star$-space but not an nano $(1,2)^\star$-α-space.

Example 6.10 In Example 6.3. Then we have $N_{(1,2)^\star}$-$\alpha C(U) = \{\phi, \{b\}, U\}$. Thus U is an nano $(1,2)^\star$-α-space but not a nano $(1,2)^\star$-$T_g^\star$-space.

Theorem 6.11 For a nano bitopological space U, the following properties are equivalent:
1. U is a nano $(1,2)^\star$-$T_g^\star$-space.
2. Every singleton subset of U is either nano $(1,2)^\star$-g-closed or nano $\tau_{1,2}$-open.

Proof. (1) $\Rightarrow$ (2). Assume that for some $a \in U$, the set $\{a\}$ is not a nano $(1,2)^\star$-g-closed in U. Then the only nano $(1,2)^\star$-g-open set containing $\{a\}^c$ is U and so $\{a\}^c$ is nano $(1,2)^\star$-$g^\star$-closed in U. By assumption $\{a\}^c$ is nano $\tau_{1,2}$-closed in U or equivalently $\{a\}$ is nano $\tau_{1,2}$-open.

(2) $\Rightarrow$ (1). Let G be a nano $(1,2)^\star$-$g^\star$-closed subset of U and let $a \in N_{\tau_{1,2}}$-$cl(G)$. By assumption $\{a\}$ is either nano $(1,2)^\star$-g-closed or nano $\tau_{1,2}$-open.
Case (a): Suppose that $\{a\}$ is nano $(1,2)^\star$-g-closed. If $a \notin G$, then $N_{\tau_{1,2}}$-$cl(G) - G$ contains a nonempty nano $(1,2)^\star$-g-closed set $\{a\}$, which is a contradiction.
Case (b): Suppose that $\{a\}$ is nano $\tau_{1,2}$-open. Since $a \in N_{\tau_{1,2}}$-$cl(G)$, $\{a\} \cap G \neq \phi$ and so $a \in G$. Thus in both case, $a \in G$ and therefore $N_{\tau_{1,2}}$-$cl(G) \subseteq G$ or equivalently G is a nano $\tau_{1,2}$-closed set of U.

Definition 6.12 The space U is called a nano $(1,2)^\star$-${}_gT_g^\star$-space if every nano $(1,2)^\star$-g-closed set in it is nano $(1,2)^\star$-$g^\star$-closed.
Example 6.13 In Example 6.3. Then U is a nano $(1,2)^\star$-${}_gT_g^\star$-space and the space U in the Example 6.2 is not a nano $(1,2)^\star$-${}_gT_g^\star$-space.

Proposition 6.14 Every nano $(1,2)^\star$-$T_{1/2}$-space is nano $(1,2)^\star$-${}_gT_g^\star$-space but not conversely.
Proof. It is obvious.
The converse of Proposition 6.14 need not be true as seen from the following example.

Example 6.15 In Example 6.3. Then U is a nano $(1,2)^\star$-${}_gT_g^\star$-space but not a nano $(1,2)^\star$-$T_{1/2}$-space.

Remark 6.16 Nano $(1,2)^\star$-$T_g^\star$-spaces and nano $(1,2)^\star$-${}_gT_g^\star$-spaces are independent.

Example 6.17 In Example 6.3 is a nano $(1,2)^\star$-${}_gT_g^\star$-space but not a nano $(1,2)^\star$-$T_g^\star$-space and the space U in the Example 6.2 is a nano $(1,2)^\star$-$T_g^\star$-space but not a nano $(1,2)^\star$-${}_gT_g^\star$-space.

Theorem 6.18 A space U is nano $(1,2)^\star$-$T_{1/2}$ if and only if it is both nano $(1,2)^\star$-$T_g^\star$ and nano $(1,2)^\star$-${}_gT_g^\star$.
Proof. Necessity. Follows from Propositions 6.4 and 6.14.
Sufficiency. Assume that U is both nano $(1,2)^\star$-$T_g^\star$ and nano $(1,2)^\star$-${}_gT_g^\star$. Let G be a nano $(1,2)^\star$-g-closed set of U. Then G is nano $(1,2)^\star$-$g^\star$-closed, since U is a nano $(1,2)^\star$-${}_gT_g^\star$. Again since U is a nano $(1,2)^\star$-$T_g^\star$, G is a nano $\tau_{1,2}$-closed set in U and so U is a nano $(1,2)^\star$-$T_{1/2}$.

CONCLUSIONS

We introduced a new class of sets, namely called nano $(1,2)^\star$-$g^\star$-closed sets in nano bitopological spaces. This class lies between the class of nano $(1,2)^\star$-closed sets and the class of nano $(1,2)^\star$-g-closed sets. Also, some other properties are studied, and suitable examples are given in this paper. We have access to a variety of topological spaces and their related applications for learning.

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RESEARCH ARTICLE

Assessment of Employability Skills among Under Graduate Students – A Study

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ABSTRACT

India is a country bound with youth dreams, as the majority of the population are in the age group of 24-35, and young citizens play a vital role in transforming the nation into a developed economy, in recent years innovative and refined government schemes have been introduced to upgrade the nation such as Digital India, Viksit Bharat 2047, Atmanirbhar etc., few schemes were solely introduced for the development of specific sectors such as Credit Guarantee Scheme for MSMEs, Rashtriya Krishi Vikas Yojana for farmers, Mahila Udyam Nidhi Scheme for women entrepreneurs, Startup India Seed Fund Scheme for startups and so on. The Economic Survey of 2023-24 reveals, the youth of the nation lack skills needed by a modern economy, concisely one in two graduates are not readily employable straight out of college, along side the skill gap is a major hindrance in employability and in turn impacts the entrepreneurial ability. Further, the 2022 survey by Deloitte states that by 2026, labour and skill shortages would be the most cited external factor disrupting the business strategy. In this regard, the present study was conducted and suggestions were inferred.

Keywords: *Curriculum Up gradation, Industry 4.0, Skill Gap, Technology Driven.***:**

INTRODUCTION

Education is a pre requisite of every child. Over the time, the system of education changed according to the emerging market and competition. Quality education is always been the motive of all institutions thus, enabling them to inculcate activity based learning and concentrate on beyond classroom teaching and learning. Addressing the skill gap between academics and industry is a big challenge as the industrial requirements change with the passage of time. The Ministry of Skill Development and Entrepreneurship has introduced more than 12 skill development schemes for all age groups, as per The Karnataka Skill Development Policy 2017-2030 the students enrolled for apprenticeship training offered under the Karnataka government is only 8,899 out of 39,605 available seats. The figure 1 indicate the future of our nation and the importance of being in par with technological advancements, these facts could be the triggering reason for 9.2% rise in unemployment rate in 2024 when compared to 8.003 in 2023 (CIME report). It is explicit for people to understand that there are job vacancies across the country, but the required skillset is lacking which needs to be focused upon.

Educational institutions hold a strong firm in transforming the youth into skilled citizens of nation, as pedagogy changes over time so does teaching styles. Institutions are steadily converting the bookish knowledge into practical learning. While on the contrary, many institutions are not ICT enabled, few institution teachers resist the usage of ICT and follow the traditional method of teaching. ICT adaption is the primary step in accepting technology and getting exposed to the world of advancement. Thus, the first inception relies on the teachers which would further help students to lead. Apart from academics and curriculum, the institutions tie up and collaboration with foreign institutions, industry experts, MOUs, offering of internship programmes, involvement of industry expert in framing the syllabus, focusing on outcome based activities and more of research would help the students to attain better skill enhancement before completing graduation.

Industrial Revolution 4.0

The industry 4.0 - a technology driven revolution majorly aiming at the skilled work force, as the manpower is rapidly being replaced by high end technologies such as artificial intelligence, machine learning, digital networking etc., alongside the manufacturing sector that contributes immensely for the economy's development is one which has huge demand for skilled workforce, thus expects skilled graduates. Understanding the urge of the current status, a few educational institutions have revamped the curriculum by introducing professional skill enhanced courses that could act as liaison between academic and industry. The collaboration with industry experts has made an immense difference in building the syllabus as per industry standards, the MOUs and foreign institution collaboration also contribute for up skilling of students.

Educational System

The Indian Education System is a conventional method of teaching and learning, right from the ancient Gurukul system to the present Educom and Smart board classes. The evolution has made changes in black and white form alone rather concentrating on the extracurricular teaching and learning. The higher secondary education has slowly geared up in focusing more of activity-based learning than theoretical as it helps students in the learning of problem-solving skills, analytical reasoning, logical analysis etc. the autonomous institutions with much flexibility shape their own syllabus and concentrates on innovative activities, tie ups and collaboration. The non-autonomous private institutions, the government colleges especially at the rural and semi urban areas lack exposure in framing the curriculum and design of methodology. There could few reasons for lag such as, the demographic area, limitation of funds, less knowledge on technology, student's interest, teacher's efficiency etc.

The educational institutions that undergo National Assessment and Accreditation Council (NAAC) cycle take an extra effort to concentrate on outcome based learning in order to obtain high grades, in one way the NAAC process is a booster for the institutions to play mindfully, as a result of this many colleges show interest in MOUs, Academic Collaborations, Internships, Short term courses to integrate skill development among students

REVIEW OF LITERATURE

Sahoo, Panda, et al., (2022) studied the employability skills in University Graduate students in the paper titled "Employability Skill among University Students In Relation To Academic Stream" with an objective to know the distinctness in employability skills between Science and Arts stream candidates. The research designed involved a sample size of 100 and application of Standardised Employability Assessment inventory of Larry Dershem, 2016. The findings of the study reveal that all skills possessed by the students were below 20% on average. Further, the study states that science stream candidates possess more skill than arts stream candidates. The authors suggest Employability Skills should be imbibed in the academic syllabus, internship pragrammes, conduct of workshops and regular review would help students to develop requires skills. Gowsalya and Preetha (2021) in the paper titled "A study on employability skills among college students in Coimbatore district, Tamil Nadu" studied the underlying elements of employability skills and the demographic profile in college students, on five different colleges in district. The study was conducted by drawing a sample size of 100 and applied Multiple Regression Analysis. The findings of the study based on regression analysis reveal that major employability skills such as time management, teamwork and leadership are all highly impacted by employability skills. Few recommendations of the study are to conduct good workshops on current industrial needs and market expectations.

Rai Ashok kumar and likhitkarBhavana (2023) in the paper titled "A Study on Enhancing Employability Skills: Key Factor And Strategies For A Dynamic Job" aimed to create an empirical model to explore how employers perceive fresher's and their employability skills, identified the factors, challenges and proposed strategies to enhance employability. The study was conducted on 282 respondents, analyzed the data using SEM to examine the perception of employers and HR managers. The outcome of the study states skill gap, highly competitive job market, vocational skills, technological advancement, gender disparity, quality education, soft skill etc are some of the major challenges for job seekers. The study suggests promotion of vocational training; soft skill development and public private partnerships would contribute in improving the skills.

TusharHasanuzzaman and SooraksaNanta (2023) in the paper titled "Global employability skills in the 21st century workplace: A semi-systematic literature review" studied the required skills expected by employers in newly passed out graduates and the transformations occurred in employability skills over the years. The research was conducted by adopting semi-systematic literature review – studied articles published between 1990 and 2019, retrieved a total of 18,162 studies. The findings reveal that communication and problem solving skills rank the top most employability skills whereas computer and hands on with technology skills became the recent developments due to the introduction of AI. Further, the former skills such as work morales. job determination etc remain the most common skills of earlier times..

Wise Mainga, Reuben M. Daniel, et al (2022) in their paper titled "Perceptions of Employability Skills of Undergraduate Business Students in a Developing Country: An Exploratory Study" determined significance of employability skills in management graduates during employment, the researchers circulated a structured questionnaire to three different groups of respondents: industry representative, teachers and students. The results of the study showed certain equal and unequal differences among the groups of respondents in perceiving the employability skills and employers opined satisfactory in the academic skills owned by fresh graduate students , the author suggested certain self-oriented traits that focuses on one's psychological well being should also be developed for a successful career path.

Hansraj and Patil.A. N. (2016) in the paper titled "A Pilot Study for Employability Skills among Students of Management Faculty under NMU, Jalgaon & SPPU, Pune (with Special Reference to MBA Students)" conducted a pilot study to know if employability skill perception among students of three universities are equal. The authors considered Teamwork & Leadership Skill, Personal Skills and Fundamental/Generic Skills, study was conducted on a

sample of 50 respondents from each university and Levene's Test for Equality was applied. The result of the study shows the employability skills perception of students from all three universities were significantly equal. Yadav Kiran, Babra Sonal, et al.,(2022) in the paper titled "A Study on Management Students Employability Skills Through Alumni Perspective" applied employability assessment model to identify and analyse the most important employability skills expected in commerce students. the study was conducted on 194 alumni representing universities from Delhi and NCR region. Explorative Factor Analysis was applied in the study; the findings reveal business communication, analytical and logical thinking and management skills are the major skill set required for employability. The study states conduct of development programmes would help students in building soft skill, thus enhancing employability factor.

Dasgupta Santanu (2019) in his paper titled "Undergraduate Hospitality Students Perception on Importance of Employability Skills: Empirical study from Kolkata, India" aimed to study the gender wise perception and to rank top ten employability skills. 72 respondents from 3 hospitality institutions in Kolkata, West Bengal were chosen for the study. Purposive random sampling method was conducted, and the findings states perception of the male and female students differ significantly about employability skill set, top ten employability skills were ranked on the basis of mean score value: Positive Thinking, Grooming, Discipline, Practical experience, Respect for self and others, Willingness to work, Positive attitude towards change, Sense of responsibility, Self-confidence and Learning skills. Aggarwal Pooja (2021) in the paper titled "Employability Skills: A Set of tools to bridge the gap between academia and the industry in the Indian perspective". The objective of the study aimed to identify the most requisite employability skills for management students as expected by the industrialist and examined the causes for poor employability skills. The study was based on secondary data, information from India Skill Report, Insight HR and Training Consultant etc. were extracted. The outcomes reveal that employers value behavioural traits in a candidate but students value completion of degree; also, motivational workshops would help new graduates to build confidence in them. Further, the recommendations of the study states fundamentals and foundations of a discipline should be concentrated, Classroom learning, creative thinking and involvement of industry experts in designing of curriculum would lead to better learning.

Timane Rajesh, Wandhe Priyanka and Band Gayathri (2024) in their paper titled "A Study of Analysis of Gap in the Employability Skills and Attributes of Management Students with Respect to Academic Output and Industry Requirement" aimed to study the skills and attributes required for Employability and conducted a gap analysis between academia and industry requirement. The study was descriptive and exploratory in nature. The authors chose seven employability skills and seven employability attributes and developed sets of questionnaires which were targeted to management students, faculty members and employers. The results reveal that management students must develop a strong grip over the core subjects as well advance in management skills for successful placements.

Objectives of the Study

1. To study the skill gap among students based on demographic profile.
2. To analyse the relationship between curriculum, short term courses on employability and employability skills.
3. To study the initiatives taken by institutions in nurturing employability skills among students.

Statement of the Problem

The present study is undertaken to assess the level of employability skills among students specifically the graduate students. Bachelor of Commerce graduates are considered for the study as the data from Statista reveal employability among Bachelor of Commerce students is about 48% in 2024, as compared to 60.62% in 2023 as of March. With the introduction of National Education Policy 2020, a question that strikes is "Does NEP 2020 serve its purpose in terms of preparing the youth to face the global challenges" thus, the study was concentrated on the first passed out batch of NEP 2020.

Research Design

The study adopted secondary and primary method of data collection involving circulation of structured questionnaire to a sample size of 164 students further, the number of filled in questionnaire received were 115. Convenience technique of sampling was chosen considering the reach of respondents. The sample were drawn from two institutions in Haveri city and statistical tests were applied to draw interpretations and recommend suggestions.

Research Hypothesis

H0: There is no significant relationship between demographic profile and employability skills possessed by students.

H1: There is significant relationship between demographic profile and employability skills possessed by students.

H0: There is no significant relationship between curriculum and employability skills possessed.

H2: There is significant relationship between curriculum and employability skills possessed.

Data Analysis and Interpretation (Fig.2)

Interpretation

The above graph indicates the highest and lowest scale on skills possessed by the respondents. The graph depicts respondents are very good in English Writing and Working and Co ordinating in Teams, good in English Speaking, Basic Computer, Oral Presentation, Aptitude and Logical Reasoning and Critical Thinking Skills, whereas the respondents opined average scale for Advanced Technological Skills. Thus, educational institutions need to introduce new courses and certification for software learning also initiate activities to improve communication skills among students.

Mann Whitney U Test

Wilcox on - Mann/ Whitney Test		
n	Sumo franks	
115	10006	Native
115	16559	Employability Skills
230	26565	total
	13282.50	Expected value
	498.10	Standard deviation
	-6.58	z, corrected forties
	4.80E-11	p-value(two-tailed)

Interpretation

The above test indicates that, since p value is less than the alpha value of 0.05 level of significance, alternate hypotheses is accepted. Hence, there is significant relationship between demographic profile and employability skills possessed by students.

Hypothesis Test: Z Test	
0.000000	Hypothesized value
2.260870	Mean 8.Curriculum is updated with Skill Based Contents
2.909783	mean All Skills
-0.648913	Mean difference(8.Curriculumisupdated with Skill Based Contents-All Skills)
0.928191	std.dev.
0.086554	std. error
115	n
-7.50	z
6.53E-14	p-value(two-tailed)

Interpretation

The above graph depicts p value is lesser than 0.05 level of significance, alternate hypothesis is accepted stating that there exists a significant relationship between curriculum and employability skills possessed. Thus, curriculum needs to be updated on regular basis for better skill enhancement.

Other Findings

1. The secondary data reveals that the institutions neither have industry collaboration nor MOUs with industrial experts which would be a major drawback for the upgradation of skills to students.
2. 69.7% respondents opined that NEP Syllabus focuses on the development of Employability Skills for better job placement, whereas 10.01% of the respondents did not agree for the same.
3. 80.7% respondents think internships helps to provide practical exposure to the corporate world, to the contrary 15.1% respondents did not attend internships during the final semester.
4. 77.3% respondents agreed that Certificate/Training/ Value Added Courses on development of Employability Skills were conducted by the institution and 22.7% did not agree for the same.

Suggestions

1. An active collaboration with autonomous institutions, industry and corporate experts, government institutes, internships would help the students to upgrade their skills and provide a wider exposure to the competitive world.
2. Many students are not aware of the government run schemes for skill development and entrepreneurship support, the enrolment for such schemes would improve if seminars, conferences and workshops are initiated from the government sector in creating awareness.
3. Conventional style of teaching is practiced by many teachers in Haveri city, an initiation to include technology and introduce activity-based learning would help students to be more interactive, in this way the presentation and coordinationskill would improve.
4. Though NEP syllabus includes value-based courses such as NSS, NCC, Sports etc., many students do not come forward for active participation. If more consideration is given to the assigning of credit points, students would actively participate.
5. Orientation and Faculty Development Programme would help the teachers to adapt new changes and execute innovative teaching and learning strategies

CONCLUSION

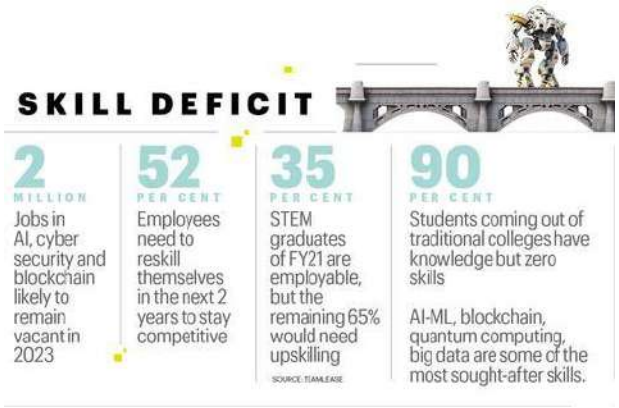
One way to make our nation a developed economy is to be in par with technology and adapt changes. A regular skill gap analysis by educational institutions would help bridge gap between academia and curriculum. Further, an effective mapping and attainment of Programme Outcome and Course Outcome by Board of Examination and Board of Studies at the university level would be a great initiative towards building critical thinking skills, as the near future demands “Do and learn” rather than understanding the theory alone. Involvement of students in collegiate level activities at the entry level would boost up the confidence and help in overcoming anxiety

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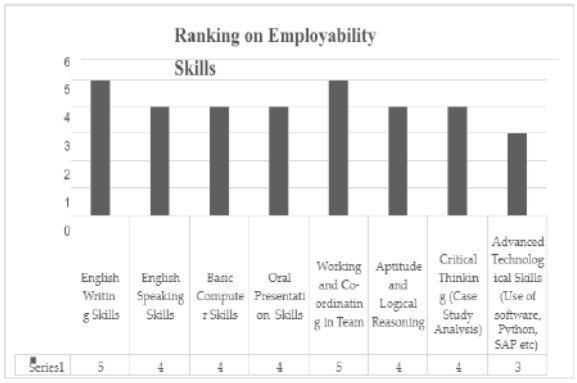
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Source: Fortune India

Fig.1. Skill Deficit



Source: Primary data

Fig.2 Ranking on Employability Skills

RESEARCH ARTICLE

Fuzzy Green Inventory Model under Cap and Trade Policy

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ABSTRACT

Maintaining sustainable environment and economic growth is an ultimate aim of every government. Several policies were designed nowadays to attain this goal. Cap and trade policy is one such initiative implemented for companies to create green world as well as to shine economically. The present study focuses on the effect of cap and trade policy and green technology in the fuzzy inventory model by considering the emission of carbon while manufacturing products. This paper provides a guideline for companies to determine their optimal order quantity and minimized total costs in uncertain situations under this policy and indicates the firm to invest in green technology. To solve this model in a fuzzy sense, signed distance method is applied. Numerical example is given to illustrate the model.

Keywords: Cap and trade policy, trapezoidal hexant fuzzy numbers, signed distance method, green technology, uncertainity.

INTRODUCTION

An environment becomes sustainable only when every functioning of gases emitted or produced is stable in nature. Carbondioxide's primary role on earth is to absorb and radiate heat. In the absence of carbondioxide, earth's natural greenhouse effect becomes too weak to maintain the average global surface temperature above freezing. But excessive amount of carbon in the earth's atmosphere makes supercharged natural greenhouse effect causing global temperature to rise. It is found that two-thirds of the total heating influence of all human released or produced greenhouse gases are mainly due to emission of carbon. Every year, because of human activities like burning coal, oil, natural gases and discharging waste water and air from industries, excess amount of CO_2 is released in the earth than

natural processes can remove and manage the atmosphere. It is observed that increased amount of carbon in the atmosphere threatens the planet and makes the ocean more acidic, putting marine life in danger and resulting in global warming. Global warming produces a severe risk to the environment, living creatures and human being. It also makes sea level to rise and causes flood, drought and so on.

In recent days, government takes several initiatives to safeguard environment from global warming by implementing several environmental policies and regulations to prevent companies from excessive discharge of carbon to the earth. Cap and trade policy is one such policy in which it is used or being developed in all parts of the world. In a cap and trade policy, the government sets an emissions cap and issues a quantity of emission allowances consistent with that cap. Manufacturers must hold allowances for every ton of greenhouse gas they emit. Under this policy, companieshave an opportunity to buy and sell allowances and hence companies or industries having ability to reduce their emissions at a lower cost can sell their excess allowances for companies facing higher costs to buy. Companies at present can also choose to invest in green technology as it is better and cheaper than buying permits.

In the current scenario, many works on inventory model focuses on examining environmental issues in order to create green society. Bonney and Jaber(2011) discussed various environmental issues in the inventory control model and demonstrated that model. Bouchery et al (2012) analysed a multi- objective EOQ model that minimizes cost and environmental damages. Chen et al (2013) discussed the impacts of carbon emission parameters in EOQ models in Green supply chain management and explained the effect of emission of carbon.Ozlu (2013) studied an inventory model under cap and trade, carbon cap and carbon tax approaches. The carbon – constrained EOQ model with carbon emission dependent demand was examined by Vincent Hovelaque& Laurent Bironneau (2015). Juanjuan Qin, Xiaojian Bai and Liangjie Xia (2015) considered sustainable trade credit and inventory policies with demand related to credit period and the environmental sensitivity of consumers under the carbon cap – and – trade and carbon tax regulations. Arindam Ghosh, J.K.Jha and S.P.Sarmah (2016) developed EOQ green model with several carbon policies in order to maintain green environment and economic growth. Hong.Z&Guo.X (2019) discussed the green product supply chain by considering environmental responsibilities. An EOQ model by Kazemi,K., Abdul – Rashid, S.H., Ghazilla R.A.R., Shekarian. E &Zanoni.S (2018) discussed about the items with imperfect quality and emission considerations. Yeu – shiang Huang, Chih – chiang Fang, Ying – An Lin (2020) framed a supply chain model with consideration of logistics, green investment and different carbon emission policies. An inventory model on the effect of investment in green technology under cap and trade policy was investigated by researchers to analyze the policy and its benefits.

The present model is a fuzzy green inventory model in which it examines the effect of green investment and discusses the model under cap and trade policy at uncertain situations. Signed distance method is used to find the optimal solution. Numerical example is solved and a diagrammatic representation is shown to analyse the result.

DEFINITIONS AND METHODOLOGIES:

Fuzzy Set

A fuzzy set $\tilde{A}$ defined on a Universe of discourse X may be written as a collection of ordered pairs, $\tilde{A} = \{(x, \mu_{\tilde{A}}(x)) : x \in X, \mu_{\tilde{A}} \in [0,1]\}$, where each pair $(x, \mu_{\tilde{A}}(x))$ is called a singleton and the element $\mu_{\tilde{A}}(x)$ belongs to the interval [0,1].The function $\mu_{\tilde{A}}(x)$ is called as membership function.

Trapezoidal Hexant Fuzzy Number

A trapezoidal hexant fuzzy number is given by $\widetilde{A_H} = (a_{1h}, a_{2h}, a_{3h}, a_{4h})$ where $a_{1h}, a_{2h}, a_{3h}, a_{4h}$ are real numbers and $a_{1h} \leq a_{2h} \leq a_{3h} \leq a_{4h}$, then its membership function is defined as

$$\mu_{\widetilde{A_H}}(x) = \begin{cases} 1^{1/6} & ,for\ x < a_{1h} \\ \left(\frac{a_{2h}-x}{a_{2h}-a_{1h}}\right)^{1/6} & ,for\ a_{1h} \le x \le a_{2h} \\ 0 & ,for\ a_{2h} \le x \le a_{3h} \\ \left(\frac{x-a_{3h}}{a_{4h}-a_{3h}}\right)^{1/6} & ,for\ a_{3h} \le x \le a_{4h} \\ 1^{1/6} & ,for\ x > a_{4h} \end{cases}$$

Cap and Trade Policy:

Cap and trade policy is a policy in which government sets an emissions cap and gives a quantity of emission allowances consistent with that cap.

Arithmetical operations of Trapezoidal hexant fuzzy number:

(i) If $\widetilde{A_H} = (a_{1h}, a_{2h}, a_{3h}, a_{4h})$, $\widetilde{B_H} = (b_{1h}, b_{2h}, b_{3h}, b_{4h})$ are two Trapezoidal Hexant Fuzzy Numbers then addition is defined by $\widetilde{A_H} + \widetilde{B_H} = (a_{1h} + b_{1h}, a_{2h} + b_{2h}, a_{3h} + b_{3h}, a_{4h} + b_{4h})$.

(ii) If $\widetilde{A_H} = (a_{1h}, a_{2h}, a_{3h}, a_{4h})$, $\widetilde{B_H} = (b_{1h}, b_{2h}, b_{3h}, b_{4h})$ are two Trapezoidal Hexant Fuzzy Numbers then Subtraction is defined by $\widetilde{A_H} - \widetilde{B_H} = (a_{1h} - b_{1h}, a_{2h} - b_{2h}, a_{3h} - b_{3h}, a_{4h} - b_{4h})$.

Signed Distance Method:

Let $\widetilde{A_H} = (a_{1h}, a_{2h}, a_{3h}, a_{4h})$ be the trapezoidal hexant fuzzy number. Then the signed distance method for $\widetilde{A_H}$ is given by

$$R = \frac{1}{2}\left[\int_0^1 [a_{2h} - \alpha^6(a_{2h} - a_{1h}) + a_{3h} + \alpha^6(a_{4h} - a_{3h})]d\alpha\right]$$

$$\therefore R = \frac{a_{1h} + 6a_{2h} + 6a_{3h} + a_{4h}}{14}$$

ASSUMPTIONS AND NOTATIONS:

ASSUMPTIONS:

- Emission of carbon occurs in the production, transportation, storage and recycling process.
- Demand and the costs of returned products are constant per supply chain cycle.
- Allowances for carbon emissions are sufficient in the market for purchasing.
- Managing waste products (or) raw materials focuses on source reduction, pollution control and disposal.

NOTATIONS:

Q_O – Order Quantity.
Q_{Ow} – Order Quantity with Green Technology.
G_t – Amount invested in Green Technology.
D_r – Demand.
O – Ordering Cost.
$I_\hbar$ – Holding Cost.
$C_\wp$ – Cost of Production.
$M_\mathcal{G}$ – Cost of Manufacturing.
T_d – Travelling Distance.
A_v – Average velocity.
α_d – Demand returned proportion.
β_s – Vehicle emission social cost.
F_a – Fixed cost per trip.
T_b – Variable cost per unit transported per distance.
L_p – Packaging labor cost per parcel.
M_L – Material cost used for packaging per parcel.
θ – Produced waste proportion per Q_O.
D_w – Disposal cost for disposing waste in the environment.

D_F – Fixed cost per waste disposal action.
C – Count of parcels.
E_o – Emission of carbon quantity from order per cycle.
E_c – Emission of carbon from manufacturing process.
$E_{ℏ}$ – Emission of carbon quantity from inventory holding.
C_s – Screening cost.
C_R – Cost of recycling per unit.
R_r – Emission of carbon from process of recycling.
R_u – Count of returned materials that are suitable for recycling.
μ_e – Efficiency factor of the carbon reduction.
δ – The offsetting carbon reduction factor.
U_L – The upper limit of emission of carbon.
C_e – Carbon trading price of carbon emission per unit.

GREEN INVENTORY MODEL UNDER CAP AND TRADE POLICY

In the considered model of cap and trade without green technology, the total cost includes cost of production, cost of manufacturing, transportation cost, holding cost, screening cost, disposal cost for disposing waste in the environment and carbon trading price of carbon. Hence the total cost for the considered green inventory model without green technology is given by,

$$TC(Q_O) = \frac{D_r}{Q_O}\left(O + D_F + (L_p + M_L)C + C_s + M_{ℏ} + C_R R_u + 2F_a\right) + \frac{Q_O I_{ℏ}}{2} + D_r\left(C_{\mathcal{P}} + T_b T_d(1+\alpha_d) + D_w(\theta+\alpha_d)\right) - C_e U_L + \frac{D_r}{Q_O} C_e\left(E_o + E_c + \frac{2\beta_s T_d}{A_v}\right) + \frac{Q_O}{2} C_e E_{ℏ} \quad ------(\mathbf{4.1})$$

Differentiating $TC(Q_O)$ with respect to Q_O,

$$\frac{\partial TC(Q_O)}{\partial Q_O} = \frac{-D_r}{{Q_O}^2}\left(O + D_F + (L_p + M_L)C + C_s + M_{ℏ} + C_R R_u + 2F_a\right) + \frac{I_{ℏ}}{2} - \frac{D_r}{{Q_O}^2} C_e\left(E_o + E_c + \frac{2\beta_s T_d}{A_v}\right) + \frac{C_e E_{ℏ}}{2}$$

Equating $\frac{\partial TC(Q_O)}{\partial Q_O}$ to zero we get the order quantity without green technology,

$$Q_O = \sqrt{\frac{2D_r\left[\left(O + D_F + (L_p + M_L)C + C_s + M_{ℏ} + C_R R_u + 2F_a\right) + C_e\left(E_o + E_c + \frac{2\beta_s T_d}{A_v}\right)\right]}{I_{ℏ} + C_e E_{ℏ}}}$$

Including the investment in green technology is also considered in the inventory model under cap and trade policy. Here reduction of carbon for green technology is given by $\mu_e G_t - \delta {G_t}^2$.Hence the total cost for the considered green inventory model with green technology is given by,

$$TC_1(Q_{Ow}, G_t) = \frac{D_r}{Q_{Ow}}\left(O + D_F + (L_p + M_L)C + C_s + M_{ℏ} + C_R R_u + 2F_a\right) + \frac{Q_{Ow} I_{ℏ}}{2} + D_r\left(C_{\mathcal{P}} + T_b T_d(1+\alpha_d) + D_w(\theta+\alpha_d)\right) - C_e U_L + G_t + \frac{D_r}{Q_{Ow}} C_e\left(E_o + E_c + \frac{2\beta_s T_d}{A_v}\right) + \frac{Q_{Ow}}{2} C_e E_{ℏ} - C_e\left(\mu_e G_t - \delta {G_t}^2\right) --- (\mathbf{4.2})$$

Differentiating $TC_1(Q_{Ow}, G_t)$ with respect to Q_{Ow},

$$\frac{\partial TC_1(Q_{Ow}, G_t)}{\partial Q_{Ow}} = \frac{-D_r}{{Q_{Ow}}^2}\left(O + D_F + (L_p + M_L)C + C_s + M_{ℏ} + C_R R_u + 2F_a\right) + \frac{I_{ℏ}}{2} - \frac{D_r}{{Q_{Ow}}^2} C_e\left(E_o + E_c + \frac{2\beta_s T_d}{A_v}\right) + \frac{C_e E_{ℏ}}{2}$$

Equating $\frac{\partial TC_1(Q_{Ow}, G_t)}{\partial Q_{Ow}}$ to zero we get the order quantity with green technology,

$$Q_{Ow} = \sqrt{\frac{2D_r\left[\left(O+D_F+\left(L_p+M_L\right)C+C_s+M_{\mathcal{b}}+C_R R_u+2F_a\right)+C_e\left(E_o+E_c+\frac{2\beta_s T_d}{A_v}\right)\right]}{I_{\hbar}+C_e E_{\hbar}}}$$

Differentiating (4.2) with respect to G_t, we get the green investment amount,

$$G_t = \frac{C_e\mu_e - 1}{2C_e\delta}$$

FUZZY GREEN INVENTORY MODEL:

To face uncertainsituations, the present green supply chain model is considered under fuzzy technique. Hence several parameters like holding cost, emission of carbon quantity from inventory holding, cost of production, packaging labor cost per parcel, emission of carbon from manufacturing process, count of returned materials that are suitable for recycling, cost of recycling per unit, travelling distance and material cost used for packaging per parcelare taken as trapezoidal hexant fuzzy numbers and it is expressed as for both without and with green technology as follows,

$\widetilde{D_r} = \left(d_{r_1}, d_{r_2}, d_{r_3}, d_{r_4}\right)$
$\tilde{O} = (o_1, o_2, o_3, o_4)$
$\widetilde{I_{\hbar}} = \left(I_{\hbar_1}, I_{\hbar_2}, I_{\hbar_3}, I_{\hbar_4}\right)$
$\widetilde{E_{\hbar}} = \left(e_{\hbar_1}, e_{\hbar_2}, e_{\hbar_3}, e_{\hbar_4}\right)$
$\widetilde{C_{\mathcal{p}}} = \left(c_{\mathcal{p}_1}, c_{\mathcal{p}_2}, c_{\mathcal{p}_3}, c_{\mathcal{p}_4}\right)$
$\widetilde{L_p} = \left(l_{p_1}, l_{p_2}, l_{p_3}, l_{p_4}\right)$
$\widetilde{E_c} = \left(e_{c_1}, e_{c_2}, e_{c_3}, e_{c_4}\right)$
$\widetilde{R_u} = \left(r_{u_1}, r_{u_2}, r_{u_3}, r_{u_4}\right)$
$\widetilde{C_R} = \left(c_{r_1}, c_{r_2}, c_{r_3}, c_{r_4}\right)$
$\widetilde{T_d} = \left(t_{d_1}, t_{d_2}, t_{d_3}, t_{d_4}\right)$
$\widetilde{M_L} = \left(m_{l_1}, m_{l_2}, m_{l_3}, m_{l_4}\right)$

Now applying above considered fuzzy numbers in (4.1) we have,

$$\widetilde{TC}(Q_O) = \frac{\widetilde{D_r}}{Q_O} \otimes \left(\tilde{O} \oplus D_F \oplus \left(\widetilde{L_p} \oplus \widetilde{M_L}\right)C \oplus C_s \oplus M_{\mathcal{b}} \oplus \left(\widetilde{C_R} \otimes \widetilde{R_u}\right) \oplus 2F_a\right) \oplus \left(\frac{Q_O \otimes \widetilde{I_{\hbar}}}{2}\right) \oplus \widetilde{D_r}$$
$$\otimes \left(\widetilde{C_{\mathcal{p}}} \oplus \left(T_b \otimes \widetilde{T_d}\right)(1+\alpha_d) + D_w(\theta+\alpha_d)\right) - C_e U_L \oplus \frac{\widetilde{D_r}}{Q_O} C_e \left(E_o \oplus \widetilde{E_c} \oplus \left(\frac{2\beta_s \otimes \widetilde{T_d}}{A_v}\right)\right) + \frac{Q_O}{2} C_e \otimes \widetilde{E_{\hbar}}$$

$$\widetilde{TC}(Q_O) = \frac{\left(d_{r_1}, d_{r_2}, d_{r_3}, d_{r_4}\right)}{Q_O}$$
$$\otimes \left[(o_1, o_2, o_3, o_4) \oplus D_F \oplus \left(\left(l_{p_1}, l_{p_2}, l_{p_3}, l_{p_4}\right) \oplus \left(m_{l_1}, m_{l_2}, m_{l_3}, m_{l_4}\right)\right)C \oplus C_s \oplus M_{\mathcal{b}}\right.$$
$$\left. \oplus \left(\left(c_{r_1}, c_{r_2}, c_{r_3}, c_{r_4}\right) \otimes \left(r_{u_1}, r_{u_2}, r_{u_3}, r_{u_4}\right)\right) + 2F_a\right] \oplus \left(\frac{Q_O \otimes \left(I_{\hbar_1}, I_{\hbar_2}, I_{\hbar_3}, I_{\hbar_4}\right)}{2}\right) \oplus \left(d_{r_1}, d_{r_2}, d_{r_3}, d_{r_4}\right)$$
$$\otimes \left[\left(c_{\mathcal{p}_1}, c_{\mathcal{p}_2}, c_{\mathcal{p}_3}, c_{\mathcal{p}_4}\right) \oplus \left(T_b \otimes \left(t_{d_1}, t_{d_2}, t_{d_3}, t_{d_4}\right)\right)(1+\alpha_d) \oplus D_w(\theta+\alpha_d)\right] - C_e U_L$$
$$\oplus \frac{\left(d_{r_1}, d_{r_2}, d_{r_3}, d_{r_4}\right)}{Q_O} C_e \left[E_o \oplus \left(e_{c_1}, e_{c_2}, e_{c_3}, e_{c_4}\right) \oplus \left(\frac{2\beta_s \otimes \left(t_{d_1}, t_{d_2}, t_{d_3}, t_{d_4}\right)}{A_v}\right)\right] + \frac{Q_O}{2} C_e$$
$$\otimes \left(e_{\hbar_1}, e_{\hbar_2}, e_{\hbar_3}, e_{\hbar_4}\right)$$

$$\widetilde{TC}(Q_O)=\begin{bmatrix}\frac{d_{r_1}}{Q_O}\left(o_1+D_F+\left(l_{p_1}+m_{l_1}\right)C+C_s+M_{\hbar}+\left(c_{r_1}r_{u_1}\right)+2F_a\right)+\frac{Q_O I_{\hbar_1}}{2}+\\ d_{r_1}\left(c_{p_1}+T_b t_{d_1}(1+\alpha_d)+D_w(\theta+\alpha_d)\right)-C_e U_L+\frac{d_{r_1}}{Q_O}C_e\left(E_o+e_{c_1}+\frac{2\beta_s t_{d_1}}{A_v}\right)+\frac{Q_O}{2}C_e e_{\hbar_1},\\ \frac{d_{r_2}}{Q_O}\left(o_2+D_F+\left(l_{p_2}+m_{l_2}\right)C+C_s+M_{\hbar}+\left(c_{r_2}r_{u_2}\right)+2F_a\right)+\frac{Q_O I_{\hbar_2}}{2}+\\ d_{r_2}\left(c_{p_2}+T_b t_{d_2}(1+\alpha_d)+D_w(\theta+\alpha_d)\right)-C_e U_L+\frac{d_{r_2}}{Q_O}C_e\left(E_o+e_{c_2}+\frac{2\beta_s t_{d_2}}{A_v}\right)+\frac{Q_O}{2}C_e e_{\hbar_2},\\ \frac{d_{r_3}}{Q_O}\left(o_3+D_F+\left(l_{p_3}+m_{l_3}\right)C+C_s+M_{\hbar}+\left(c_{r_3}r_{u_3}\right)+2F_a\right)+\frac{Q_O I_{\hbar_3}}{2}+\\ d_{r_3}\left(c_{p_3}+T_b t_{d_3}(1+\alpha_d)+D_w(\theta+\alpha_d)\right)-C_e U_L+\frac{d_{r_3}}{Q_O}C_e\left(E_o+e_{c_3}+\frac{2\beta_s t_{d_3}}{A_v}\right)+\frac{Q_O}{2}C_e e_{\hbar_3},\\ \frac{d_{r_4}}{Q_O}\left(o_4+D_F+\left(l_{p_4}+m_{l_4}\right)C+C_s+M_{\hbar}+\left(c_{r_4}r_{u_4}\right)+2F_a\right)+\frac{Q_O I_{\hbar_4}}{2}+\\ d_{r_4}\left(c_{p_4}+T_b t_{d_4}(1+\alpha_d)+D_w(\theta+\alpha_d)\right)-C_e U_L+\frac{d_{r_4}}{Q_O}C_e\left(E_o+e_{c_4}+\frac{2\beta_s t_{d_4}}{A_v}\right)+\frac{Q_O}{2}C_e e_{\hbar_4}\end{bmatrix}$$

Applying Signed distance method for the total cost without green technology we have,

$$R\left(\widetilde{TC}(Q_O)\right)=\frac{1}{14}\begin{bmatrix}\begin{bmatrix}\frac{d_{r_1}}{Q_O}\left(o_1+D_F+\left(l_{p_1}+m_{l_1}\right)C+C_s+M_{\hbar}+\left(c_{r_1}r_{u_1}\right)+2F_a\right)+\frac{Q_O I_{\hbar_1}}{2}+\\ d_{r_1}\left(c_{p_1}+T_b t_{d_1}(1+\alpha_d)+D_w(\theta+\alpha_d)\right)-C_e U_L+\frac{d_{r_1}}{Q_O}C_e\left(E_o+e_{c_1}+\frac{2\beta_s t_{d_1}}{A_v}\right)+\frac{Q_O}{2}C_e e_{\hbar_1}\end{bmatrix}\\ +6\begin{bmatrix}\frac{d_{r_2}}{Q_O}\left(o_2+D_F+\left(l_{p_2}+m_{l_2}\right)C+C_s+M_{\hbar}+\left(c_{r_2}r_{u_2}\right)+2F_a\right)+\frac{Q_O I_{\hbar_2}}{2}+\\ d_{r_2}\left(c_{p_2}+T_b t_{d_2}(1+\alpha_d)+D_w(\theta+\alpha_d)\right)-C_e U_L+\frac{d_{r_2}}{Q_O}C_e\left(E_o+e_{c_2}+\frac{2\beta_s t_{d_2}}{A_v}\right)+\frac{Q_O}{2}C_e e_{\hbar_2}\end{bmatrix}\\ +6\begin{bmatrix}\frac{d_{r_3}}{Q_O}\left(o_3+D_F+\left(l_{p_3}+m_{l_3}\right)C+C_s+M_{\hbar}+\left(c_{r_3}r_{u_3}\right)+2F_a\right)+\frac{Q_O I_{\hbar_3}}{2}+\\ d_{r_3}\left(c_{p_3}+T_b t_{d_3}(1+\alpha_d)+D_w(\theta+\alpha_d)\right)-C_e U_L+\frac{d_{r_3}}{Q_O}C_e\left(E_o+e_{c_3}+\frac{2\beta_s t_{d_3}}{A_v}\right)+\frac{Q_O}{2}C_e e_{\hbar_3}\end{bmatrix}\\ \begin{bmatrix}\frac{d_{r_4}}{Q_O}\left(o_4+D_F+\left(l_{p_4}+m_{l_4}\right)C+C_s+M_{\hbar}+\left(c_{r_4}r_{u_4}\right)+2F_a\right)+\frac{Q_O I_{\hbar_4}}{2}+\\ d_{r_4}\left(c_{p_4}+T_b t_{d_4}(1+\alpha_d)+D_w(\theta+\alpha_d)\right)-C_e U_L+\frac{d_{r_4}}{Q_O}C_e\left(E_o+e_{c_4}+\frac{2\beta_s t_{d_4}}{A_v}\right)+\frac{Q_O}{2}C_e e_{\hbar_4}\end{bmatrix}\end{bmatrix}$$

$$-------(\mathbf{5.1})$$

Differentiating $R\left(\widetilde{TC}(Q_O)\right)$ with respect to Q_O and equating to zero gives an optimum fuzzy Order Quantity for the model under cap and trade without green technology,

$$\widetilde{Q_O}^{*}=\sqrt{\frac{2\begin{bmatrix}\left[d_{r_1}\left[\left(o_1+D_F+\left(l_{p_1}+m_{l_1}\right)C+C_s+M_{\hbar}+\left(c_{r_1}r_{u_1}\right)+2F_a\right)+C_e\left(E_o+e_{c_1}+\frac{2\beta_s t_{d_1}}{A_v}\right)\right]\right]\\ +6\left[d_{r_2}\left[\left(o_2+D_F+\left(l_{p_2}+m_{l_2}\right)C+C_s+M_{\hbar}+\left(c_{r_2}r_{u_2}\right)+2F_a\right)+C_e\left(E_o+e_{c_2}+\frac{2\beta_s t_{d_2}}{A_v}\right)\right]\right]\\ +6\left[d_{r_3}\left[\left(o_3+D_F+\left(l_{p_3}+m_{l_3}\right)C+C_s+M_{\hbar}+\left(c_{r_3}r_{u_3}\right)+2F_a\right)+C_e\left(E_o+e_{c_3}+\frac{2\beta_s t_{d_3}}{A_v}\right)\right]\right]\\ +\left[d_{r_4}\left[\left(o_4+D_F+\left(l_{p_4}+m_{l_4}\right)C+C_s+M_{\hbar}+\left(c_{r_4}r_{u_4}\right)+2F_a\right)+C_e\left(E_o+e_{c_4}+\frac{2\beta_s t_{d_4}}{A_v}\right)\right]\right]\end{bmatrix}}{\left(I_{\hbar_1}+C_e e_{\hbar_1}\right)+6\left(I_{\hbar_2}+C_e e_{\hbar_2}\right)+6\left(I_{\hbar_3}+C_e e_{\hbar_3}\right)+\left(I_{\hbar_4}+C_e e_{\hbar_4}\right)}}$$

$$-------(\mathbf{5.2})$$

Now let us consider (**4.2**), the total cost with consideration of investment in green technology and fuzzify its several parameters as trapezoidal hexant fuzzy numbers as follows,

$$\widetilde{TC_1}(Q_{Ow}, G_t) = \frac{\widetilde{D_r}}{Q_{Ow}} \otimes \left(\tilde{O} \oplus D_F \oplus \left(\widetilde{L_p} \oplus \widetilde{M_L}\right)C \oplus C_s \oplus M_{\mathfrak{b}} \oplus \left(\widetilde{C_R} \otimes \widetilde{R_u}\right) \oplus 2F_a\right) \oplus \left(\frac{Q_{Ow} \otimes \widetilde{I_{\hbar}}}{2}\right) \oplus \widetilde{D_r} \otimes \left(\widetilde{C_{\mathscr{p}}} \oplus \left(T_b \otimes \widetilde{T_d}\right)(1+\alpha_d) + D_w(\theta+\alpha_d)\right) - C_e U_L \oplus G_t \oplus \frac{\widetilde{D_r}}{Q_{Ow}} C_e \left(E_o \oplus \widetilde{E_c} \oplus \left(\frac{2\beta_s \otimes \widetilde{T_d}}{A_v}\right)\right) + \left(\frac{Q_{Ow}}{2} C_e \otimes \widetilde{E_{\hbar}}\right) - C_e\left(\mu_e G_t - \delta {G_t}^2\right)$$

$$\begin{aligned}
\widetilde{TC_1}(Q_{Ow}, G_t) = {} & \frac{\left(d_{r_1}, d_{r_2}, d_{r_3}, d_{r_4}\right)}{Q_{Ow}} \\
& \otimes \left[(o_1, o_2, o_3, o_4) \oplus D_F \oplus \left(\left(l_{p_1}, l_{p_2}, l_{p_3}, l_{p_4}\right) \oplus \left(m_{l_1}, m_{l_2}, m_{l_3}, m_{l_4}\right)\right) C \oplus C_s \oplus M_{\mathfrak{b}}\right. \\
& \left. \oplus \left(\left(c_{r_1}, c_{r_2}, c_{r_3}, c_{r_4}\right) \otimes \left(r_{u_1}, r_{u_2}, r_{u_3}, r_{u_4}\right)\right) + 2F_a\right] \oplus \left(\frac{Q_{Ow} \otimes \left(I_{\hbar_1}, I_{\hbar_2}, I_{\hbar_3}, I_{\hbar_4}\right)}{2}\right) \oplus \left(d_{r_1}, d_{r_2}, d_{r_3}, d_{r_4}\right) \\
& \otimes \left[\left(c_{\mathscr{p}_1}, c_{\mathscr{p}_2}, c_{\mathscr{p}_3}, c_{\mathscr{p}_4}\right) \oplus \left(T_b \otimes \left(t_{d_1}, t_{d_2}, t_{d_3}, t_{d_4}\right)\right)(1+\alpha_d) \oplus D_w(\theta+\alpha_d)\right] - C_e U_L \oplus G_t \\
& \oplus \frac{\left(d_{r_1}, d_{r_2}, d_{r_3}, d_{r_4}\right)}{Q_{Ow}} C_e \left[E_o \oplus \left(e_{c_1}, e_{c_2}, e_{c_3}, e_{c_4}\right) \oplus \left(\frac{2\beta_s \otimes \left(t_{d_1}, t_{d_2}, t_{d_3}, t_{d_4}\right)}{A_v}\right)\right] + \frac{Q_{Ow}}{2} C_e \\
& \otimes \left(e_{\hbar_1}, e_{\hbar_2}, e_{\hbar_3}, e_{\hbar_4}\right) - C_e\left(\mu_e G_t - \delta {G_t}^2\right)
\end{aligned}$$

$$\widetilde{TC_1}(Q_{Ow}, G_t) = \begin{bmatrix}
\left(\begin{matrix} \frac{d_{r_1}}{Q_{Ow}}\left(\begin{matrix} o_1 + D_F + \left(l_{p_1} + m_{l_1}\right)C + \\ C_s + M_{\mathfrak{b}} + \left(c_{r_1} r_{u_1}\right) + 2F_a \end{matrix}\right) + \frac{Q_{Ow} I_{\hbar_1}}{2} + d_{r_1}\left(\begin{matrix} c_{\mathscr{p}_1} + T_b t_{d_1}(1+\alpha_d) + \\ D_w(\theta+\alpha_d) \end{matrix}\right) \\ -C_e U_L + G_t + \frac{d_{r_1}}{Q_{Ow}} C_e \left(E_o + e_{c_1} + \frac{2\beta_s t_{d_1}}{A_v}\right) + \frac{Q_{Ow}}{2} C_e e_{\hbar_1} - C_e\left(\mu_e G_t - \delta {G_t}^2\right) \end{matrix}\right), \\
\left(\begin{matrix} \frac{d_{r_2}}{Q_{Ow}}\left(\begin{matrix} o_2 + D_F + \left(l_{p_2} + m_{l_2}\right)C + \\ C_s + M_{\mathfrak{b}} + \left(c_{r_2} r_{u_2}\right) + 2F_a \end{matrix}\right) + \frac{Q_{Ow} I_{\hbar_2}}{2} + d_{r_2}\left(\begin{matrix} c_{\mathscr{p}_2} + T_b t_{d_2}(1+\alpha_d) + \\ D_w(\theta+\alpha_d) \end{matrix}\right) \\ -C_e U_L + G_t + \frac{d_{r_2}}{Q_{Ow}} C_e \left(E_o + e_{c_2} + \frac{2\beta_s t_{d_2}}{A_v}\right) + \frac{Q_{Ow}}{2} C_e e_{\hbar_2} - C_e\left(\mu_e G_t - \delta {G_t}^2\right) \end{matrix}\right), \\
\left(\begin{matrix} \frac{d_{r_3}}{Q_{Ow}}\left(\begin{matrix} o_3 + D_F + \left(l_{p_3} + m_{l_3}\right)C + \\ C_s + M_{\mathfrak{b}} + \left(c_{r_3} r_{u_3}\right) + 2F_a \end{matrix}\right) + \frac{Q_{Ow} I_{\hbar_3}}{2} + d_{r_3}\left(\begin{matrix} c_{\mathscr{p}_3} + T_b t_{d_3}(1+\alpha_d) + \\ D_w(\theta+\alpha_d) \end{matrix}\right) \\ -C_e U_L + G_t + \frac{d_{r_3}}{Q_{Ow}} C_e \left(E_o + e_{c_3} + \frac{2\beta_s t_{d_3}}{A_v}\right) + \frac{Q_{Ow}}{2} C_e e_{\hbar_3} - C_e\left(\mu_e G_t - \delta {G_t}^2\right) \end{matrix}\right), \\
\left(\begin{matrix} \frac{d_{r_4}}{Q_{Ow}}\left(\begin{matrix} o_4 + D_F + \left(l_{p_4} + m_{l_4}\right)C + \\ C_s + M_{\mathfrak{b}} + \left(c_{r_4} r_{u_4}\right) + 2F_a \end{matrix}\right) + \frac{Q_{Ow} I_{\hbar_4}}{2} + d_{r_4}\left(\begin{matrix} c_{\mathscr{p}_4} + T_b t_{d_4}(1+\alpha_d) + \\ D_w(\theta+\alpha_d) \end{matrix}\right) \\ -C_e U_L + G_t + \frac{d_{r_4}}{Q_{Ow}} C_e \left(E_o + e_{c_4} + \frac{2\beta_s t_{d_4}}{A_v}\right) + \frac{Q_{Ow}}{2} C_e e_{\hbar_4} - C_e\left(\mu_e G_t - \delta {G_t}^2\right) \end{matrix}\right)
\end{bmatrix}$$

Applying Signed distance method for the total cost with green technology we have,

$$R\left(\widetilde{TC_1}(Q_{Ow}, G_t)\right) = \frac{1}{14}\begin{bmatrix}
\left(\begin{matrix} \frac{d_{r_1}}{Q_{Ow}}\left(\begin{matrix} o_1 + D_F + \left(l_{p_1} + m_{l_1}\right)C + \\ C_s + M_{\mathfrak{b}} + \left(c_{r_1} r_{u_1}\right) + 2F_a \end{matrix}\right) + \frac{Q_{Ow} I_{\hbar_1}}{2} + d_{r_1}\left(\begin{matrix} c_{\mathscr{p}_1} + T_b t_{d_1}(1+\alpha_d) + \\ D_w(\theta+\alpha_d) \end{matrix}\right) \\ -C_e U_L + G_t + \frac{d_{r_1}}{Q_{Ow}} C_e \left(E_o + e_{c_1} + \frac{2\beta_s t_{d_1}}{A_v}\right) + \frac{Q_{Ow}}{2} C_e e_{\hbar_1} - C_e\left(\mu_e G_t - \delta {G_t}^2\right) \end{matrix}\right) + \\
6\left(\begin{matrix} \frac{d_{r_2}}{Q_{Ow}}\left(\begin{matrix} o_2 + D_F + \left(l_{p_2} + m_{l_2}\right)C + \\ C_s + M_{\mathfrak{b}} + \left(c_{r_2} r_{u_2}\right) + 2F_a \end{matrix}\right) + \frac{Q_{Ow} I_{\hbar_2}}{2} + d_{r_2}\left(\begin{matrix} c_{\mathscr{p}_2} + T_b t_{d_2}(1+\alpha_d) + \\ D_w(\theta+\alpha_d) \end{matrix}\right) \\ -C_e U_L + G_t + \frac{d_{r_2}}{Q_{Ow}} C_e \left(E_o + e_{c_2} + \frac{2\beta_s t_{d_2}}{A_v}\right) + \frac{Q_{Ow}}{2} C_e e_{\hbar_2} - C_e\left(\mu_e G_t - \delta {G_t}^2\right) \end{matrix}\right) + \\
6\left(\begin{matrix} \frac{d_{r_3}}{Q_{Ow}}\left(\begin{matrix} o_3 + D_F + \left(l_{p_3} + m_{l_3}\right)C + \\ C_s + M_{\mathfrak{b}} + \left(c_{r_3} r_{u_3}\right) + 2F_a \end{matrix}\right) + \frac{Q_{Ow} I_{\hbar_3}}{2} + d_{r_3}\left(\begin{matrix} c_{\mathscr{p}_3} + T_b t_{d_3}(1+\alpha_d) + \\ D_w(\theta+\alpha_d) \end{matrix}\right) \\ -C_e U_L + G_t + \frac{d_{r_3}}{Q_{Ow}} C_e \left(E_o + e_{c_3} + \frac{2\beta_s t_{d_3}}{A_v}\right) + \frac{Q_{Ow}}{2} C_e e_{\hbar_3} - C_e\left(\mu_e G_t - \delta {G_t}^2\right) \end{matrix}\right) + \\
\left(\begin{matrix} \frac{d_{r_4}}{Q_{Ow}}\left(\begin{matrix} o_4 + D_F + \left(l_{p_4} + m_{l_4}\right)C + \\ C_s + M_{\mathfrak{b}} + \left(c_{r_4} r_{u_4}\right) + 2F_a \end{matrix}\right) + \frac{Q_{Ow} I_{\hbar_4}}{2} + d_{r_4}\left(\begin{matrix} c_{\mathscr{p}_4} + T_b t_{d_4}(1+\alpha_d) + \\ D_w(\theta+\alpha_d) \end{matrix}\right) \\ -C_e U_L + G_t + \frac{d_{r_4}}{Q_{Ow}} C_e \left(E_o + e_{c_4} + \frac{2\beta_s t_{d_4}}{A_v}\right) + \frac{Q_{Ow}}{2} C_e e_{\hbar_4} - C_e\left(\mu_e G_t - \delta {G_t}^2\right) \end{matrix}\right)
\end{bmatrix}$$

$$--------(\mathbf{5.3})$$

Differentiating $R\left(\widetilde{TC_1}(Q_{Ow}, G_t)\right)$ with respect to Q_{Ow} and equating to zero gives an optimum fuzzy Order Quantity for the model under cap and trade with green technology,

$$\widetilde{Q_{Ow}}^* = \sqrt{\frac{2\begin{bmatrix}\left[d_{r_1}\left[(o_1 + D_F + (l_{p_1} + m_{l_1})C + C_s + M_{\mathscr{b}} + (c_{r_1}r_{u_1}) + 2F_a\right) + C_e\left(E_o + e_{c_1} + \frac{2\beta_s t_{d_1}}{A_v}\right)\right]\right] \\ +6\left[d_{r_2}\left[(o_2 + D_F + (l_{p_2} + m_{l_2})C + C_s + M_{\mathscr{b}} + (c_{r_2}r_{u_2}) + 2F_a\right) + C_e\left(E_o + e_{c_2} + \frac{2\beta_s t_{d_2}}{A_v}\right)\right]\right] \\ +6\left[d_{r_3}\left[(o_3 + D_F + (l_{p_3} + m_{l_3})C + C_s + M_{\mathscr{b}} + (c_{r_3}r_{u_3}) + 2F_a\right) + C_e\left(E_o + e_{c_3} + \frac{2\beta_s t_{d_3}}{A_v}\right)\right]\right] \\ +\left[d_{r_4}\left[(o_4 + D_F + (l_{p_4} + m_{l_4})C + C_s + M_{\mathscr{b}} + (c_{r_4}r_{u_4}) + 2F_a\right) + C_e\left(E_o + e_{c_4} + \frac{2\beta_s t_{d_4}}{A_v}\right)\right]\right]\end{bmatrix}}{(I_{\hbar_1} + C_e e_{\hbar_1}) + 6(I_{\hbar_2} + C_e e_{\hbar_2}) + 6(I_{\hbar_3} + C_e e_{\hbar_3}) + (I_{\hbar_4} + C_e e_{\hbar_4})}}$$

$$--------(\mathbf{5.4})$$

Differentiating $R\left(\widetilde{TC_1}(Q_{Ow}, G_t)\right)$ with respect to G_t yields an optimum amount to be invested in green technology and it is given by,

$$G_t^* = \frac{C_e\mu_e - 1}{2C_e\delta} \qquad --------(\mathbf{5.5})$$

NUMERICAL EXAMPLE:

CRISP MODEL

Numerical values for several cost parameters are as follows,

$D_r = 4000,\ O = \$110,\ I_{\hbar} = \$10,\ C_{\mathscr{p}} = \$100,\ T_d = 200\ km,\ A_v = 40\ km/hr,\ \alpha_d = 0.1,\ \beta_s = \$10,\ F_a = \$20,\ T_b = \$2,\ L_p = \$5,\ M_L = \$7,\ \theta = 0.4,\ D_w = \$0.7,\ D_F = \$0.9,\ C = 14,\ C_R = \$110,\ M_{\mathscr{b}} = \$140,\ E_o = \$120, E_c = \$150,\ E_{\hbar} = \$45,\ C_s = \$0.1, R_r = \$120, R_u = 40, U_L = 5000,\ C_e = \$1.7,\ \mu_e = 3,\ \delta = 0.01$

Green Investment amount is given by, $G_t = \frac{C_e\mu_e - 1}{2C_e\delta} = 120.58.$

Order Quantity without and with green technology:

$$Q_O = \sqrt{\frac{2D_r\left[(O + D_F + (L_p + M_L)C + C_s + M_{\mathscr{b}} + C_R R_u + 2F_a) + C_e\left(E_o + E_c + \frac{2\beta_s T_d}{A_v}\right)\right]}{I_{\hbar} + C_e E_{\hbar}}}$$

$$Q_O = \sqrt{\frac{(2\times 4000)\left[(110 + 0.9 + (5+7)14 + 0.1 + 140 + (110\times 40) + (2\times 20)) + 1.7\left(120 + 150 + \left(\frac{2\times 10\times 200}{40}\right)\right)\right]}{10 + (1.7\times 45)}}$$

$\therefore Q_O = 712.4329$

$$Q_{Ow} = \sqrt{\frac{2D_r\left[(O + D_F + (L_p + M_L)C + C_s + M_{\mathscr{b}} + C_R R_u + 2F_a) + C_e\left(E_o + E_c + \frac{2\beta_s T_d}{A_v}\right)\right]}{I_{\hbar} + C_e E_{\hbar}}}$$

$$Q_{Ow} = \sqrt{\frac{(2\times 4000)\left[(110 + 0.9 + (5+7)14 + 0.1 + 140 + (110\times 40) + (2\times 20)) + 1.7\left(120 + 150 + \left(\frac{2\times 10\times 200}{40}\right)\right)\right]}{10 + (1.7\times 45)}}$$

$\therefore Q_{Ow} = 712.4329$

Total cost without and with green technology

$$TC(Q_O) = \frac{D_r}{Q_O}\left(O + D_F + \left(L_p + M_L\right)C + C_s + M_{\hbar} + C_R R_u + 2F_a\right) + \frac{Q_O I_{\hbar}}{2} + D_r\left(C_{\wp} + T_b T_d(1+\alpha_d) + D_w(\theta+\alpha_d)\right) - C_e U_L + \frac{D_r}{Q_O} C_e\left(E_o + E_c + \frac{2\beta_s T_d}{A_v}\right) + \frac{Q_O}{2} C_e E_{\hbar}$$

$$TC(Q_O) = \frac{4000}{712.4329}\left(110 + 0.9 + (5+7)14 + 0.1 + 140 + (110\times 40) + (2\times 20)\right) + \left(\frac{712.4329\times 10}{2}\right) + 4000\left(100 + (2\times 200)(1+0.1) + 0.7(0.4+0.1)\right) - (1.7\times 5000) + \frac{4000}{712.4329} \times 1.7\left(120 + 150 + \left(\frac{2\times 10\times 200}{40}\right)\right) + \frac{712.4329}{2}(1.7\times 45)$$

$\therefore TC(Q_O)$ =2214525.449.

$$TC_1(Q_{Ow}, G_t) = \frac{D_r}{Q_{Ow}}\left(O + D_F + \left(L_p + M_L\right)C + C_s + M_{\hbar} + C_R R_u + 2F_a\right) + \frac{Q_{Ow} I_{\hbar}}{2} + D_r\left(C_{\wp} + T_b T_d(1+\alpha_d) + D_w(\theta+\alpha_d)\right) - C_e U_L + G_t + \frac{D_r}{Q_{Ow}} C_e\left(E_o + E_c + \frac{2\beta_s T_d}{A_v}\right) + \frac{Q_{Ow}}{2} C_e E_{\hbar} - C_e\left(\mu_e G_t - \delta {G_t}^2\right)$$

$$TC_1(Q_{Ow}, G_t) = \frac{4000}{712.4329}\left(110 + 0.9 + (5+7)14 + 0.1 + 140 + (110\times 40) + (2\times 20)\right) + \left(\frac{712.4329\times 10}{2}\right) + 4000\left(100 + (2\times 200)(1+0.1) + 0.7(0.4+0.1)\right) - (1.7\times 5000) + 120.58 + \frac{4000}{712.4329} \times 1.7\left(120 + 150 + \left(\frac{2\times 10\times 200}{40}\right)\right) + \frac{712.4329}{2}(1.7\times 45) - 1.7\left((3\times 120.58) - (0.01\times (120.58)^2)\right)$$

$TC_1(Q_{Ow}, G_t) = 2214278.243$

Fuzzy Model

The corresponding values of parameters fuzzified are as follows,

$\widetilde{D_r}$ = (3999.8,3999.9,4000.1,4000.2)

$\tilde{O}$ = (109.8,109.9,110.1,110.2)

$\widetilde{I_{\hbar}}$ = (9.8,9.9,10.1,10.2)

$\widetilde{E_{\hbar}}$ = (44.8,44.9,45.1,45.2)

$\widetilde{C_{\wp}}$ = (99.8,99.9,100.1,100.2)

$\widetilde{L_p}$ = (4.8,4.9,5.1,5.2)

$\widetilde{E_c}$ = (149.8,149.9,150.1,150.2)

$\widetilde{R_u}$ = (39.8,39.9,40.1,40.2)

$\widetilde{C_R}$ = (109.8,109.9,110.1,110.2)

$\widetilde{T_d}$ = (199.8,199.9,200.1,200.2)

$\widetilde{M_L}$ = (6.8,6.9,7.1,7.2)

Optimum Green Investment amount is given by, ${G_t}^* = \frac{C_e\mu_e - 1}{2C_e\delta} = 120.58$.

Fuzzy Order Quantity without and with green technology:

By substituting values in (**5.2**), $\widetilde{Q_O}^* = 712.43$.

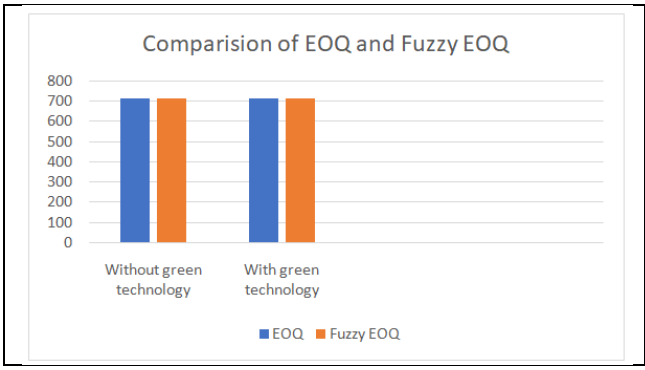
By substituting values in (**5.4**), $\widetilde{Q_{Ow}}^* = 712.43$.

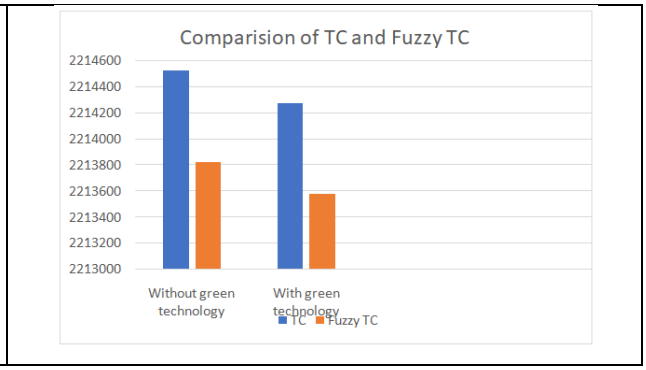
Fuzzy Total cost without and with green technology:

By substituting values in (**5.1**), $R\left(\widetilde{TC}(Q_O)\right) = 2213825.559$

By substituting values in (**5.3**), $R\left(\widetilde{TC_1}(Q_{Ow}, G_t)\right) = 2213578.353$

Comparision of Crisp and Fuzzy Model:





CONCLUSION

As every consumer at present are aware of the consequences of the excess of carbon in the atmosphere and since nowadays people are willing to use eco-friendly products, initiating and creating an effective green environment is an ultimate aim of every sector. To reach this goal, even though manufacturing sectors take initiatives, every government all over the world implemented many policies related to carbon emission in order to reduce excess carbon and also to maintain economic growth of every country. Hence the present work on fuzzy inventory model under cap and trade policy helps industrial sectors to manufacture products with minimum excess of carbon under the cap and motivates them to invest in green technology. An optimal solution for the present model is compared for both green technology and for without green technology to analyse the result under ambiguous situations.

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RESEARCH ARTICLE

Phytochemical Analysis and FTIR Characterization of the Moss *Taxiphyllum taxirameum* (Mitt.) M. Fleish

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ABSTRACT

Bryophytesare remarkable for their resilience, unique life cycles, and ability to thrive in various ecological niches.*Taxiphyllum taxirameum*, an unexplored hypnaceacean moss, holds traditional significance in Indian and Chinese medicines, yet lacks scientific chemical profiling. This study aimed to address this gap through phytochemical screening. Qualitative and quantitative analyses unveiled a diverse array of secondary metabolites, including Phenols, Tannins, Alkaloids, Flavanoids, Saponins, Quinones, Glycosides, Steroids, and Fatty Acids. Chemical characterization utilized FTIR fingerprinting techniques, revealing distinct functional groups within *T. taxirameum*, such as hydroxy compounds, aromatic compounds, aliphatic lipids, nitrile compounds, ketones, metal carbonyls and aryl disulphides. This scientific validation of traditional knowledge not only sheds light on the medicinal potential of *T. taxirameum* but also opens avenues for future drug formulations.

Keywords: *Taxiphyllum taxirameum,* Hypnaceae, FTIR-spectroscopy, Phytochemicals, Bryophytes

INTRODUCTION

Bryophytes, among the lesser-explored plant forms within the Plant Kingdom, comprise approximately 24,000 species globally and are also known as embryophytes. Despite lacking true roots, leaves, and stem-like structures, bryophytes exhibit remarkable resilience in adverse conditions and display diverse ecological characteristics[1]. Mosses, constituting the second-largest taxonomic group within Bryophytes with around 14,000 species worldwide, represent the simplest form of these plants. Despite their abundance, Bryophytes remain relatively unexplored in terms of their secondary metabolites due to challenges in identification and collection. Studies suggest that they contain a rich array of compounds, including carbohydrates, polyphenols, tannins, flavonoids, volatile oils, terpenoids, and steroids. However, only a small fraction of mosses and liverworts have been subjected to chemical analysis[2]. *Taxiphyllum taxirameum* (Mitt.) M. Fleisch, a moss from the family Hypnaceae, inhabits shaded areas, commonly found on rocks, soil banks, and logs, particularly near riparian habitats. Its habitat encompasses Teak

plantations, moist deciduous, semi-evergreen, and evergreen forests. This species thrives in tropical regions and exhibits a wide distribution across various locations, including South India (such as Kerala, Tamil Nadu, and Karnataka), North-east India (including Mussoorie, Simla, Nainital, and Almora), as well as Sri Lanka, Myanmar, Sumatra, Java, New Guinea, the Philippines, Taiwan, Yunnan, Korea, Japan, Siberia, Oceania, and Australia. Exploration of Bryophytes, including mosses like *Taxiphyllum taxirameum*, holds promise for discovering novel biologically active compounds with potential therapeutic applications[3].

Although *Taxiphyllum taxirameum* may not be widely recognized, it holds significant ethnopharmacological importance across various cultures, notably in Chinese, Indian, and Native American medicine[4]. Numerous scientists have documented its use in treating a range of ailments, including wound healing, nosebleeds, antimicrobial diseases, and maintaining homeostasis. In 2012, Afro Alam[5] identified *Taxiphyllum taxirameum* as possessing antiphlogistic properties and being effective for hemostasis and external wounds in regions such as the Western and Eastern Himalayas, South India, and Central India. However, there has been no investigation into the phytochemical composition of *Taxiphyllum taxirameum* to date. In this juncture the present study aims to fill this gap by identifying the phytochemical constituents present in *Taxiphyllum taxirameum*for assessing their potential biological activities.

MATERIALS AND METHODS

The plant material of *Taxiphyllum taxirameum* was sourced from Ponmudi, Thiruvananthapuram, Kerala, the collected mosses were identified and deposited in the Calicut University Herbarium, Kerala. The plant appears glossy-green and prostrate, with variously branched structures. The main stem can reach up to 6 cm in length, with small branches measuring 0.5-1 cm long. Both stem and branch leaves are similar, oblong-lanceolate in shape, gradually tapering to a pointed tip, with serrated margins near the apex, measuring up to 1.5 x 0.04 mm. The cells are linear to rhomboid-linear, with papillose tips, and the upper cells measure 30-32 x 5-7 μm, while the extreme leaf base cells are rectangular and hyaline, measuring 65-72 x 5-7 μm. Pseudoparaphyllia are triangular and foliar, and the costa is double but indistinct. The seta is 10 mm long, leading to a cylindrical, erect capsule containing spores measuring 15-20 μm diagonally[6].

Cold Extraction

The chosen extraction method was the cold extraction technique. Approximately 60 grams of powdered plant material were placed into a conical flask, followed by the addition of 250 milliliters of solvent. Successive extractions were carried out using petroleum ether, chloroform, acetone, ethyl acetate, and methanol. The flask was sealed with a stopper, vigorously shaken by placing it in a shaking incubator, and left to stand for 48 hours. The resulting extract was then filtered and concentrated by evaporating to dryness on a water bath. The obtained extract was weighed and stored in a labeled sample bottle for further analysis[7].

Preliminary Phytochemical analysis (Qualitative)

The qualitative analysis of the various solvent extracts obtained after cold extraction was conducted using standard protocols [8-10].

Quantitative Estimation of Secondary Metabolites

The quantitative estimation of secondary metabolites in *Taxiphyllum taxirameum* was conducted using various methods. Total phenol content was estimated using the method proposed by Meda et al., [11]. Aluminium chloride assay was employed to quantify total flavonoids in the extract[12]. The total alkaloid content was determined following the protocol established by Fazel Shamsa et al.,[13]. The Folin-Ciocalteu Method was conducted for the detection of total tannin content[14].

FTIR Analysis

FTIR spectroscopic analysis involves the use of a Fourier Transform Infrared Spectrophotometer, which is a powerful tool for identifying the types of functional groups present in phytochemicalcompounds. In FTIR analysis, the

wavelength of light absorbed serves as a salient feature of the chemical bond. By interpreting the infrared absorption spectrum, the chemical bonds present in a compound can be determined. For the analysis of *Taxiphyllum taxirameum*, dried powders of the entire thallus were utilized. The plant extract was loaded into the FTIR spectroscope, and the scan range was set from 4000 to 400 cm^-1 with a resolution of 4 cm^-1[15].

RESULTS AND DISCUSSION

The phytochemical analysis of plant extracts conducted in various solvents revealed the presence and absence of different plant metabolites. Abundant secondary metabolites were unveiled, encompassing phenols, tannins, flavonoids, saponins, terpenoids, alkaloids, glycosides, steroids, quinones, and fatty acids. These findings suggest the diverse biochemical composition of *Taxiphyllum taxirameum*. The enhanced biopotential activities associated with these phytochemicals underscore their efficacy and broaden their potential applications in pharmaceuticals. The table 2 below is presenting the phytochemical screening results of the moss *T. taxirameum* in different solvents: The therapeutic value of plants lies in the principle components that have potential physiological roles in the human body. Structural peculiarities of phytochemicals exhibit wide variation, which in turn influences the range of activities. Terpenoids found in bryophytes exhibit diverse bioactivities, including anti-bacterial, anti-inflammatory, antifungal, phytotoxicity, and insect antifeedant activities. Polyphenols, which include flavonoids and phenols, possess antioxidative effects, antihypertensive properties, immunomodulation, antimicrobial and antiviral activity, as well as anticancer potential [16]. In 2012, Adedeji[17] reported the presence of terpenoids, flavonoids, alkaloids, phenols, saponins, and steroids in two moss species, *Thuidium gratum* and *Barbula indica*. Screening for flavonoids and phenols was also conducted in *Brachytheciastrum velutinum* and *Kindbergia praelonga*. The present study also reports similar findings.These findings underscore the rich phytochemical diversity and potential pharmacological significance of bryophytes and mosses.

Quantitative estimation:

Quantitative estimation of secondary metabolites in *Taxiphyllum taxirameum* indicates variation with different solvent systems. The ethyl acetate extract exhibits a higher flavonoid content compared to other solvents and also shows a high phenolic content. Summary of quantitative estimation of secondary metabolites in *Taxiphyllum taxirameum* is shown in the table 3. Swathi Singh et al.,[18] conducted an estimation of total phenolic and flavonoid content in the moss *Barbula javanica*. Their investigations revealed a comparatively higher amount of total phenolics and flavonoid content in the methanol extract compared to ethyl acetate, di-ethyl ether, and hexane extracts. Both flavonoids and many other phenolic components are known for their effective antioxidant, anticancer, antibacterial, cardioprotective, anti-inflammatory, immune system-promoting, UV radiation skin protection, and potential pharmaceutical and medical applications [19]. Tannins have been shown to prevent neurodegenerative diseases and metabolic disorders, as well as possessing antibacterial and anticancer activity [20]. Alkaloids exhibit a wide range of biological effects, including anti-inflammatory, demulcent, ganglionic blocking, anti-plasmodic, and hepatoprotective properties[21]. These findings highlight the diverse pharmacological potentials of secondary metabolites present in mosses, underscoring their significance in various medical and pharmaceutical applications.

FTIR Analysis:

FTIR spectroscopic analysis serves as a valuable tool for detecting phytochemicals present in plant extracts, offering insight into their potential bioactivities and biopharmacy applications. While IR fingerprinting studies have largely focused on agriculturally important crops and medicinal herbs, there remains a scarcity of research in bryophytes. Each functional group exhibits characteristic peak values, aiding in spectral interpretation. Peaks obtained from the crude extract of *Taxiphyllum taxirameum* confirmed the presence of various functional groups, including hydroxy compounds, aromatic compounds, aliphatic lipids, nitrile compounds, ketones, metal carbonyls, and aryl disulfides. The FTIR spectroscopic analysis of *Taxiphyllum taxirameum* extract revealed the presence of various functional groups, each corresponding to specific phytocompounds. Non-bonded O-H stretch at 3726 cm^-1 indicates the presence of hydroxy groups. O-H stretch at 3280 cm^-1, along with hydrogen bonding, suggests the presence of hydroxy compounds. Symmetric stretching of -CH (CH2) vibration at 2919.05 cm^-1 indicates the presence of saturated aliphatic compounds, particularly lipids. Multiple bonding observed at 2160.05 cm^-1 suggests the

presence of nitrile compounds. The presence of carbonyl compound frequency at 1979.20 cm^-1 suggests the presence of transition metal carbonyls. C=O stretching at 1629.68 cm^-1 indicates the presence of ketone compounds. C=C-C aromatic ring stretch observed at 1054.06 cm^-1 suggests the presence of aromatic compounds. S-S stretching observed at 442.98 cm^-1 indicates the presence of aryl disulfides. These functional groups provide valuable information regarding the chemical composition of *Taxiphyllum taxirameum* and its potential pharmacological activities. The presence of diverse functional groups suggests potential for various pharmacological activities, highlighting the significance of bryophytes and mosses in medical and pharmaceutical research. FTIR spectroscopy emerges as a valuable tool for exploring the chemical composition of mosses and shedding light on their taxonomical relationships. In a study by Zhen Cao et al.[23], Fourier-transform infrared (FT-IR) spectroscopy was utilized to differentiate between fourteen samples from three moss families: Mielichhoferiaceae, Bryaceae, and Mniaceae [24]. This method provided insights into the unique chemical fingerprints of each moss sample, facilitating their classification and enhancing understanding of their taxonomical relationships. Furthermore, mosses contain polyunsaturated fatty acids, as emphasized by Bardan et al.,[25]. These fatty acids play significant roles in human medicine, including preventing atherosclerosis and cardiovascular disease, reducing collagen-induced thrombocyte aggregation, and lowering plasma triacylglycerol and cholesterol levels. This highlights the importance of further research into mosses and their chemical constituents for potential therapeutic applications in human health.

CONCLUSION

In conclusion, the extracts of *Taxiphyllum taxirameum*, obtained using various solvents, exhibit a diverse array of biopotent secondary metabolites, encompassing phenols, tannins, flavonoids, saponins, terpenoids, alkaloids, glycosides, steroids, quinones, and fatty acids. Understanding the chemical nature of these phytochemical compounds provides valuable insights into the potential medicinal properties of *Taxiphyllum taxirameum*. The presence of different functional groups observed in the various extracts suggests the existence of hydroxy compounds, ketones, carbonyl compounds, and disulfide compounds. Further scientific studies on the bioactivity of *Taxiphyllum taxirameum* are warranted to explore its potential efficacy in therapeutics. This novel study may pave the way for both the conservation and pharmaceutical utilization of *Taxiphyllum taxirameum*, contributing to a broader understanding of its medicinal value and ecological significance.

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Table 1: Preliminary Phytochemical Analysis of *Taxiphyllum taxirameum* (Qualitative Tests)

Sl.No.	Name of Secondary metaboolite	Name of test
1.	Phenol	Lead acetate Test
2.	Tannin	Ferric chloride Test
3.	Flavanoid	Ferric chloride Test
4.	Saponin	Foam Test
5.	Terpenoid	Lierbermann- Burchard Test
6.	Alkaloid	Wagner's Reagent
7.	Glycoside	Kellar- Killani Test
8.	Steroid	Lierbermann- Burchard Test
9.	Quinones	HCL Method
10.	Fatty acid	Filter paper test

Table 2: Preliminary Phytochemical Analysis of *Taxiphyllum taxirameum* (Qualitative)

Sl.No.	Phytochemicals	Extracts				
		Petroleum ether	Chloroform	Acetone	Ethyl acetate	Methanol
1.	Phenols	+	+	+	+	+
2.	Tannins	+	+	+	+	+

3.	Flavanoids	+	+	+	+	+
4.	Saponin	+	-	-	-	-
5.	Terpenoids	+	+	+	+	+
6.	Alkalloids	+	+	+	+	+
7.	Glycosides	+	-	+	+	-
8.	Steroids	-	-	-	+	+
9.	Quinones	+	-	+	+	-
10.	Fattyacid	+	+	+	+	+
	'+ ' Presence and '-' Absence					

Table 3:- Quantitative Estimation of Secondary Metabolites in *Taxiphyllum taxirameum*

Sl.No.	Phytochemicals	Extracts (µg/mg)				
		Petroleum ether	Chloroform	Acetone	Ethyl acetate	Methanol
1.	Phenol	0.48±0.02	1.57±0.02	4.68±0.13	7.96±0.2	12.92±0.32
2.	Flavanoid	4.23±0.43	2.44±0.87	56.79±0.8	66.54±0.7	23.5±0.4
3.	Alkaloids	37.89±0.09	41.78±0.1	42.33±0.5	27.33±0.4	45.67±0.2
4.	Tannins	5.67±0.72	1.68±0.85	14.20±0.24	8.00±0.12	16.47±0.5

Table 4:- FT-IR spectral analysis showing the peaks and respective functional groups of *Taxiphyllum taxirameum* [22].

SL.NO.	Wave number (cm^{-1})	Functional group identified	Phytocompounds correspomding(Sahayarajet al., 2015)
1.	3726	Non bonded, O-H stretch	Hydroxy group
2.	3280	O-H stretch, H-bonded	Hydroxy compound
3.	2919.05	symmetric stretching of –CH (CH2) vibration	Saturated aliphatic compound-Lipids
4.	2160.05	Multiple bonding	Nitrile compounds
5.	1979.20	Carbonyl compound frequency	Transition metal carbonyls
6.	1629.68	C=Ostretching	Ketone compound
7.	1054.06	C=C_C, Aromatic ring stretch	Aromatic compound
8.	442.98	S-S stretch	Aryl disulfide

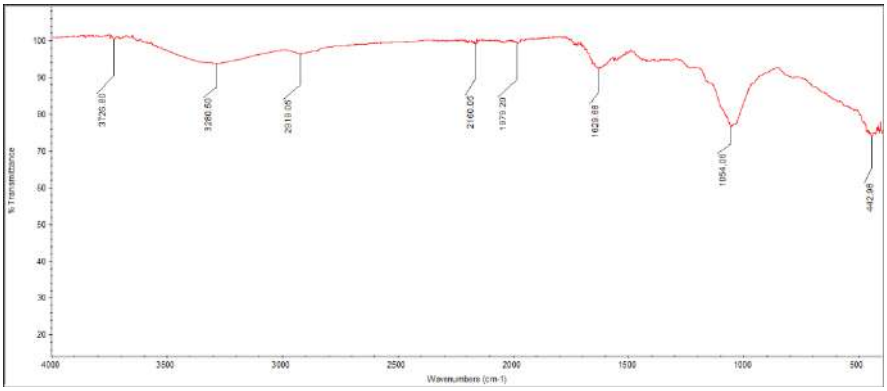


Figure 1. FT-IR finger printing profile of *Taxiphyllum taxirameum*

RESEARCH ARTICLE

Precision in Pulmonary Evaluation: Crafting a Consistent Formula for Western Area Pulmonary Function Test

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ABSTRACT

When there are risk factors for lung illness, occupational exposures, and pulmonary toxicity, pulmonary function tests (PFTs) enable doctors to assess their patients' respiratory health in a variety of clinical settings.It is important to note that pulmonary function tests do not diagnose specific illnesses, but rather they enable precise and repeatable evaluation of the respiratory system's functioning condition. The ability to breathe in and out in proportion to time is measured by a physiological test known as spirometry. Spirometry is a diagnostic test used to rule out a variety of common respiratory disorders, such as asthma and chronic obstructive pulmonary disease (COPD).Therefore, the study's goal is to use anthropometric factors to create a newer projected equation for the people in western India. At a tertiary hospital in Surat, a prospective observational research was conducted, enrolling healthy individuals aged 35–55 who were of western Indian ethnicity. The ATS/ERS-2005 criteria were followed for performing the spirometry measurements, and a Clarity spirometer, non-heated was used. To find the optimal prediction equations, data was evaluated using SPSS for Pearson's correlation analysis, multiple linear regressions, and variable log conversions. Thus the conclusion of the study was proposal of the new regression equations for spirometry variables for the adult middle-aged population in mainly western part of India over the age of 35-55 years. Thus, the long-felt desire to update these equations has been satisfied, and this will eventually be helpful in the care of patients with respiratory conditions. The wide variability in lung functioning is caused by a combination of variables. This has been shown in several research for all groups with regard to age, sex, and height. However, our research indicates a strong link between the parameter and FVC, FEV1, FEV1/FVC, MEFR and PEFR; hence, further extensive population studies are necessary to validate the idea.

Keywords: spirometry, evaluation, COPD, population.

INTRODUCTION

PULMONARY FUNCTION TEST

for the measurements and interpretation of PFT are revised on a regular basis. They were created by an international joint Task force consisting of the American Thoracic Society (ATS) and the European Respiratory Society (EUR/ATS), and they were published in 2022.The patient's exertion has an impact on the PFT readings. PFT values should be compared with pertinent medical history, physical examination findings, and laboratory data in order to aid make a diagnosis, as they do not offer a precise diagnosis. PFTs also give doctors the ability to monitor lung diseases over time, evaluate how well they are responding to treatment, and determine the severity of the condition. (1) Testing for pulmonary function enables precise, repeatable evaluation of the respiratory system's functioning status. It is worth emphasizing that pulmonary function tests do not diagnose specific diseases. A battery of pulmonary function tests will show varying patterns of abnormalities depending on the condition. By measuring the severity of respiratory diseases, these patterns help us identify the condition early on, describe its course, and assess how well it responds to therapy. (2) This information can help your healthcare provider diagnose and decide the treatment of certain lung disorders. (3) Pulmonary function tests (PFTS) are an important tool in the investigation and monitoring of patients with respiratory pathology. The pulmonary parenchyma, the size and integrity of the pulmonary capillary bed, and the major and small airways are among the crucial details they give. While they don't offer a diagnosis in and of themselves, the many respiratory disorders they indicate can be diagnosed based on distinct patterns of anomalies. The reasons for PFTS are explained, along with abnormal findings and their correlation with underlying disease. (4) A variety of direct and indirect measures are part of pulmonary function testing (PFT), which helps characterize respiratory physiology. These studies play an essential role in the diagnosis and management of patients with or at risk for respiratory disease. They provide the clinician with objective assessments, which may be correlated with highly subjective symptoms, such as dyspnea. Their quantitative results also allow for longitudinal monitoring of patient's respiratory health, particularly when respiratory symptoms correlate poorly with disease severity and progression. (5)

SPIROMETRY

Asthma and chronic obstructive pulmonary disease (COPD) are two prevalent respiratory disorders for which spirometry is a diagnostic test. Additionally, it helps track how different respiratory conditions are developing.It is also instrumental in monitoring the progression of various respiratory disorders. FEV1/FVC ratio, forced expiratory volume exhaled in the first second (FEV1), and forced vital capacity (FVC) are the primary outcomes of spirometry. There are three stages to the spirometry procedure: 1) maximum inhalation; 2) a "blast" of expiration; and 3) continuous full exhale until the test is completed. There are within-maneuver acceptability and between-maneuver reproducibility criteria for spirometry.(1) Spirometry is important in the screening, diagnosis and monitoring of respiratory diseases.16 Forced vital capacity (FVC) indicates how much air the lungs can hold. Forced expiratory volume in one second (FEV1) indicates how well the large- and medium-sized airways are functioning. The ratio of FEV1/FVC is a more sensitive indicator of airway obstruction than FVC or FEV1 alone. Peak expiratory flow (PEF) describes the mechanical characteristics of the lung, such as lung compliance and elastic lung recoil, which are indicative of a more comprehensive airway function. Known as maximal mid-expiratory flow (FEF25–75), forced expiratory flow is a gauge of the patency of narrow airways.(6)

FACTORS AFFECTING PULMONARY FUNCTION

The factors which were responsible for affecting the PFT were Age, Weight, BMI, Smoking, Surgery, Chest deformities and Pollution.(7) Lung function reference values are traditionally based on anthropometric factors, such as weight, height, sex, and age. As we age, our volumes and capacities—like FRC and RV—increase while our FVC and FEV1 decrease.TLC, VC, RV, FVC and FEV1 are affected by height, since they are proportional to body size.(8)

In the realm of respiratory health diagnostics, the need for a standardized approach to pulmonary function testing in the Western region has become increasingly apparent. This study endeavors to fill this crucial gap by embarking on a

comprehensive exploration of diverse factors influencing pulmonary function. Our research is dedicated on accuracy and dependability, and we aim to develop a standard formula that improves clinical assessment accuracy while accounting for local variations. By delving into the intricate details of respiratory dynamics, we aim to contribute valuable insights that will not only refine diagnostic procedures but also bolster the overall quality of patient care in the Western healthcare landscape. "Therefore, via a review of several publications, the components that worked were discovered; nevertheless, this study also attempts to create a standardized formula by utilizing the review and its impact on the formula.

AIMS AND OBJECTIVES

AIMS-

The aim of this study is to formulate the formula to measure the pulmonary function test in western part of India.

OBJECTIVES-

The following are the objectives of the study

1) To check the effectiveness of the factors i.e. age, height, weight, BMI, and Gender

2) To formulate the formula for the normal standard value for the people of the western part of the India.

MATERIALS AND METHODS

- Computerized spirometer (Clarity- Spirotech)
- laptop /Computer
- Ball pen
- Assessment Form/ Participant form
- Paper
- Chair/ stool
- Weighing machine
- Stadiometer
- Nose clip
- Disposable Mouth piece

STUDY DESIGN: Randomized Controlled Trail

STUDY SETTING: OPD DEPT OF SPB PHYSIOTHERAPY COLLEGE, Surat, Gujarat, India.

STUDY POPULATION: Both male and female of all categories who all are normal individuals.

SAMPLING: Convenient sampling for selection of subjects

SAMPLE SIZE: minimum of 384 patients (EPI info software version 7.2.6.0 was used to calculate the sample size). Population size – was infinite because it was healthy normal individual, alpha level = 0.05 and 5% margin of error; the minimum estimated sample size is 384 patients.

Selection Criteria

Selection criteria are a set of already defined characteristics for identifying participants for a research purpose. Appropriate inclusion & exclusion criteria provide homogeneity of the selected sample and reduce the effect of confounding factors in the study.

Inclusion criteria

- Normal healthy individual (9,10)
- Non-smoker (9,10)
- Age group 35-50 years (11)

Exclusion criteria:

- Unstable cardiovascular status such as myocardial infarction within previous 1 month
- Recent thoracic or abdominal surgery (within previous 6 weeks)
- Recent eye or ear surgery (within previous 6 weeks)
- Proven or suspected active pulmonary tuberculosis
- Thoracic, abdominal, or cerebral aneurysm
- Oral or facial pain exacerbated by mouthpiece
- Active hemoptysis
- Uncontrolled blood pressure
- Acute illnesses that may interfere with performance of the procedure such as acute respiratory tract infection, nausea, vomiting, chest pain, or abdominal pain
- Last trimester of pregnancy
- Any congenital heart disease

PROCEDURE

The methodology for the study is covered in the upcoming chapter. The technique describes how the evaluation was carried out and the procedure was applied to the samples. The study was divided into 2 phases. In Phase 1, after the subjects were gathered, they were given an explanation of the study's core methodology. After providing them with information regarding informed consent, they were chosen to undergo the surgery. Participants found suitable for the study were briefed about the present research study's aim, objectives, and purpose. Further, they were encouraged to ask their questions/ queries.

In Phase 2, Demographic data of each participant was taken on a data collection sheet. Each participant was given instruction and a demonstration regarding how to perform the pulmonary function on the machine using the computer. They were also explained briefly about the study procedure through power point presentation. According to sample size calculation (Epi.info), there were total 395 samples but the total number of 450 participants were screened as per the participant selection criteria. Out of 450 participants, 400 participants were included in the present study 50 were excluded due to their medical condition. After the selection, the individuals were instructed about the procedure and they were allowed to perform the pulmonary function testing using the software version SPIROTECH CMSP-01. They were instructed to perform the 3 trails and the best of all were selected and the values for the same were taken and recorded by the computer and saved as the PDF. After collecting the data of all the 400 participants, the data was analyzed using the regression analysis i.e., linear regression was done and the adjusted r value was found out using SPSS. The 5 values were calculated which were FEV1, FVC, FEV1/FVC, PEFR and MEFR (25-75). The significance was found out, then formulas for all of the parameters was formed.

RESULT

Appropriate statistical analysis of the data using adequate statistical techniques is essential for any research. Statistical analysis helps to mention the data meaningfully and to present the complex data in a very simple manner. The results are mentioned as tables, graphs with its interpretation and discussed. Statistical analyses were performed using SPSS version 20.0 IBM Company. Statistical analysis for designing of predictive model is explained by Linear regression.

DESIGNING MODEL

Regression is the measure of average relationship between two or more different variable in terms of original data. After knowing relationship between two variables, based on value of independent variable or predicting variable, one can estimate value of dependent variable or explained variable. Regression analysis allows researcher to estimate value of dependent variable based on independent variable. Effect of these 8 factors were analyzed for 400 samples. Linear regression at confidence interval 95% was applied in which 8 factors were kept as independent variables and

FEV1, FVC, FEV1/FVC, PEFR and MEFR (25-75). was kept as dependent variable. The linear regression was done using SPSS version SPSS ((Version 20.0) for Windows statistical package (SPSS Inc, Chicago, USA). Confidence interval was taken as 95% and the margin of error was taken as 5%. Level of significance was decided as p value >0.05.

According to the analysis, the FEV1 is having age, height, weight and gender which had p value less than 0.05 indicative of significance. One predictive formula for the same is designed from all above factors which is as follow

FEV1= -0.930 + (-0.030 *AGE) +(0.027*HEIGHT) +(0.011*WEIGHT) +(-0.366*GENDER)

According to the analysis, the FVC is having age, height and gender which had p value less than 0.05 indicative of significance. One predictive formula for the same is designed from all above factors which is as follows:

FVC= -0.204 + (-0.035*AGE) + (0.031* HEIGHT) + (-0.569 *GENDER)

According to the analysis, the PEFR is having weight and gender which had p value less than 0.1 indicative of significance. One predictive formula for the same is designed from all above factors which is as follows:

FEV1/FVC = 41.132 + (0.162* WEIGHT) + (4.747 *GENDER)

According to the analysis, the PEFR is having age, height, weight and gender which had p value less than 0.05 indicative of significance. One predictive formula for the same is designed from all above factors which is as follows:

PEFR = -0.675 + (-0.041 *AGE) +(0.052* HEIGHT) +(0.029 * WEIGHT) +(-1.697 * GENDER)

According to the analysis, the is having age, height, weight and gender which had p value less than 0.05 indicative of significance. One predictive formula for the same is designed from all above factors which is as follows:

MEFR OR FEF 25%-75% = -1.552 + (-0.023 *AGE) + (0.025*HEIGHT) + (0.017 * WEIGHT) + (-0.302 *GENDER)

Thus, the summary of the phase 2 is that to find the predictive value of the individual with particular age, weight, height, gender and BMI, the above formulas is needed.

DISCUSSION

In this part of the chapter, we specifically address accuracy in the context of Pulmonary Function Tests (PFTs) and traverse the complex terrain of pulmonary assessment in the West. The main objective is to develop a thorough and standardized testing process before delving into the specifics of respiratory health evaluation. The process includes reviewing current approaches, spotting any problems, and putting together an improved formula that should provide accurate and dependable pulmonary function evaluation. In order to enhance diagnostic and treatment decision-making, this talk aims to further the current discussion in respiratory healthcare by highlighting the significance of accuracy in pulmonary assessments.A total of 402 patients with age group of 35-55 years participated in the trial, and they were assessed based on the inclusion and exclusion criteria. After being instructed to sign an informed consent form, they were instructed to take a pulmonary function test. The result showed that FEV1 showed positive result with age, weight, height and gender; similarly, with the PEFR and MEFR. For FVC age, height and gender has positive correlation and smoking, pollution and weight has negative correlation. Lastly the ratio FEV1/FVC has positive correlation only with the weight and gender. Thus, there are various parameters which are related to different outcomes of the pulmonary function test. Therefore, the formulas were formulated for the calculations of these parameters.

Numerous studies that demonstrated correlations between various populations and regions of India are being used to take into account the anthropometric parameters for the results of pulmonary function tests. These studies' references are then used to discuss the reasons behind both positive and negative impacts on lung function. In order

to interpret PFT in a clinically useful way, predictive reference values are necessary. Reference value, expressed in terms of a specific variable known as the reference variable, characterizes the index level for a population of healthy individuals (the reference population). Reference factors that are frequently utilized include age, gender, ethnic group, and one or more body size indexes. As a consequence, reference values are produced from an equation, and the outcome for a specific subject is acquired by adding the values of that subject's characteristics to the equation. According to previous studies, the current study has demonstrated a link between pulmonary function indices and age, height, weight, BMI, and BSA. All anthropometric measures and the pulmonary function indicators show a highly significant connection ($p<0.01$) in the teenage girl group as a whole. Height was often associated with the greatest correlations. The strongest association between body height and FVC and FEV1 was observed. Anthropometric factors were used in many research conducted on school-age Indian children to predict various regression equations for lung functions (15–19 years old). Age, height, and weight, age and height , age and BSA , or height alone were included as independent variables in a few studies to predict lung function. These investigations have demonstrated that the respondents' varied ethnic backgrounds have an impact on the lung function values (12).The study conducted in the central India demonstrates that, aside from gender and ethnicity, an individual's age and height are the most significant determinants of pulmonary function measures, with weight having a negligible effect. All of the pulmonary function indicators showed an increase correlated with height and a reduction correlated with age. These results are in line with earlier research conducted in India on a distinct population. It was discovered that the observed values, especially for FVC, FEV1, and PEFR in both males and females, were lower than the expected values, indicating variations between various populations. Thus, until more accurate prediction models are developed, the adult population of Central India is encouraged to utilize these equations in a multicentric investigation using a very big sample size and random sampling. (13)

When the study conducted in the eastern India where the predictive equation was found out the it was found that all three spirometry values, with the exception of the FEV1, showed a negative association with age and a positive connection with height. where height had a negligibly modest impact on the FVC ratio. These align with previous research conducted in other demographics. They performed regression analysis and compared the equation from the 20-year-old formula, demonstrating the necessity of creating a new equation to update all of the parameters. (14)Similarly, when the prediction equation was developed for the northern population of India it was found that with the exception of the FEV1, age and height were significant predictors for almost all the measures in both males and females. FVC ratio that was only correlated with age. The results show that all the characteristics decrease with age while increasing with height. Age had a negative coefficient, whereas height had a positive coefficient. Although it had a very minor impact, weight was a significant extra predictor for FVC, FEV1/FVC ratio, and FEF75 in males. These findings align with the majority of earlier research conducted in India and among other communities in other nations. Other than gender and ethnicity, age and height continue to be the most significant determining variables for lung function measures. Usually, weight has a little or insignificant impact. (15)

It is clear from experimental studies that the lung airways' compliance increases with age. This observation was quantified using simulations, and we found that the compliance increased by 37% for the 80-year-old compared to the 50-year-old, indicating that additional effort would be needed to bring in a normal volume of air for an 80-year-old. Additionally, the airway resistance changed very slightly with age, specifically by 2–7%, from 50 to 80 years old, and this result compared well with the experimental data. (16)(17)

According to the study, male students who are taller (height > 167.4 cm) had an average vital capacity that was higher than that of male students who are shorter (height ≤167.4 cm). This variance can be attributed to the fact that when height increases, so does chest circumference and thoracic area, which increases lung surface area overall. Taller individuals have a bigger vital capacity because they have more space accessible for air exchange than do shorter people. As a result, more air can enter and exit taller people. A taller person might have greater TLC, FRC, and VC. According to a Nigerian research, vital capacity rises with height. (18) Thus, it can be proved that the age, height, weight, gender and BMI is related to the pulmonary function of the lungs and also its effectiveness can be used for formulating the formula to form the standard predictive equation for the people of the western INDIA.

CONCLUSION

Using the most recent ATS/ERS 2005 standardization standards for lung function testing, we propose new regression equations for spirometry variables for the adult middle-aged population in mainly western part of India over the age of 35-55 years. Thus, the long-felt desire to update these equations has been satisfied, and this will eventually be helpful in the care of patients with respiratory conditions. The wide variability in lung functioning is caused by a combination of variables. This has been shown in several research for all groups with regard to age, sex, and height. However, our research indicates a strong link between the parameter and FVC, FEV1, FEV1/FVC, MEFR and PEFR; hence, further extensive population studies are necessary to validate the idea.

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Table 1- Tabular Representation of The Linear Regression of All 4 Parameters With The Factors

Factors	FEV1					FVC				
	Unstd. Coeff.		Unstd. Coeff.	t	Sig	Unstd. Coeff.		Std. Coeff.	t	Sig
	B	Std. Error	Beta			B	Std. Error	Beta		
(Constant)	-0.93	0.877		-1.061	0.289	-0.204	0.993		-0.206	0.837
AGE	-0.03	0.004	-0.289	-7.424	0	-0.035	0.005	-0.282	-7.549	
HEIGHT	0.027	0.005	0.329	5.789	0	0.031	0.005	0.319	5.837	0
WEIGHT	0.011	0.005	0.12	2.245	0.025	0.009	0.005	0.085	1.669	0.096
BMI	-0.01	0.008	-0.067	-1.288	0.198	-0.012	0.009	-0.064	-1.268	0.206
GENDER CODE	-0.366	0.08	-0.238	-4.601	0	-0.569	0.09	-0.314	-6.315	0
SMOKING CODE	0.063	0.058	0.041	1.085	0.279	0.026	0.066	0.014	0.393	0.695
SURGERY	-0.029	0.059	-0.019	-0.491	0.624	-0.045	0.067	-0.024	-0.664	0.507
POLLUTION	-0.044	0.079	-0.021	-0.554	0.58	-0.131	0.09	-0.053	-1.457	0.146
Factors	FEV1/FVC					PEFR				
	Unstd. Coeff.		Std. Coeff.	t	Sig	Unstd. Coeff.		Std. Coeff.	t	Sig
	B	Std. Error	Beta			B	Std. Error	Beta		
(Constant)	41.132	15.026		2.73	0	-0.675	2.5		-0.269	0.788
AGE	-0.029	0.069	-0.021	-0.416	0.678	-0.041	0.012	-0.143	-3.562	
HEIGHT	0.112	0.079	0.104	1.406	0.161	0.052	0.013	0.229	3.921	0
WEIGHT	0.162	0.082	0.136	1.963	0.05	0.029	0.014	0.115	2.09	0.037
BMI	-0.02	0.137	-0.01	-0.145	0.885	0.002	0.023	0.005	0.093	0.926
GENDER CODE	4.747	1.36	0.235	3.483	0.001	-1.697	0.227	-0.398	-7.463	0
SMOKING CODE	1.286	1	0.064	1.284	0.2	0.147	0.167	0.034	0.879	0.38
SURGERY	0.001	1.01	0	0.001	0.999	-0.145	0.17	-0.034	-0.855	0.393
POLLUTION	2.243	1.36	0.081	1.649	0.1	-0.044	0.227	-0.007	-0.192	0.848

Table 2- Tabular Representation of The Linear Regression of MEFR(25%-75%) Parameters With The Factors

Model	MEFR (25-75)				
	Unstd. Coeff.		Unstd. Coeff.	t	sig
(Constant)	-1.552	1.555		-.998	.319
AGE	-.023	.007	-.153	-3.245	.001
HEIGHT	.025	.008	.206	2.992	.003
WEIGHT	.017	.009	.129	1.993	.047
BMI	-.016	.014	-.072	-1.128	.260
GENDER CODE	-.302	.141	-.135	-2.144	.033
SMOKING CODE	.106	.104	.047	1.021	.308
SURGERY	.019	.105	.008	.183	.855
POLLUTION	.157	.141	.051	1.114	.266

REVIEW ARTICLE

Menstrual Cycle and Causative Factor for Early Menstruation According to Ayurveda: A Review Article

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ABSTRACT

The first menstrual cycle or the onset of menstrual flow is known as the menarche. Given that it indicates the potential for reproduction, it is sometimes seen as the pivotal moment in female adolescence from both a special and medical perspective. Ayurveda, the greatest science of life, studies every aspect of a woman's life at every stage. Puberty is a progressive, nonlinear process that leads from prepubescent to full sexual maturity through the cooperation and interplay of biological, physical, and psychological changes. It would appear that eating healthfully during infancy, youth, and puberty is necessary for appropriate pubertal development.

Keywords : Menstrual cycle, menarche, *Prakriti*.

INTRODUCTION

Menstruation indicates that the reproductive system is still developing, thus it needs specific attention. Puberty is the first step towards becoming a mother in the future. During puberty, some medical disorders may get worse or initially manifest. Puberty is the period of physical development during which sexual reproduction and secondary

sex traits emerge. Puberty involves a series of physical, psychosocial and emotional, social development[1] .The onset of puberty varies among individuals. Girls typically go through puberty between the ages of 10 and 16[2]. Environmental and nutritional variables may have contributed to this transformation. The start of puberty may vary depending on body composition and fat percentage. Medical monitoring is essential since failing to pay enough attention to one's health during adolescence can result in a variety of health and reproductive problems. In this age of health consciousness, ayurvedic treatment would give women the mental, emotional, and spiritual energy they need to fulfill all of their responsibilities without feeling worn out.[3].

In females, puberty is the transitional stage between childhood and adulthood. It is a time when secondary sexual traits gradually develop[4]. It involves the complex development of the growth spurt, thelarche, pubarche, and menarche and happens between the ages of 8 and 13[5]. Ayurvedic classics mention Utpatti of Rajah and Prathama Rajodarshana directly in a number of Samhitas.

ESSENTIAL FACTORS FOR FORMATION OF *RAJAH/ARTAVA:*
Rasa Dhatu
Rakta Dhatu

Role of *Doshas* in Process of *Artava Utpatti*:
Regarding the factors affecting menstruation, three Doshas have been mentioned. In turn, Rasa is processed by Vata, Pitta, and Kapha, and each Dosha regulates a certain menstrual cycle.

***Raja Srava Kala*:**
The phase is influenced mainly by *Vata.*
Vata has the most influence on this period. In actuality, the Vataprakopa initiates this phase as soon as the menstrual cycle begins. Pitta Prakopa commences enter into a stage of Pittashama, Vata plays its part throughout the period. However, when Pitta declines, Kapha enters the picture, and if one takes into account Kaphachaya during the Rajahkala phase, one can easily understand why the endometrium begins to regrade during the menstrual phase.
Vata always acts through *Dhamanee. Dhamanee* means arteries. The spasm in the straight of arterioles as a causative phenomenon of bleeding is similar to the action of *Vata* through *Dhamnee.*

Ritukala:
This phase is influenced mainly by *Kapha.*
At the end of Rajahkala, the level of Kapha begins to increase (Kaphachaya). Ritukala is the time when Kapha's level is at its highest. We refer to this as Kapha Prakopa. The second part of Ritukala is when the level of Pitta begins to rise. Pittachaya is the term for this phase. Vata remains constant during the entire duration. Vatashama is the term for this Vata condition.

Ritukala is a phase that resembles the proliferative phase, and according to Ayurveda, Vata retards growth and Kapha is necessary for regeneration and growth. Always acting through Rasa is Kapha. Rasa is defined as plasma, which includes lymph and interstitial fluid. Since the involvement of plasma in the development of the endometrium is evident, it is easy to comprehend the role of Kapha through Rasa. The body's overall mechanism strives to maintain a Swastha, or normal, state.

There are differing views in the classic Ayurvedic texts regarding the length of Ritukala. Ritukala is divided into twelve days, sixteen days, or a whole month if the reproductive system is in good health, according to Acharya Sushruta and Vagabhatta.
According to *Indu, Beeja* (Sperm) deposited during this period are likely to bear fruit (Conception) hence it is termed as *Ritukala.*

According to *Kashyapa, Ritukala* is different for different caste. (Ka.Sa.Sha.5/5)
12 days - *Brahmins*
11 days - *Kshatriyas*
10 days – *Vaishayas*
9 days – *Kshudra*

Indu has commented that since the seeds deposited during this period are likely to bear fruit (conception), hence it is termed as *Ritukala.*

Role of *Agni*
Agni Dushti would be the primary cause of any Artavavahasroto Vikara. Since Agni plays a significant part in Artava's creation. When we comprehend the Artava process in connection to its Utpatti, Vahana, and Nishkramana, this becomes evident. Any disruption to this process results in Dushti of Artava, which causes a variety of problems in women.

Role of *Srotas:*
Each process—Artavautpatti, Vahana, and Nishkramana—takes place in its own Srotas. Artavavaha Srotas, with Garbhashaya as its Moola. According to Sushruta Samhita, harm to this Srotas causes infertility and other problems. The Sarabhaga enters the Garbhashaya through Siras and also as Rasa Sara Bhaga, Saumyaguna. After then, Artava becomes Artavavahasrotas, its proper Srotasi, and is released through Srotas as "Rajah.''
So, any obstacle formed in *Siras* or *Srotas*, gives rise to problems like irregular menstruation, PCOD, infertility etc. due to *Srotorodha, Dushtavata* & *Kapha* are active in *Artavavaha Srotas.*

Role of *Prakriti* and *Kala :*
Three Doshas govern the menstrual cycle, or Ritu Chakra. Dosha alterations in the body brought on by the effect of Kala and Prakriti. One can establish the relationship between Kala, Prakriti, and Rituchakra with the use of traditional Tantrayuktis. Tantrayuktis are fundamental to comprehending the Samhitas and are essential to a deeper comprehension of the classics. Consequently, by using Yoga Tantrayukti, the complete effect of Prakriti, Kala on Ritusrava may be comprehended.

DESHA
***Desha* (Land): -**
Ayurveda provides rich knowledge on the geographical and socioeconomic aspects of India, in addition to medical issues and their treatment. In *Ayurveda*, the term *Desha* refers to both the direction and the location of a directed or divided component. *Desha* has been employed and discussed in two-dimensional terms in *Ayurvedic* classics such as *Bhumi Desha* (Specific section of land or geographical component) and *Atura Desha* (Site and place) (the site of disease body and mind). When assessing the Hetu (etiological variables) and therapy alternatives, one of the components that must be taken into account is Desha. Hippocrates is credited with founding medical geography, an increasingly significant field in contemporary medicine. But the Charaka Samhita provides further details on medical geography centuries before Hippocrates did.

Bhumi Desha is a term used to characterize a variety of aspects of living, including drug use, air quality, river water quality, and architectural design. Each direction's air and water have their own special qualities.

Concept of *Jangal Desha :*
In addition to providing crucial details about India's geographical and sociological circumstances, it also covers medical diseases and remedies.

DERIVATION AND DEFINITION OF THE WORD *DESHA: -*
The word *Jangal Pradesh* is derived from two words i.e. *Jangal+ Pradesh*

Jangal

I*n M. Monier Williams' Sanskrit-English dictionary, the term "means is arid, sparingly grown with trees and plants" doesn't mean "infertile." "Desert air countries" is what the word "Jangal" in "Vaidak Shabd Sindhu" signifies.*

DISCUSSION

Development of menarche:

At post-conception week six, GnRH neurons are located in the olfactory pit. By week nine, they have migrated from the forebrain to the hypothalamus. By week 12, the pituitary starts to release luteinizing hormone (LH) and follicle-stimulating hormone (FSH) into the fetal blood. By midgestation, or roughly 20 to 24 weeks, LH and FSH reach their peak levels. Low amounts of LH and FSH are present at birth, but they rise after placental estrogens are removed[6] .As was previously mentioned, menarche and puberty depend on the pulsatile release of GnRH and, consequently, LH and FSH. Thelarche, or breast blossoming, is a sign of female puberty that usually appears after the age of eight. Growth spurt, menarche, and pubarche—the development of pubic hair—come after thelarche.

Menarche happens six months after peak height velocity (PHV) is reached and two to three years after thelarche. The peak velocity recorded during the pubertal growth surge is known as PHV[7]. Tanner stage IV or sexual maturity rating (SMR) is where menarche most frequently happens. Menarche before the onset of secondary sexual development is considered abnormal. Vaginal bleeding in prepubertal females should be evaluated for other possible causes, such as bleeding disorders, tumors, genital damage from sexual assault, or other medical conditions. About 98% of girls will have had menarche by the time they are 15 years old, marking the physical maturity of the teenage female body. Although ovulation and fertility are not guaranteed, menarche is frequently linked to the capacity to ovulate and procreate. Adolescence is a time when irregular menstrual periods are common, especially in the transition from the first to the second cycle. Early menarche-related HPO axis immaturity causes anovulation and irregular cycles, which can vary in length from less than 20 days to more than 45 days. 60–80% of menstrual cycles are 21–34 days long by the third year following menarche, which is typical of an adult cycle[8].

Almost all of the cycles in females who menarche early are ovulatory by the fifth year after menarche, with 50% of them being ovulatory in the first year[9].Conversely, women who menarche later take eight to twelve years to begin their menstrual cycles.Menarche is considered early when it occurs at or before the age of ten, and late when it occurs at or after the age of fifteen.

Role of Prakriti in Process of *Artava Utpatti:*

Nature, or Swabhava, is Prakriti. Ayurveda recognizes six distinct types of Prakriti. That is to say, Doshanupatini, Deshanupatini, and Kalanupatini.

Doshanupatini Prakriti

Vatapradhana Prakriti causes a woman to have infrequent, painful menses. A lady suffering from Pittapradhana Prakriti experiences comparatively greater painless Artava flow, while a woman with Kaphapradhana Prakriti experiences a moderate level of painless blood flow**.**

Deshanupatini Prakriti:

Two kinds of desha—Deha Desha and Bhumi Desha—have been described in Ayurvedic texts. Vata dosha is dominant in Jangaldesha, Kapha dosha is dominant in Anupadesha, and all three doshas are equally distributed in Sadharanadesha.

On observation of *Doshas* with *Rajodarshana,* it is found that *Rajodarshana* in *Jangaldesha* is irregular, in *Anupadesha* it is delayed and it is regular in *Sadharanadesha. Rajadarshana* is earlier in *Ushna Desha* in comparison of *Sheeta Desha*. (A.H.Su. 1/23).

Role of *Mahabhutas* in Process of *Rajo Utpatti*

Similar to Raja, every single component of the body is made up of a combination of Panchamahabhutas. The following illustrates the relationship between Mahabhutas and Rajah Utpatti.

Bhumi → Vistrata
Apa → Dravata
Agni → Ragata
Vayu → Spandana
Akash → Laghuta

Artava Ekatrikarana Evam Visarjana:

Yonimukha is where the blood gathered by Dhamanee (uterine vessels and their endometrial capillaries) for the entire month is carried down for elimination, providing that the patient has Ishatkrishna Varna and a particular Gandha.

Vishwamitra has clearly mentioned that hair like thin vessels fill the *Garbhashaya* for whole month to receive *Beeja* (*Artava).*

Every month, blood from adult females at every stage of their reproductive cycle enters Garbhakoshtha, according to Acharya Kashyapa. This function is performed by the Rajovaha Siras, who are the bearers of the Rajah generated by Agni's action against the Rakta and are located in the uterus. These Siras populate the Uterus once a month, and after a whole month they drive out the Rajah.

CONCLUSION

There is a physiological increase in the level of a specific Prakruthi, which may have an impact on the menstrual features. Certain illnesses that fall within the category of physiological disorders may result from such impacts according to an individual's Prakruthi. It is therefore necessary to comprehend the Doshic role and apply medication, nutrition, and regiment control appropriately in order to restore the menstrual cycle's ideal action, which is extremely important for maintaining a woman's health.

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RESEARCH ARTICLE

Cytotoxic Potential of Green Synthesized Citric Acid Mediated Selenium Nanoparticles on Human Breast Adenocarcinoma Cell Line : A Comparative Study using *Anacardium occidentale* L. Leaf Extract

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ABSTRACT

Breast cancer remains a global health challenge, with increased incidence of aggressive subtypes like Triple Negative Breast Cancer (TNBC). This necessitates exploration into alternative therapies for breast cancer management as available conventional treatments often face limitations. Several in - vitro studies have established the use of Nanotechnology, particularly with Selenium nanoparticles (SeNPs) in various cancers. Instead of the conventional methods of synthesis of nanoparticles, green synthesis remains ecofriendly, feasible and cost effective. In this study, SeNPs were green synthesized using *Anacardium occidentale* leaf extract, and the cytotoxic potential was compared with that of aqueous crude extract of *Anacardium occidentale* against MDA-MB-231 Triple negative breast cancer cells using MTT Assay. A dose-dependent decrease in cell viability with green synthesized SeNPs was found in both the groups. The cytotoxic effect of SeNPs was higher when compared to aqueous crude extract. Morphological changes were more pronounced in the group treated with SeNPs. In Apoptotic fluorescent assay using dualAO/EtBr staining, though apoptotic features were observed in both the groups in dose dependent

manner, SeNPs had more apoptotic potential compared to aqueous crude extract. The results of the study established the cytotoxic potential of green synthesized SeNPs in breast cancer therapy

Keywords: Nanotechnology, Selenium nanoparticles, green synthesis of selenium nanoparticles, *Anacardium occidentale* , Triple negative Breast Cancer

INTRODUCTION

Cancer is one of the significant public health challenges globally and ranks as the second most common cause of mortality. Breast cancer is the second most prevalent cancer worldwide with 11.6% of total new cancer cases and the frequently diagnosed cancer in India consisting 13.5% of all cancer cases according to the latest estimates from the International Agency for Research on Cancer's Global Cancer Observatory [1, 2] . Despite advancements in screening, detection and treatment, breast cancer remains a significant health concern, impacting millions of women annually. The fact that breast cancer mortality, ranking fourth globally at 6.9%, highlights the need for more effective interventions and improved healthcare strategies. In India, breast cancer is the leading cause of cancer related deaths (10.6% of all cancer deaths) [3] . Triple negative breast cancer (TNBC) is an aggressive type of breast cancer with impaired expression of progesterone, oestrogen (usually & lt;1%) and Human Epidermal growth factor Receptor (HER-2) (0 to +1) as determined by immunohistochemistry [4 , 5] . Tsai et al reported 24 % of newly diagnosed breast cancers to be Triple negative with a steady increase in their incidence [6] . Yin et al reported that triple negative breast cancer represents 15 – 25 % of all breast cancer cases [7] . The aggressive clinical course of Triple negative breast cancer along with characteristic metastatic pattern, poor prognosis, higher rates of recurrence and lack of targeted therapy pose significant challenges in managing it effectively. Development of innovative treatment options is the need of the hour for reducing mortality rates particularly in aggressive and in cases which are resistant to conventional treatments.

In light of these challenges, there has been increasing interest in exploring alternative approaches to treatment. Nanotechnology driven methods for cancer therapy has gained attention in the recent past, owing to their unique physicochemical properties, with hopeful prospects for targeted drug delivery with minimal side effects and improved drug resistance in cancer therapy [8] . Palazzolo et al opined that Nano therapeutic drugs enabled combination therapy and inhibition of drug resistance mechanisms has made advancements in drug delivery systems [9] . Among the nanoparticles, Selenium based have gained attention for their selective cytotoxic potential against cancer cells specifically breast adenocarcinoma cells, while being biocompatible with low toxicity to normal cells [10 , 11] . Brenna Flowers et al highlighted the importance of Selenium supplementation in curbing breast cancer cases [12] .

Abbas Haddadin et al studied the anticancer activity of Niosomes loaded selenium nanoparticles and found significant results [13] . Selenium nanoparticles driven drugs have demonstrated improved anti-cancer activity through several mechanisms including cellular homeostasis disruption, intra cellular increase in reactive oxygen species, mitochondrial dysfunction, DNA fragmentation, cell cycle arrest and activation of apoptotic pathways [14 , 15] . Exploring natural sources for nanoparticle synthesis is vital in contemporary cancer research. In contrast to the traditional physical and chemical methods of metallic nanoparticle synthesis, green synthesis of metallic nanoparticles using natural extracts or biomolecules utilizing high – energy renewable materials have emerged as an eco-friendly and cost-effective approach [16 , 17] . Green synthesis of metallic nanoparticles mainly uses microorganisms, animals and plant extracts [18 , 19] . The green particles can act as reducing agents, end capping agents and dispersal agents simultaneously and hence the energy consumption is reduced to a greater extent. The use of hazardous chemicals is also avoided in green synthesis [20] .

The leaf extract of *Anacardium occidentale* L., a tropical evergreen tree, recognized for its rich phytochemical composition (flavonoids, tannins, alkaloids etc) has demonstrated potential as both a reducing and stabilizing agent in the green synthesis of nanoparticles [21] . *Anacardium occidentale* L., plant is rich in polyphenols, tannins, flavonoids and dietary fibres [22] . The anti-oxidant activity of *Anacardium occidentale* L., plant is well established by several studies [23 , 24] . In the study done by Adrielle Rodrigues Costa et al it was found that the bark extract of *Anacardium occidentale* L., to be highly cytotoxic to tumor cells (HL-60, NCI–H292, HCT- 116, P815 and L929) [25] . Hence the drug was selected for the green synthesis of Selenium nanoparticles in the current study.

Our current study aims to compare the cytotoxic potential of *Anacardium occidentale* L., leaf extract, crude versus the green synthesized SeNPs on MDA-MB-231 cell lines, a triple negative breast cancer cell line through MTT Assay. The impact of green synthesized Selenium nanoparticles on cell viability and apoptosis was analyzed. Bridging the traditional herbal knowledge with modern oncology, this study aims to contribute to the growing body of research on nanotechnology-based approaches for breast cancer therapy, with a specific focus on green- synthesized Selenium nanoparticles utilizing natural plant extracts.

MATERIALS AND METHODS

Synthesis of Selenium nanoparticles

For biosynthesis of selenium nanoparticles, 50 mL of *Anacardium occidentale* leaf extract and 50 mL of 40 mM selenium in citric acid were mixed at room temperature for one hour using magnetic stirring. The presence of SeNPs was confirmed by a gradual change in the colour of solution to orange. Following this, the solution was centrifuged at 9000 rpm to obtain SeNPs, which were subsequently cleaned by rinsing the sample three times with distilled water and twice with 100% ethanol. The cleaned SeNPs were then stored overnight at 50°C, resulting in a dry, brown-colored powder.

In - vitro Cytotoxic assay of Selenium nanoparticles on MDA – MB 231 cell lines:

Cell viability of human triple negative breast cancer (MDA-MB-231 cell line) was assessed using MTT Assay. A comparison was made between the cytotoxic potential of green synthesized SeNPs with crude extract of *Anacardium occidentale* . The method quantifies the transformation of yellow dye to purple formazan crystals formed due to the activity of NADP dependent oxidoreductase enzymes in mitochondria of living cells. Cell lines were procured and cultured in DMEM Gibco. DMEM Media is warmed up to 37°C and the MDA-MB-231 cells are thawed to 37 °C. 1 ml of thawed MDA-MB-231 cells is transferred to 3 ml of DMEM S+ media and centrifuged for 3 min at 300 x g. The supernatant suspended cells in MDA-MB-231 cells were aspirated in 10 ml of DMEM S+ and plate on 10 cm dish. The cells were incubated in a 5% CO_2 incubator at 37°C for 24 hours. The cells were then seeded at a density of 1x10 4 cells/cm 2 in 96-well plates and incubated at 37°C in a 5% CO_2 environment.

Different concentrations of SeNPs and aqueous crude extract were prepared and each concentration was subsequently added to the medium containing MDA-MB-231 cells. The concentrations of SeNPs used in the experiment were 7.5, 10, 12.5, 15, and 17.5 µg/ml, and for aqueous extract 100, 200, 300, 400, and 600 µg/ml. After 24 hours of exposure, the cell viability was determined using MTT Assay. 20 µl of MTT solution in PBS (5 mg/ml) was added to each well and the cells were then incubated for 4 hours at 37°C in a 5% CO_2 incubator and allowed to grow up to 80% confluence. The optical density at 450 nm was recorded, and the cytotoxicity was determined using the following equation, as described by Chavez-Garcia et al 2020.

Percentage of cellular inhibition= 100 - (Sample absorbance/ control absorbance) ×100

Apoptotic fluorescent Assay with Dual AO/EtBr staining:
The breast cancer cell line MDA-MB-231 was cultured in 6-well plates at a density of 1×10 6 cells per well. SeNPs were administered at dosages of 10, 15 µg/ml, while aqueous extract was administered at dosages of 200 and 400 µg/ml. Following a 24 – hour incubation period, cells were collected from the wells and stained with Acridine Orange/Ethidium Bromide (AO-EtBr) dye mix (1:1 v/v from 100 µg/mL in PBS). The stained cells were observed unde a fluorescent microscope (Biorad), following the protocol outlined by Jamali et al 2018.

Statistical analysis
All the data were calculated in mean ± SD pattern by performing in triplicates. Antibacterial test results were calculated for probability (p) value, p < 0.05 considered as statistically significant.

RESULTS

Cytotoxic and apoptotic effects on the MDA-MB-231cells:
To determine the cytotoxicity of the SeNPs, MTT assays were carried out on MDA- MB- 231 breast cancer cell lines, and a comparison study was performed along with the crude plant extract. In the study, both the group treated with SeNPs and aqueous crude extract exhibited cytotoxicity in a dose dependent manner with higher concentration of SeNPs exhibiting lower cell viability. In the group of cells treated with aqueous crude extract, the mean cell viability in the lowest concentration (100 µg) was 91.79% while it was 35.96% inthe highest concentration (600 µg). (Fig.No.1). The IC 50 value was 380.50 ±35.068. (Fig.No.2) In the group treated with green synthesized SeNPs, the mean cell viability was 81.45% with the lowest concentration (7.5 µg/ml) while it was only 19.03% for the highest concentration (17.5 µg/ml).Concentrations 12.5, 15 and 17.5 µg/ml had less than 50% viable cells. (Fig.No.3) The inhibitory concentration (IC 50) of synthesized SeNPs against MDA-MB-231 cells was 12.2 µg/ml. (Fig.No.4).

Apoptotic Fluorescent Assay with dual AO/EtBR staining
Both the groups of cells treated with aqueous crude extract and SeNPs had significant changes in the cell morphology (Fig.No.5). Considerable number of apoptotic and necrotic cells were observed in the cells treated with Selenium nanoparticles when compared to aqueous crude extract. AO/EtBr staining revealed that after treating with SeNPs and aqueous crude extract, the cells showed typical morphological features such as chromatin condensation, nuclear margination, nuclear fragmentation, blebbing of cell membranes, which were consequences of apoptotic trigger. Also, late apoptotic features like loose membrane, loss of membrane integrity and apoptotic bodies were also observed. Thus, early and late apoptotic features were observed in both the groups with prominent features in higher doses. (Fig.No.6)

DISCUSSION

Tumour drug sensitivity test helps us in identifying the most sensitive anti-cancer drug. In our study, it has been evaluated utilizing both the MTT assay and dual AO/EtBr staining methods. It provides valuable insights into the cytotoxic effects of green synthesized Selenium nanoparticles on MDA-MB-231 breast cancer cells. Cell viability, morphological changes and mechanism of cell death induced by the Selenium nanoparticles synthesized using *Anacardium occidentale* L was assessed and compared with its aqueous crude extract.

A dose – dependent decrease in cell viability was noted in MDA-MB-231 cells treated with increasing concentrations of SeNPs suggesting potent cytotoxic effect of SeNPs. Cytotoxic effects were evaluated for both crude plant extract and green synthesized Selenium nanoparticles. Results demonstrated a proportional increase in the percentage of cellular apoptosis with rising concentrations. The highest concentration (17.5 µg/ml) of SeNPs resulted in only 19.03% cell viability while the highest concentration of the aqueous crude extract (600 µg/ml) resulted in cell viability of 35.96%. SeNPs exhibited greater efficacy i n their cytotoxic potential against Breast cancer cells, underscoring the beneficial impact of the green synthesized SeNPs on these cells.

The IC 50 values derived from the MTT assay provide quantitative measures of the effectiveness of SeNPs and aqueous crude extract in inducing cell death. In our study, the IC 50 of SeNPs against MDA-MB-231 cells was 12.2 µg/ml. Comparatively, the IC 50 for the aqueous crude extract was found to be 380.50 µg/ml, indicating a significantly lower potency compared to the SeNPs. This suggests that SeNPs have a much stronger cytotoxic effect on MDA-MB-231 cells compared to that of crude extract at a very lower concentration which possess a significant advantage in using it as a drug for treatment.

The dual AO/EtBr staining assay further revealed the morphological changes and mechanisms of cell death induced by SeNPs. Acridine orange (AO) permeates all cells and renders their nuclei green while Ethidium bromide (EtBr) is taken up only by cells which have lost cytoplasmic membrane integrity, staining their nuclei red. Thus, in dual staining with AO/EtBR, live cells exhibit typical green nucleus, while nuclei of early apoptotic cells appear bright green with condensed or fragmented chromatin and late apoptotic cells display condensed and fragmented orange chromatin [26] . The observation of apoptotic and necrotic cells, suggests that SeNPs induce programmed cell death pathways. The presence of late apoptotic features, such as loss of membrane integrity and formation of apoptotic bodies, further corroborates this conclusion.

In our study significant alterations in cell morphology was observed in both groups of cells treated with the aqueous crude extract and SeNPs indicative of necrotic and poptotic cell death. However, notable difference was found in the extent of apoptotic and necrotic cell populations between the two groups, with a considerable number of changes observed in the cells treated with SeNPs compared to the aqueous crude extract. Also, Apoptotic changes was more pronounced with higher doses of both SeNPs and the aqueous crude extract, indicating a dose-dependent effect on apoptosis induction.

The results of the current study are in coherence with the systemic review conducted by Fernando Martinez Esquivias et al [27] . Bisht et al in their study assessed the cytotoxic effect of Selenium Nanoparticles synthesised using Auricularia auricula – judae against MCF -7, MDA – MB – 468 and MDA – MB-231 and found significant potential of SeNPs. Elaheh Khaledizade et al studies the anti – cancer activity of SeNPs synthesized using Bacillus coagulans supernatant and reported a concentration dependent cytotoxic activity of biosynthesized SeNPs with an IC 50 of 17.56 µg/mL [28] . Haiying Luo et al in their study on cytotoxic effect of SeNPs on HeLa and MDA – MB- 231 cells reported 60% reduction in cell viability in MDA – MB- 231 cells [29] . In flow cytometry, they observed that SeNPs arrested S phase at the concentration of 10 µmol/L. The viable cell percentage in the current study is less than the cell viability observed in the study done by Luo et al suggesting the effectiveness of green synthesized SeNPs using *Anacardium occidentale* against MDA – MB – 231 cells. Khurana et al explained the various mechanisms through which SeNPs exhibited anti-cancer activity [30] . Hossein vahidi et al conducted systemic review on the anticancer activity of biosynthesized SeNPs and analysed the various mechanisms associated with cytotoxic activity. Vetrivel Chittarasu et al demonstrated cytotoxic activity of green synthesized SeNPs using Ceropegia bulbosa tuber's aqueous extracts in MDA – MB – 231 breast cancer cells at IC 50 values of 34 µg/ml [31] . Menon et al evaluated the chemo preventive influence of SeNPs and their speculated anticancer mechanisms [32] .

Several other studies on Selenium based nanoparticles demonstrated anti – cancer activity of SeNPs against other cancers like lung, colo-rectal cancer, prostate cancer etc [33 , 34 , 35] . Nanoparticle based drug delivery being a novel method possess the advantage of being used at a very lower concentration to produce the desired effect when compared with crude extract. The available dataset illustrates the ability of the SeNPs in triggering apoptosis in the cancer cells. The findings of the current study align with the existing scientific literature on the effectiveness of SeNPs.

CONCLUSION

Our study demonstrated the cytotoxic potential of the green synthesized SeNPs using *Anacardium occidentale* against MDA-MB-231 breast cancer cells. The results of the apoptotic fluorescent dual staining AO/EtBR assay complement the findings of the MTT assay, highlighting the cytotoxic potential of *Anacardium occidentale* citric acid mediated SeNPs against triple negative breast cancer cells. These findings lay the groundwork for further investigation into the underlying mechanisms of action of SeNPs and their potential as therapeutic agents in the treatment of breast cancer.

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Data that support the findings of this study will be available from corresponding author upon reasonable request.

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Declaration of Competing Interest
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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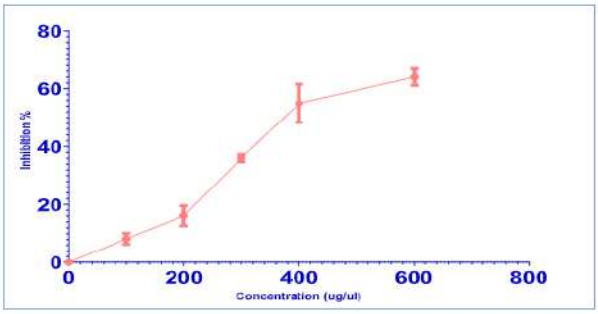


Fig.No.1: Dose response curve of MDA MB 231 cells to *Anacardium occidentale* L crude extract during 24hrs treatment. Data are shown as Mean ± Standard deviation.

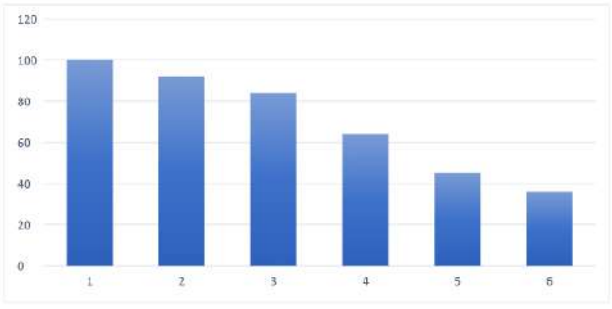


Fig.No.2: Half maximal inhibitory concentrations (IC 50) of *Anacardium occidentale* L. crude extract in MDA MB 231 cells over 24 hours of exposure using MTT Assay. Data was analyzed using Analysis of Variance (ANOVA). Values are shown as Mean ± Standard; P<0.005.

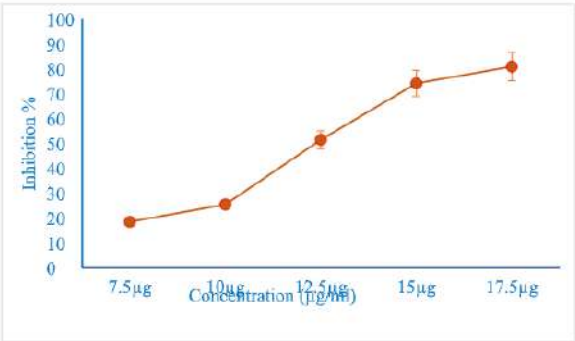


Fig.No.3: Dose response curve of MDA MB 231 cells to green synthesized SeNPs during 24hrs treatment. Data are shown as Mean ± Standard deviation

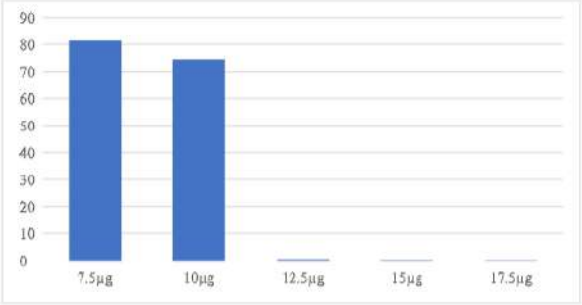


Fig.No.4: Half maximal inhibitory concentrations (IC 50) of green synthesized SeNPs in MDA MB 231 cells over 24 hours of exposure using MTT Assay. Data was analyzed using Analysis of Variance (ANOVA). Values are shown as Mean ± Standard; P<0.005.

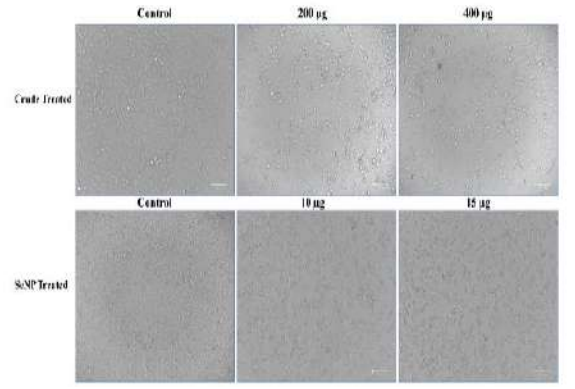


Fig.No.5: Morphological changes observed upon treatment with *Anacardium occidentale* crude extract and SeNP - *Anacardium occidentale* treated cancer cells compared with untreated control MDA-MB -231 breast cancer cells. The Photomicrograph (20x) shows
the control group before administration of the crude extract and synthesized SeNP. The pathological alterations in the cellular level of MDA-MB -231 breast cancer cells include cellular shrinkage, loss of adhesion between cells, membrane blebbing, and distortion of the cellular shape as seen in the treated groups.

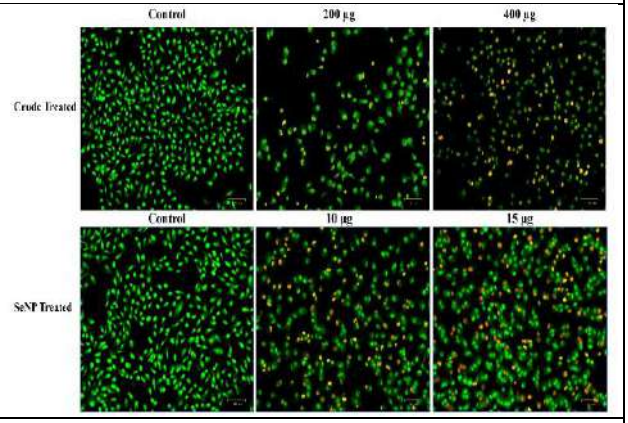


Fig.No.6: Alterations in Untreated control, *Anacardium occidentale* crude extract and SeNP - *Anacardium occidentale* treated Breast cancer (MDA MB 231) cells for 24 hours. The Photomicrograph (20x) shows green fluorescence on imaging indicates that apoptosis is
absent in the untreated cells. The yellowish-orange fluorescence indicates the early stage of apoptosis and red florescence indicates the later stage of apoptosis. Cells treated with crude extract at 400µg/mL and SeNp's at 15mcg/ mL has more apoptotic change when compared with untreated control cells. Morphological changes representing the later stage of apoptosis such as loss of membrane integrity and blebbing are noticed more in the SeNp treated (15µg/ mL) compared to crude extract treated cells (400µg/ mL).

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RESEARCH ARTICLE

Design Formulation and *In Vitro* Evaluation of Self Microemulsifying Drug Delivery System (SMEDDS) of Atorvastatin Calcium by Simplex Lattice Design

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ABSTRACT

An HMG-CoA inhibitor with an anti-hyperlipidemic effect is atorvastatin calcium. Since it is classified under the BCS II class, creating a microemulsion will improve its oral bioavailability by increasing its solubility and dissolution. By using the water titration method, isopropyl myristate, tween 80, and polyethylene glycol 600 as the oil, surfactant, and co-surfactant, respectively, are used to prepare the microemulsion formulation. The pseudo ternary phase diagrams developed at different ratios (1:1, 2:1 and 3:1). contain a single isotropic region that is thought to be a self-micro emulsifying one. The prepared microemulsion formulations were characterized for their percent transmittance, viscosity, particle size determination, thermodynamic stability by zeta potential and *in vitro* cumulative percent drug release. From pseudo ternary phase diagram 3:1 ratio was optimized and used for further optimization. The formulation was optimized by Design Expert 13 Software using Simplex lattice design in terms of percent transmittance and *in vitro* cumulative percent drug release. Compared to the pure

drug, the optimised formulation exhibits a high drug release of 98.3 ± 1.13% within 12 hours. The solubility-enhancing properties of the surfactant and co-surfactant may be the cause of the high release.

Key words: Atorvastatin calcium, SMEDDS, Design Expert 13, Simplex lattice design, Ternary Phase diagram.

INTRODUCTION

The oral administration of these medications frequently associated with low dose proportionality, high intra-inter subject variability, and low bioavailability. About 40% of potential new drugs are poorly soluble in water [1]. A combination of medications, oil, surfactants, and/or additional additives make up SMEDDS. Micro-emulsions with droplet sizes between 200 nm and 5 μm are produced when these components are gently mixed in aqueous media. Drug absorption has been demonstrated to be enhanced by SMEDDS through fast self-micro emulsification in the stomach, where micro-emulsion droplets then disperse to absorbable sites in the gastrointestinal tract. Providing a large interfacial area for drug to be partitioned between oil and water is another benefit of SMEDDS over basic oily solutions [2].

Quality by Design, or QbD, is an organised method of development that begins with predefined objectives and emphasises process control and product and process understanding. It is backed up by excellent risk management and science. Emulsions and other mixtures can be optimised with the help of Simplex Lattice Design. To maximise the composition of SMEDDS, simplex lattice design employed. Three factors were evaluated in this design by varying their concentrations concurrently while maintaining a constant total concentration. An equilateral triangle represents the three-component system's simplex lattice design **[3, 4].** Oral administration is most convenient route of administration even though it is having bioavailability problem. Atorvastatin Calcium is having 12% oral bioavailability. To improve the oral bioavailability Atorvastatin Calcium SMEDDS were prepared. To maximise the composition of SMEDDS, a simplex lattice design was employed. Three factors were evaluated in this design by varying their concentrations concurrently while maintaining a constant total concentration. An equilateral triangle represents the three-component system's simplex lattice design **[5-7].**

MATERIALS AND METHODS

Method of preparation

Phase diagrams can be used to illustrate the phase titration method used to prepare microemulsions. Drug was mixed with oil and stirred until it dissolves. Smix was added and stirred for 30 mins. After stirring fixed amount of water (200ml) was added to the above mixture. Kept for homogenization for 10 min. Checked for a clear solution. In simplex lattice design, effect of independent variables (also called factors or components) such as % Oil, % Surfactant and % of Cosurfactant on dependent variables (also called responses- % Transmittance and Cumulative percent Drug release) was found. Given in Table 1.

Characterization of microemulsion:

Visual Evaluation: Following each addition of water to the mixture of oil and surfactant or surfactant and co-surfactant, a visual inspection was conducted. Through visual inspection, the samples were classified as microemulsion, emulsion, or gel formation [8].

Viscosity and pH: In order to ascertain the rheological characteristics of formulations, the viscosities were measured. For this, a Brookfield (LVDV 111+ CP)-Viscometer (30°C) and a CPE 42 spindle running at 5 rpm were utilised. Using a pH-meter, the formulations pH was determined [9-11].

Measurement of zeta potential: Generally, zeta potential is found using a zeta potential analyser or zeta meter system. Zeta potential analyser estimation, following the appropriate dilution, indicates the emulsion's consistency. More zeta potential is a sign of better consistency in the formulation [12].

Zeta-potential analysis and particle size distribution (PSD): At 37 ± 0.5˚C, 100 times the SMEDDS formulation was diluted with distilled water. Using a magnetic stirrer, the resulting emulsions were prepared by gently stirring for 10 minutes. Using a Malvern zetasizer, the final microemulsion's PSD and zetapotential were calculated [13].

% Transmittance measurement: Using a UV spectrophotometer set to 247 nm, the transmittance of several formulations was determined, with water serving as a reference. percentage transmittance at 650 nm was calculated, the transmittance of the SMEDDS formulation was ascertained, with distilled water acting as the blank. 10 mL of distilled water was added to 100 µL of the SMEDDS formulation in order to dilute it and measure the transmittance **[14, 15].**

Cumulative percent drug release

Using the membrane method, a cumulative percent drug diffusion study was conducted. The dialysis bag was saturated for the entire night in a 6.8 pH buffer.A dialysis bag was filled with 1 millilitre of atorvastatin calcium SMEDDS diluted with aqueous phase. One end of the instilled solution was tied with thread, and the dialysis bag was placed in 900 millilitres of 6.8 pH buffer as a dissolution medium at 37±0.5˚C. The pace of paddle revolution was maintained at 50 revolutions per minute. At regu1ar intervals of - 0, 0.5, 1, 1.5, 2, 4, 6, 8, 10 and 12 hours, a 5 m1 aliquot was removed [16-18].

RESULTS AND DISCUSSION

Ternary phase diagrams given in Figure 1. Atorvastatin calcium calibration curve given in Figure 2.

FTIR studies of Atorvastatin calcium optimized formulation and Pure drug

Comparison of FTIR graph of Atorvastatin calcium optimized formulation and Pure drug given in Figure 3. FTIR spectra analysis of pure drug and optimized formulation given in Table 1.

CHARACTERIZATION OF SMEDDS OF ATORVASTATIN CALCIUM

In visual inspection, F1, F4 an F6 were clear. The other formulations were found to be translucent, milky and turbid. Viscosity was found to be in the range of 13.25 ± 0.02 to 16.74 ± 0.01cps. Drug content was in the range of 92.07 ± 0.64 to 96.35 ± 0.96 %. Given in the Table 3. Zeta potential of Atorvastatin calcium SMEDDS was found to be -13.6 for F1 formulation. Quality of the result was found to be good. Given in Figure 4. Particle size distribution (PSD). Narrow particle size distribution and the resulting small mean size of the microemulsion were present regardless of the dispersion medium. The size of microemulsion was found to be 471 nm. The result quality was found to be good. Given in Figure 5.

Transmittance (%T), a measure of transparency, was used to assess the microemulsions' clarity. SMEDDS creates an o/w microemulsion because the external phase is water. The transmittance value of the optimised formulation F1 is 99.6%. These outcomes demonstrate the microemulsion's high clarity. Atorvastatin calcium's cumulative percent drug release was found to be between 82.4 ± 1.07 to 98.3 ± 1.52%. The F1 optimized formulation cumulative percent drug release was found to be 98.3 ± 1.52 %. Given in Figure 6.

Sums of squares of Type I are used in inference for linear mixtures. L_Pseudo is the code for the mixture component. Type III - Partial sums are square sums. With an F-value of 82.54, the model is considered significant. Only 0.01% of cases with an F-value this high could be the result of noise. P-values<0.0500 show the significance of model terms. If the model terms have values greater than 0.1000, they are considered non-significant. If there are many terms in your model that are not necessary, model reduction may be able to help.

The F-value of 3.42 for the lack of fit. With a 39.17% probability, noise could be the cause of a high F-value for lack of fit. It's ideal to have a very small mismatch. There is a small discrepancy <0.2 between the Adjusted R^2 of 0.9477 and the Predicted R^2 of 0.9164. With sufficient precision, the signal/noise ratio is measured. Preferably, the ratio should be greater than 4. Ratio of 22.741 suggests that the signal is strong. This model can assist you in navigating the design space. ANOVA results for (Response 1) Percentage Transmittance Test given in Table 4.

Type I sums of squares are used in linear mixture inference. Type III: Pseudo Sum of Squares is the code for the partial mixture component. The model's F-value of 6227.86 indicates that the model is significant. The noise being the cause of this kind of large F-value 0.01%. Model terms with P-values<0.0500 are deemed significant. If the values are more than 0.1000, the model terms are not significant.The 0.18 Lack of Fit F-value suggests that the Lack of Fit is not statistically significant when compared to the pure error.

86.03% of large F-values in the Lack of Fit category are likely the result of noise. A small mismatch is beneficial. The Adjusted R^2 of 0.9998 and the Predicted R^2 of 0.9983 differ by less than 0.2, suggesting a reasonable agreement. Sufficient precision is used in measuring the signal/noise ratio which is >4. You have a strong enough signal with a ratio of 199.999. This model can be used to navigate the design space. Results of the ANOVA for (Response 2). The cumulative percent drug release is displayed in Table 5 along with a contour plot of that percentage. Figure 9 shows the overlay plot from Figure 8. The Coefficient Table is found in Table 6.

CONCLUSION

An HMG-CoA inhibitor with an anti-hyperlipidemic effect is atorvastatin calcium. Since it is classified under the BCS II class, creating a microemulsion will improve its oral bioavailability by increasing its solubility and dissolution. The water titration method is used to prepare the microemulsion formulation by using Isopropyl myristate, tween 80, Polyethylene glycol 600. The single isotropic region present in the pseudo ternary phase diagrams developed at varying ratios (1:1, 2:1 and 3:1) is believed to be a self-micro emulsifying one. The prepared microemulsion formulations characterized for percent transmittance, viscosity, particle size determination, thermodynamic stability by zeta potential and *in vitro* cumulative percent drug release. From phase diagram 3:1 ratio was optimized and used for further optimization. The formulation was optimized by Design Expert 13 Software using Simplex lattice design in terms of percent transmittance and *in vitro* cumulative percent drug release.The optimised formulation has a high drug release rate, i.e., 98.3 ± 1.13% 12 hr as compared to the pure drug. The solubility-enhancing properties of the surfactant and co-surfactant may be the cause of the high release.

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Table 1: FTIR spectra analysis

Functional groups	Wave number (cm^{-1})	Pure Drug (cm^{-1})	Optimized formulation (cm^{-1})
N-H	3000 – 3500	3363.39	3423.65
C=C	1400-1600	1512.34	1510.66
C-OH	1050-1200	1160.00	1090.34
C-H	2850-3100	2972.82	2921.83
C=O	1680-1415	1578.11	1577.29

Variables and Responses of components from Simplex lattice design given in Table 2.

Table 2: Variables and Responses of components from Simplex lattice design

	Component 1	Component 2	Component 3	Response 1	Response 2
Run	A: Oil	B: Surfactant	C: Cosurfactant	% Transmittance Test	Cumulative percent Drug release
	%	%	%		
1	1.5	6.75	1.75	99.6	98.3
2	7.4	0.75	1.85	96.5	82.4
3	5.86	1.89	2.25	97.4	84.3
4	2.55	5.2	2.25	99.1	97.4
5	7.35	2.4	0.25	97.8	88.5
6	5.42	3.48	1.1	98.5	94.4
7	3.77	5.98	0.25	99.3	97.9
8	5.42	3.48	1.1	98.3	94.2
9	3.9	3.85	2.25	98.1	94.3
10	9	0.75	0.25	96.5	84.6

Table 3: Characterization of SMEDDS of Atorvastatin Calcium

Formulation code	Visual inspection	Viscosity (cps)	Drug content (%)
F1	Clear	15.19±0.02	96.35±0.96
F2	Turbid	16.13±0.02	93.86±0.17
F3	Turbid	16.15±0.01	92.33±0.73
F4	Clear	14.25±0.02	93.41±0.27
F5	Translucent	16.39±0.01	92.29±0.95
F6	Translucent	16.49±0.01	93.78±0.73
F7	Clear	13.25±0.02	94.65±0.82
F8	Milky	15.23±0.01	92.07±0.64
F9	Milky	16.15±0.02	93.35±0.96
F10	Turbid	16.74±0.01	92.84±0.63

Table 4: ANOVA results for (Response 1) Percentage Transmittance Test

Source	Sum of Squares	Df	Mean Square	F-value	p-value	
Model	10.16	2	5.08	82.54	< 0.0001	Significant
[(1)]Linear Mixture	10.16	2	5.08	82.54	< 0.0001	
Residual	0.4308	7	0.0615			
Lack of Fit	0.4108	6	0.0685	3.42	0.3917	not significant
Pure Error	0.0200	1	0.0200			
Cor Total	10.59	9				

Table 5: ANOVA results for (Response 2) Cumulative percent drug release

Source	Sum of Squares	Df	Mean Square	F-value	p-value	
Model	336.61	6	56.10	6227.86	< 0.0001	Significant
[(1)]Linear Mixture	302.43	2	151.21	16786.15	< 0.0001	
AB	0.1006	1	0.1006	11.16	0.0444	
AC	3.46	1	3.46	384.44	0.0003	
BC	1.00	1	1.00	111.36	0.0018	

AB^2C	10.16	1	10.16	1127.98	< 0.0001	
Residual	0.0270	3	0.0090			
Lack of Fit	0.0070	2	0.0035	0.1756	0.8603	not significant
Pure Error	0.0200	1	0.0200			
Cor Total	336.64	9				

Table 6: Coefficient Table

	A	B	C	AB	AC	BC	AB^2C
% Transmittance Test	96.7605	100.875	96.4588				
p-values	<0.0500						
Drug release	84.6002	106.09	1.18915	**-3.29566**	**90.5111**	**56.663**	**656.74**
p-values				**0.0444**	**0.0003**	**0.0018**	**< 0.0001**

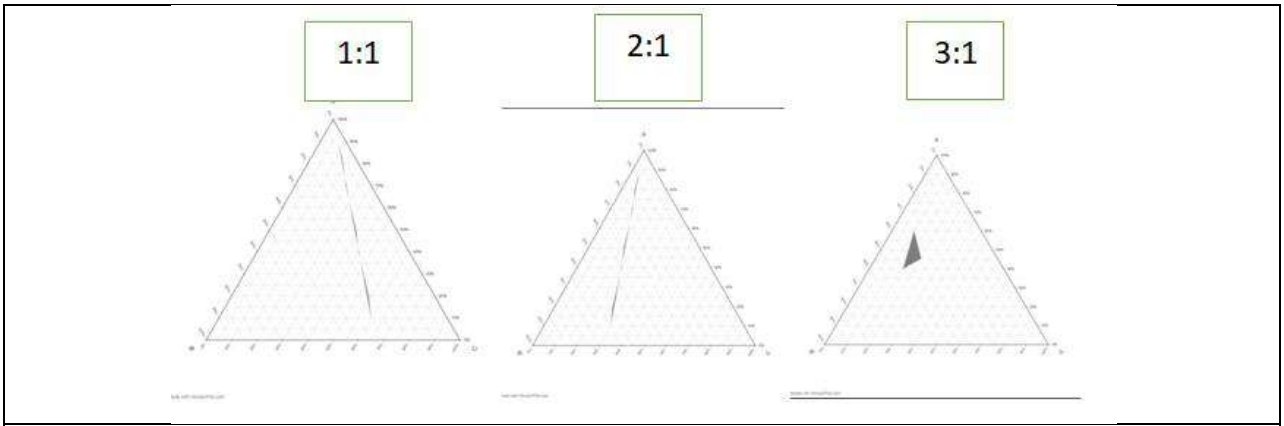


Figure 1: Ternary phase diagrams

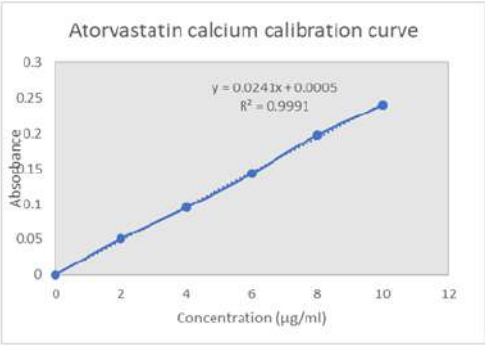


Figure 2: Atorvastatin calcium calibration curve

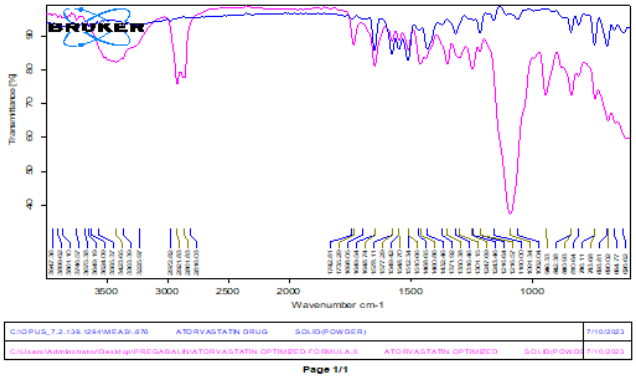


Figure 3: FTIR graph of Atorvastatin calcium optimized formula and Pure drug

Zeta Potential Report

v2.3

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Sample Details

Sample Name: ATORVASTATIN CALCIUM SELF-MICROEMULSION 1
SOP Name: SAROJINI NAIDU COLLEGE ZETA.sop
General Notes: Average result created from record number(s): 17 18 19

File Name: RBVRR COLLEGE.dts
Record Number: 21
Date and Time: 26 July 2023 12:58:17
Dispersant Name: Water
Dispersant RI: 1.330
Viscosity (cP): 0.8872
Dispersant Dielectric Constant: 78.5

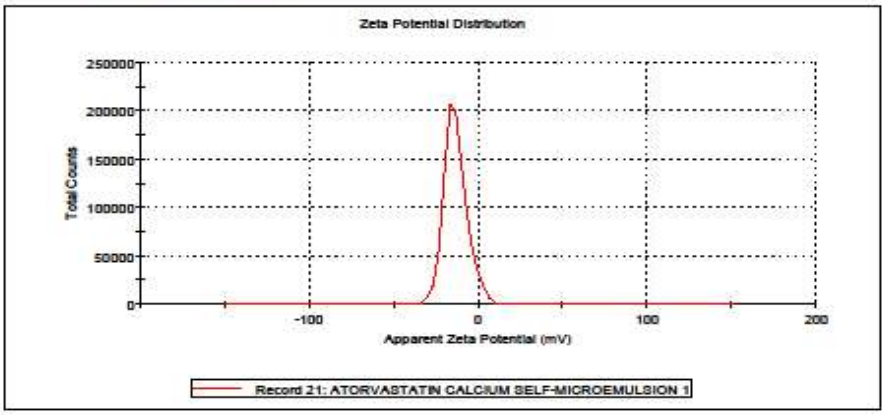
System

Temperature (°C): 25.0
Count Rate (kcps): 69.8
Cell Description: Clear disposable zeta c...
Zeta Runs: 12
Measurement Position (mm): 2.00
Attenuator: 8

Results

		Mean (mV)	Area (%)	St Dev (mV)
Zeta Potential (mV): -13.6	**Peak 1:**	-13.5	100.0	6.71
Zeta Deviation (mV): 6.58	**Peak 2:**	-27.4	7.2	2.24
Conductivity (mS/cm): 0.185	**Peak 3:**	0.00	0.0	0.00

Result quality Good



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Zetasizer Ver. 7.13
Serial Number : MAL1089121

File name: RBVRR COLLEGE
Record Number: 21
26 Jul 2023 12:58:29

Figure 4: Zeta Potential report of Atorvastatin calcium optimized formulation

Size Distribution Report by Intensity

v2.2

Malvern

Sample Details

Sample Name: ATORVASTATIN CALCIUM SELF-MICRO EMULSION 1 AVG
SOP Name: SAROJINI NAIDU COLLEGE.sop
General Notes: Average result created from record number(s): 11 12 13

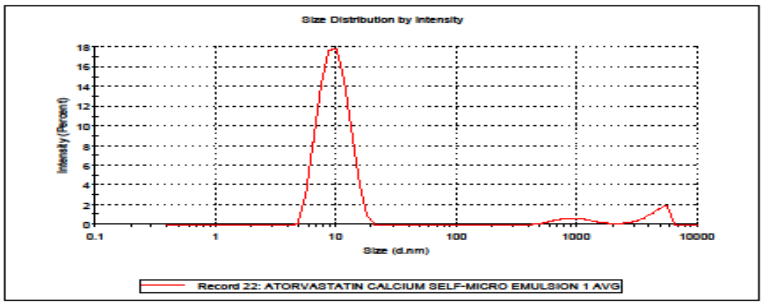
File Name: RBVRR COLLEGE.dts
Record Number: 22
Material RI: 1.43
Material Absorbtion: 0.010
Dispersant Name: Water
Dispersant RI: 1.330
Viscosity (cP): 0.8872
Measurement Date and Time: 26 July 2023 13:01:25

System

Temperature (°C): 25.0
Count Rate (kcps): 182.2
Cell Description: Disposable sizing cuvette
Duration Used (s): 70
Measurement Position (mm): 4.65
Attenuator: 8

Results D(10): 6.76 nm D(50): 9.94 nm D(90): 471 nm

			Size (d.n...	% Intensity:	St Dev (d....
Z-Average (d.nm):	10.94	Peak 1:	9.896	89.8	2.636
PdI:	0.277	Peak 2:	4505	6.1	988.5
Intercept:	0.928	Peak 3:	1007	4.1	353.1
Result quality	Good				



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Zetasizer Ver. 7.13
Serial Number : MAL1089121

File name: RBVRR COLLEGE
Record Number: 22
26 Jul 2023 13:01:37

Figure 5: Particle size distribution report of Atorvastatin calcium optimized formulation

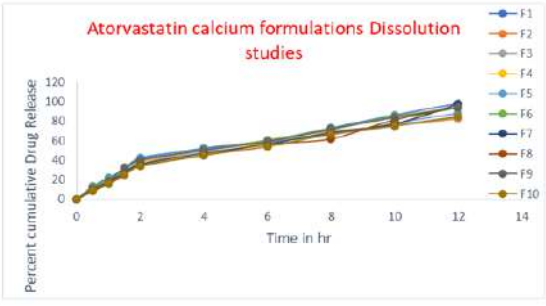


Figure 6: Dissolution Studies graph of atorvastatin calcium

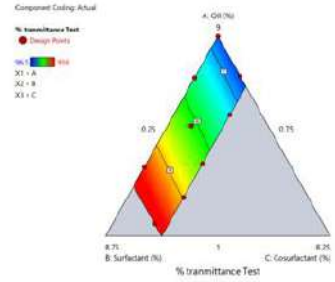


Figure 7: % Transmittance Contour plot

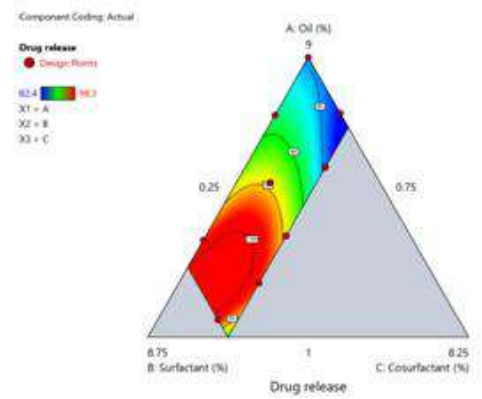


Figure 8: Contour plot of cumulative percent drug release

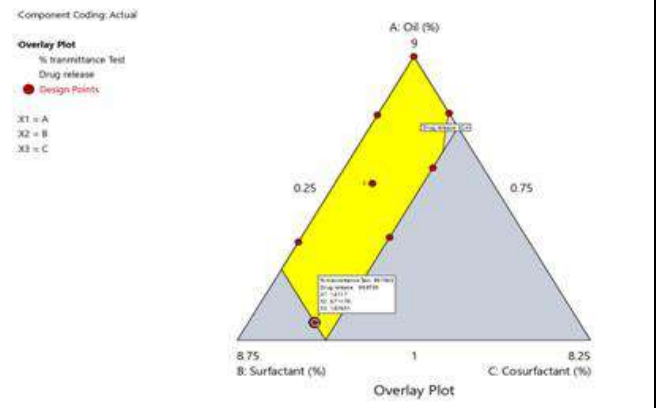


Figure 9: Overlay Plot

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RESEARCH ARTICLE

Fuzzy Multi-Objective Linear Programming of Fuzzy Optimization Techniques for the Land Allocation in Thiruvarur District, Tamil Nadu

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ABSTRACT

A number of competing optimization criteria that impede decision-making in the planning of agricultural production are the hallmarks of modern agriculture. Typicalexamples of such criteria are total cost, total production, net profit, etc. At the same time, fuzzy (not predictable) or accidently occurring data are frequently used in the agricultural production planning decision-making process. These include information on the yields of different crops, the costs of goods and raw materials, the demand for the product, and the quantities of labour and water that are accessible for production. A fuzzy multi-criteria mathematicalprogramming paradigmis introduced inthis study. The idealproductionplan is reached in Thiruvarur district of Tamilnadu where paddy is grown in the Kharif and Rabi Seasons, The purpose of this study was todetermine thebestway to allocate landfor paddy in order to maximize yield while balancing the competing goals of cost reduction and profit maximization in light of demand and water constraints. Only the availability of landconstraint is seen as a crisp in nature while aims and other restrictions are treated as fuzzy. It has been noted that the MOFLP is a useful technique for managing several objectives in a hazy, unclear setting.

Keyword: FuzzyMulti-ObjectiveLinearProgrammingProblem,CropPlanning. Mathematics Subject Classification (MSC2020) : 03E72, 90C08.

INTRODUCTION

In the 1960s, Lofti A. Zadeh was the driving force behind the earliest and most important effort to formalise fuzziness mathematically. Through his publications, Zadeh has established a new avenue for the advancement, dissemination, and practical application of fuzzy logic to real-world issues. In order to precisely study hazy concepts, fuzzy set theory offers a rigorous mathematical framework. The field of fuzzy set theory is undergoing continuous advancement, with multiple endeavours underway to investigate its potential as a valuable instrument for the mathematical examination of practical issues. Fuzzy set theory may not be a theory in search of applications, but rather a helpful tool for the expression of professional judgements, as evidenced by recent applications to a variety of scientific fields, including Artificial Intelligence, Image processing, Decision Theory, Military Science, Medical Science, Sociology, Economics, Psychology, Biology, Management Science, Expert Systems, Control Theory, Mathematics, and Statistics. Bellman and Zadeh [1] (1970) have emphasized the idea of making decisions in ambiguous situations. They took into account the traditional decision-making model and proposed a model in which the constraint(s) and the objective function are both ambiguous.

They argued that both the constraints and the fuzzy goal function are characterised by their membership functions. Zimmermann proposed the first version of fuzzy linear programming in 1976 [2], [3]. Subsequently, other authors examined diverse kinds of fuzzy linear programming issues and suggested multiple methods to address them. Fuzzy linear programming was first presented by Zimmermann as traditional LP. He employed linear membership functions and the min operator as an aggregator for these functions while thinking about LP problems with fuzzy goals and fuzzy constraints. Finding "optimal" solutions to many real-world issues is not possible with a single criterion or objective function. Multi-criteria decision making has given rise to a variety of assessment techniques as well as the creation of vector-maximum mathematical programming problems.

First introduced by Kuhn and Tucker in 1951, the Multi-Objective Decision Making (MODM) problem is also referred to as the "vector maximum" problem. In the context of agricultural production planning (APP), MODM is examined in this research. To meet demand, they manage profit and expense while making use of available resources. In actuality, though, they are frequently ambiguous or unclear. Because precise parameter fitting requires human observations or approximations, it can be challenging to obtain exact parameters. It might not be feasible to discover the ideal solution under these circumstances. A slight infringement of limitations and requirements could result in a more effective resolution. In these circumstances, the fuzzy notion is used. The fuzzy application programme permits the imprecision in estimating demand and the parameters related to manufacturing costs, labour, machinery, and water availability. The goal of an agricultural processing system's operation is profit maximization. It's critical to realise that maximizing crop output frequently does not equal maximizing profit. Furthermore, even once agricultural productivity reaches its peak, profit and loss are still determined in part by price.

LITERATURE REVIEW

Many methods in the management sciences have been developed over time to address multi-objective decision making issues. The three most popular methods for handling MOLP problems are the interactive methodology, objective formulation, and linear optimal procedure. In the majority of real-world scenarios, the option variable has many extreme points. In a cloudy situation, [1] can also support a decision-making process. Further actions were taken by Advanced to identify a feasible resolution to the MOLP issues in light of their findings and the recommended fix. The methodologies were improved further with the aim of identifying compromise solutions. Then [4] and [5] came after it in the opposite direction. Agricultural production and decision-making are significantly impacted by uncertainty, so the sector was not exempt. The use of fuzzy goal programming techniques for difficult agricultural planning problems is suggested by a number of academics, including [6] and [7]. [8] played a crucial role in drawing the attention of experts to the application of unknown factors in agricultural planning as a way to get around the drawbacks of linear programming.

Strong support for the comparative analysis, [9] conducted in a production planning issue employing fuzzy, predictable, and random approaches came from a study by [10] that used possibility measurements. [10] A methodology for optimising the maximum and minimum benefit for decision makers was supplied, along with a case study of a problem involving farm planning with ambiguity as a population parameter. In this study, the multi-objective mathematical programming problem of crop growth with income as a population parameter is attempted to be solved. To develop agriculture strategy that will assist decision-makers in maximising profit, the challenge has been transformed into a fuzzy mathematical problem solving programme.

Mathematical Model

The majority of real-world decision-making challenges require the decision-maker to optimise many competing objectives while adhering to certain restrictions. The multi- objective optimization model with p objectives, n variables, and m constraints is expressed in general as

Maximize $[Z_1(x), Z_2(x), \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots, Z_p(x)]$

Subject to $g_i(x) \leq 0$ $i = 1,2,3,\ldots,q$, $x \geq 0$
where, $x = (x_1, x_2, \ldots\ldots, x_n) \in R^n$ and $Z_i(x)$, j= 1,2,……,p

are objective functions. Above equation represents a mathematical model of a multi-objective optimization issue where p objectives have to be maximized under q restrictions. In most real-world problems, there are goals that need to be both minimized and maximized.

The fuzzy method

A mathematical method called fuzzy logic (FL) is used to handle inaccurate data and issues with multiple possible answers. A mathematical tool for capturing the ambiguities inherent in human cognitive processes, such as thinking and reasoning, fuzzy logic allows approximation human reasoning abilities to be applied to knowledge-based systems.

Theory of fuzzy sets

It was created expressly to give formalised methods for handling the imprecision inherent in many problems as well as a mathematical representation of uncertainty and vagueness. A set is referred to as fuzzy informally if it is uncertain if an element exists or belongs in the set. The following is a formal definition:

Let X be a nonempty set. A fuzzy set A in X is characterized by its membership function $\mu_A(X) : X \rightarrow [0,1]$ is interpreted as the degree of membership of element x in fuzzy set A for each $x \in X$ Then a fuzzy set A in X is a set of ordered pairs: $A = \{(x, \mu_A(X)) : x \in X\}$.

The value zero denotes complete non-membership, the value one denotes complete membership, and values in between denote intermediate degrees of membership. The range of the membership function is [0,1].

Categories of membership roles

One of the key tasks in fuzzy logic is choosing an appropriate membership function for a fuzzy set. The user must decide which function best captures the fuzzy idea that has to be modelled. According to Dubois and Prade (1980) and Zimmermann (1996), the following membership functions are the most often used:

(i) linear membership function
(ii) triangular membership function
(iii) trapezoid membership function
(iv) sigmoid membership function

(v) ∏-type membership function
(vi) Gaussian membership function

Multi-objective Fuzzy Linear Programming

If many objective functions are present, the task of identifying the best solution in a fuzzy environment becomes more challenging. Multi-criteria fuzzy programming analysis is the domain that results from this. From the 1970s onward, this area has experienced rapid growth. Problems involving multiple objective functions have been addressed in a variety of ways. The actions were regarded as clearly specified and the objective functions as real valued in all of these methods. Multi-objective optimization problems generally have the following characteristics: p constraints, n decision variables, k objectives to be maximized, and m objectives to be minimized.

$Max_k\ Z_k\ (x), Min_m\ Z_m(x)$ such that $g_i\ (x)_{x\geq 0} \leq b_i i=1,2,\ldots,p$ Where, $x = (x_1, x_2, \ldots, x_n) \in R^n Z_k(x)$ and $Z_m(x)$ are objective functions. If all the objective functions and constraints of above model are fuzzy then its fuzzy model of can be rewritten as:

subject to

$A_j X \leq b$

$X_i \geq 0,\ \forall I = 1,2,3.....n$ & $j=1,2,3m$

A generalized FMOLP issue with n variables, m restrictions, and p goals can also be described in terms:

$$Maximize\ Z_1 = \sum_{j=1}^{n} c_{1i}\, x_j$$

$$Maximize\ Z_2 = \sum_{j=1}^{n} c_{2i}\, x_j$$

.

.

.

$$Maximize\ Z_k = \sum_{j=1}^{n} c_{pi}\, x_j$$

$$p = 1,2,3.....,q$$

subject to

$$Ax_i \leq b,$$

$$x_i \geq 0, i = 1,2,.....n \qquad (1)$$

$Z_1(x), Z_2(x), \ldots\ldots, Z_p(x)$ are the k distinct linear objective functions of x.

C_{ij} represents the cost vector, where i = 1, 2,.....,n, j = 1, 2,....., m, and A represents the *nxm* restriction matrix, where b represents a p vector including all accessible resources.To find the chosen vector x.

When i = 1, 2..., n, and j = 1, 2..., m, A is the restriction matrices, b is a p-dimensional vector representing all resources, and C_{ij} represents the cost vector. The x decision vectors are calculated.

$$\exists\, Z_p(x) \geq Z_p(x^*)\, \forall p$$

Where $Z(x^*) \forall\ p$ specific goals and decision criteria that must be optimized are represented.

The goal function of equation (1) is to be fuzzy.

The optimal membership function $\mu_q(\xi) \forall k$ is solution is calculated by generating an ideal solution cost matrix in such a way that

$$\mu_q(x) = \min\{\mu_1(x), \mu 2(x), \mu 3(x), \ldots\ldots, \mu_p(x)\}$$

The solution can be discovered by addressing the problem of maximizing μq(x)

Subject to

$$Max\left(Min\left(\mu_p(x)\right)\right)$$

In this manner$x \epsilon X$

Let $\gamma = Min\, \mu_p(x)\ \ \forall p, x \in X$

$$Ax_i \le b, x_i \ge 0 \qquad (2)$$

Problem (2) is solvable using the MOLP method.

Algorithm

The fuzzy desire levels are identified by computing every optimal solution for its maximum and minimum values; as a consequence, membership functions are built, and the problem is reduced to its core. An ideal solution is attempted using Zimmermann's recommended max-min operator. As a result, the fuzzy multi-objective programming technique is predicted to provide a flexible, realistic optimal solution. Rabi, which begins in November and lasts until February or March, and kharif, which begins in June and lasts until October or November, are the two most important seasons. Fuzzy target levels are found by computing the greatest and lowest values of each ideal solution. After that, the membership functions are provided, and the issue is made simpler. An optimal solution is analyzed using the max-min operator introduced by Zimmermann.

It follows that an adaptable, practical, and ideal compromise solution should be produced by the fuzzy multi-objective programming technique. The two main seasons are rabi, which starts in November and can last until February or March, and kharif, which starts in July and seems to last until October and November. The following information is required for a specific crop, assuming it will be harvested: the quantity of land used for agriculture, the number of seeds used, the cost of fertilizers in agriculture, the cost of labour used in energy production, the cost of wildlife energy, unforeseen costs, the total capital price, and the return per unit of land. Objective functions and constraints are defined and resolved using readily available statistical data.

Step-1

Using linear programming techniques, each goal is calculated while keeping the constraints in view.

Step-2

For each objective function, the lower Z_p^l and upper bounds Z_p^u are determined. Let μ_p be a non-decreasing linear membership function between Z_p^l and Z_p^u, ∀q

$$\text{Where } \mu_p(x) = \begin{cases} 1, & if\ Z_p = Z_p^u \\ \dfrac{Z_p - Z_p^l}{Z_p^u - Z_p^l}, & if\ Z_p^l \le Z_p \le Z_p^u \\ 0, & if\ Z_p < Z_p^l \end{cases}$$

Step- 3

Now, with the linear programming model, convert the problem of multi-objective linear programming to

$$\mu_p(x) = \frac{Z_p - Z_p^l}{Z_p^u - Z_p^l} \geq \lambda, x \in X$$

$$Maxmize\ Z_p(x) = \sum_{j=1}^{n} c_{kl} x_j,\ 0 \leq \lambda \leq 1$$

$$ie.\ Z_p - \lambda\left(Z_p^u - Z_p^l\right) \geq Z_p^l$$

$$ie.\ \sum_{j=1}^{n} c_{pi} x_j - \left(Z_p^u - Z_p^l\right) \geq Z_p^l,\ \forall p, x \in X.$$

It is easily solved using the simplex method.

Crop Production Planning Problem

The goal of the problem is to maximize profit and productivity. In Tamil Nadu Thiruvarur district, the best agricultural output solution was found by progressively improving the computer approach. Farmers in this area plant paddy, ground nuts, green and black gram, and maize during the kharif season. Farmers in this area plant paddy, ground nuts, sesame, green and black gram, and maize during the Rabi. There are 253650 hectares of land available. The labour availability for the Kharif season is fixed at 280 man days and 280 man days for the Rabi season. For his yearly grain demands, a small farmer needs at least 25 kg of sesame, 180 kg of green gram, and 130 kg of black gram.

Season	Crop	Labor (Per hec.)	Production (kg/hec.)	Profit (Rs/hec.)
Kharif Season	Paddy ($x_{1,1}$)	155	5213	23458
	Green Gram ($x_{1,2}$)	75	1791	55521
	Black Gram ($x_{1,3}$)	80	666	25974
	Maize ($x_{1,4}$)	70	89	1335
	Groundnut ($x_{1,5}$)	95	1392	16704
Rabi Season	Paddy ($x_{2,1}$)	150	7438	81818
	Black Gram ($x_{2,2}$)	85	1395	47430
	Green Gram ($x_{2,3}$)	80	2391	74121
	Sesame ($x_{2,4}$)	60	190	17290
	Groundnut ($x_{2,5}$)	85	1697	15273
	Maize ($X_{2,6}$)	66	88	1320

The objective functions are:

Production

$$Maximize\ Z_1 = 5213\ x_{11} + 1791\ x_{12} + 666\ x_{13} + 89\ x_{14} + 1392\ x_{15} + 7438\ x_{21} + 1395\ x_{22} + 2391\ x_{23} + 190\ x_{24} + 1697\ x_{25} + 88\ x_{26}$$

Profit

$$Maximize\ Z_2 = 23458\ x_{11} + 55521\ x_{12} + 25974\ x_{13} + 1335\ x_{14} + 16704\ x_{15} + 81818\ x_{21} + 47430\ x_{22} + 74121\ x_{23} + 17290\ x_{24} + 15273\ x_{25} + 1320\ x_{26}$$

Subject to constraints:

Labour:

$$155\ x_{11} + 75\ x_{12} + 80\ x_{13} + 70\ x_{14} + 95\ x_{15} \leq 280$$

$$150\ x_{21} + 85\ x_{22} + 80\ x_{23} + 60\ x_{24} + 85\ x_{25} + 66\ x_{26} \leq 280$$

Land:

$$x_{11} + x_{12} + x_{13} + x_{14} + x_{15} \leq 253650$$

$$x_{21} + x_{22} + x_{23} + x_{24} + x_{25} + x_{26} \leq 253650$$

Food Requirements:

$1791\ x_{12} + 2391\ x_{23} \geq 180$

$190\ x_{24} \geq 25$

$666\ x_{13} + 1395\ x_{22} \geq 130$

Where all $x_{i,j} \geq 0, i = 1,2\ \&\ j = 1\ to\ 6$

Using the simplex method to solve this linear programming problem in LINGO 19.0 software

For objective functions,

Production $Z_1 = 22599$

$X^{(1)} =$

x_{11}	1.757821 he. (Paddy)
x_{12}	0.100503 he. (Green Gram)
x_{21}	1.761227 he.(Paddy)
x_{22}	0.931900 he. (Block Gram)
x_{24}	0.1315789 he. (Sesame)

These optimal solution values substituting in *Maximize* Z_2

$Maximize\ Z_2 = 23458\ (1.757821) + 55521\ (0.100503) + 25974\ (0) + 1335\ (0) + 16704\ (0)$
$+ 81818\ (1.761227) + 47430\ (0.931900) + 74121\ (0) + 17290\ (0.1315789) + 15273\ (0) + 1320\ (0)$

$Maximize\ Z_2 = 41234.965018 + 5580.027063 + 144100.070686 + 44200.017 + 2274.999181$

$Maximize\ Z_2 = 237390$

Profit $Z_2 = 458743$

$X^{(2)} =$

x_{12}	3.733333 he. (Green Gram)
x_{22}	0.931900 he. (Block Gram)
x_{23}	3.302301 he. (Green Gram)
x_{24}	0.1315789 he. (Sesame)

These optimal solution values substituting in *Maximize* Z_1

$Maximize\ Z_1 = 5213\ (0) + 1791\ (3.733333) + 666\ (0) + 89\ (0) + 1392\ (0) + 7438\ (0)$
$+ 1395\ (0.931900) + 2391\ (3.302301) + 190\ (0.1315789) + 1697\ (0) + 88\ (0)$

$Maximize\ Z_1 = 6686.399403 + 1300.0005 + 7895.801691 + 24.999991$

$Maximize\ Z_1 = 15907$

Positive solution for idleness:

	Z_1	Z_2
$X^{(1)}$	22599	237390
$X^{(2)}$	15907	458743

Lower and upper bounds are projected from the pay-off matrix as

$15907 \le Z_1 \le 22599$
$237390 \le Z_2 \le 458743$

Maximize is used to convert the above-mentioned multi-objective linear programming problem into linear programming.

$Maximize\ \mu$

Such that

Production:

$$5213\ x_{11} + 1791\ x_{12} + 666\ x_{13} + 89\ x_{14} + 1392\ x_{15} + 7438\ x_{21} + 1395\ x_{22} + 2391\ x_{23} + 190\ x_{24} + 1697\ x_{25} + 88\ x_{26} - 6692\ \mu \ge 15907$$

Profit:

$$23458\ x_{11} + 55521\ x_{12} + 25974\ x_{13} + 1335\ x_{14} + 16704\ x_{15} + 81818\ x_{21} + 47430\ x_{22} + 74121\ x_{23} + 17290\ x_{24} + 15273\ x_{25} + 1320\ x_{26} - 221353\ \mu \ge 237390$$

Labour:

$$155\ x_{11} + 75\ x_{12} + 80\ x_{13} + 70\ x_{14} + 95\ x_{15} \le 280$$
$$150\ x_{21} + 85\ x_{22} + 80\ x_{23} + 60\ x_{24} + 85\ x_{25} + 66\ x_{26} \le 280$$

Land:

$$x_{11} + x_{12} + x_{13} + x_{14} + x_{15} \le 253650$$
$$x_{21} + x_{22} + x_{23} + x_{24} + x_{25} + x_{26} \le 253650$$

Food Requirements:

$$1791\ x_{12} + 2391\ x_{23} \ge 180$$
$$190\ x_{24} \ge 25$$
$$666\ x_{13} + 1395\ x_{22} \ge 130$$

When the above mentioned linear programming problem is solved using LINGO 19.0 software.

The following is the optimal crop plan for the acreage of different crops (in hectares):

$x_{1,2}$	3.733333 he(Green Gram)
$x_{2,1}$	1.678827 he (Paddy)
$x_{2,2}$	0.931900 he (Black Gram)
$x_{2,3}$	0.154501 he (Green Gram)
$x_{2,4}$	0.131579 he (Sesame)

$\mu = 0.566486$

RESULTS AND DISCUSSION

The FMOLP can be solved by taking one objective at a time, as described in the algorithm, to provide the following solutions. Take one objective at a time and solve the FMOLP, identifying the upper and lower bounds for each one from the answers obtained. The tolerance levels for both the profit and cost objectives can be determined from these bounds. These values allow for the formulation of the crisp version of the fuzzy FMOLP, which can subsequently be solved using any technique for solving FMOLP models. Here's how a compromise solution was reached utilizing the fuzzy multi-objective linear programming method. The majority of farmers in the Thiruvarur District are from the semi-middle or middle classes. We draw firm conclusions based on a comparison of annual output figures for various crops throughout the Kharif and Rabi seasons. During the Kharif season, paddy and green gram production are at their maximum. The basic requirement is maize. During the Rabi season, overall maize and same productionis substantial in the Thiruvarur District, however; flax is in the lowest output category. According to the statistics, a farmer can make a maximum profit of Rs 4,58,743 based on the results. Similar to this, a farmer can achieve his goal of 22599 kg of maximum output by 11 organizing a course of action through various specific chores.

CONCLUSION

In this case, the decision maker can change the tolerance values assigned to the fuzzy constraints to suit their preferences. To get a better, more satisfying answer, this can be accomplished by focusing on the membership values of the fuzzy constraints and objectives. Since the solution in this particular case study results in zero value for the membership functions, it is crucial to take into account the production costs and the availability of water for agricultural activities in the Thiruvarur district of Tamilnadu during the Kharif and Rabi seasons. Therefore, Multi Objective Fuzzy Linear Programming is a better method for dealing with ambiguity while creating multiple goal plans. It provides a strong method for managing fuzzy parameter optimization issues. Since there is always a fuzzy environment when it comes to agricultural difficulties, MOFLP is a superior strategy to find a more effective solution. Also, it should be mentioned that a more practical solution can be achieved by altering the kind of membership function. Our findings may offer agricultural planners using FMOLP techniques a useful analytical tool to recommend to farmers how best to allocate crop acreage. The fuzzy notion has been successfully applied in decision-making to achieve the intended outcomes of profit and output quantity in the cropping pattern, with good investment value anticipated, by adjusting ambiguity components.

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RESEARCH ARTICLE

A Cross - Sectional Research on Women with Irregular Menstruation and Obesity in Assam, Northeast India

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ABSTRACT

Obesity has a strong correlation with menstrual irregularity. Women who are obese often experience oligomenorrhea, amenorrhea, or irregular periods. Moreover, it also increases the risk of developing gynecological diseases, including infertility and menstrual dysfunction. However, it is important to note that a variety of sex hormones also play a crucial role in these disorders. to examine the connection between irregularity of menstruation and obesity among the adult women of Assam. Between February 2022 and August 2022, 100 women, aged 18 to 42 years, who often attended an outpatient obesity clinic at Pratiksha Hospital in Guwahati were the subjects of a cross-sectional research. The women's current height (m) and weight (kg) were measured. These measures were used to compute the body mass index (BMI) and waist-to-hip ratio (WHR). Women's BMIs are used to calculate obesity. A digital sphygmomanometer was used to record the blood pressure. Patients were asked to document menstrual cycle aspects for three months. A range of biological indicators were also looked at. Out of 100 women, women with regular menstrual cycles are found to be 66 (66.00%), women with oligomenorrhea are found to be 22 (22.00%), and women with amenorrhea are found to be 12 (12.00%). The results found that 34 (34.00%) women have had menstrual irregularities. The average age of women with regular menstrual cycles (66), oligomenorrhea (22) and amenorrhea (12) is found to be (29.82±5.63), (28.86±5.87), and (30.08±5.81), respectively. The study shows an association of obesity with ologomenorrhea and amenorrhea.

Keywords: obesity, oligomeorrhea, amenorrhea, menstrual irregularity.

INTRODUCTION

Obesity has an adverse effect on public health and is becoming more common in both developed and developing nations [1-4]. In the modern world, obesity poses a greater hazard to public health than communicable illnesses [3-6]. The WHO reports that between 1980 and 2014, the prevalence of obesity more than quadrupled globally [7]. Studies on migration and comparisons between rural and urban areas show that industrialization has increased the incidence of obesity; in several countries, 50% of people are overweight or obese [8-12]. Obesity received little attention until recently in India, the most populous country, where undernutrition has been the main public health problem for the past few decades [1,13,14]. According to growing data, childhood and adult obesity rates are rising [5,15-18]. In addition to being linked to a number of non-communicable illnesses, such as diabetes, cancer, hypertension, and cardiovascular disorders, obesity is a major risk factor for mortality and disability worldwide [9-12,19-21]. Because of biological differences, females are more likely to be fat [22,23]. Obese women experience menstruation problems, PCOS and infertility [24-29]. Several studies have clearly shown that obese women with PCOS are more likely to experience irregular menstrual periods [26-31]. Although several sex hormones also play a significant part in these problems, obesity significantly raises the chance of developing gynecological diseases, such as menstrual dysfunction and infertility [32-35]. Gynecological issues encompass a broad spectrum of irregularities, such as irregular menstrual cycles, prolonged menstrual cycles, and blood loss throughout the menstrual cycle. Among obese women, irregular menstrual cycles are more common[34,36,37,38]. Additionally, a number of studies have shown a connection between women's menstrual cycle disruption and endometrial, breast, and cardiovascular cancers[28,39-42]. According to Tang *et al.*[43] (2020), women who are overweight have a much higher chance of having endometrial hyperplasia.

Abnormal menstrual periods are associated with obesity. A correlation exists between body mass index (BMI) and irregular menstrual cycles, as reported by Wei *et al.*[44]. According to Wei *et al.*[44], oligomenorrhea and irregular menstruation are more common in people with BMIs over 25 kg/m2. According to a number of studies [28,29,38,45-47], obese women experience a larger percentage of abnormal menstrual cycles than the general population. Weight loss improves women's cycles. Obesity and menstruation are fundamentally related because fat cells contain cholesterol molecules that can be converted into "estrone", a weak form of estrogen. Women carrying additional fat cells have "little estrogen-making factories", which have an estrogenic influence on their glands. The excess estrogen may lead to irregular periods or bleeding[34,48]. Therefore, we examined the relationship between obesity levels and abnormal menstrual cycle length in a group of obese women, as well as the incidence of amenorrhea and oligomenorrhea, as a means of understanding the impact of obesity on reproduction.

MATERIALS AND METHODS

We conducted a cross-sectional study between February and August 2022, involving 100 women from the age range of 18 to 42 years who attended an obesity clinic at Pratiksha Hospital in Guwahati. Women with PCOS on ultrasonography and those who claimed to be pregnant or to have experienced menstrual problems in the past were not included. We measured the subjects' current body weight (kg), height (cm). The narrowest point above the hip served as the measurement point for the waist, while the highest point of the gluteus protuberance served as the measurement point for the hip. Waist-to-hip ratio (WHR) and body mass index (BMI) was calculated from these measurements. Obesity is calculated through the BMI of the women. Blood pressure was recorded by using a digital sphygmomanometer.

For three months, women recorded the length of their menstrual cycles. Women were diagnosed with oligomenorrhea if their periods lasted between 36 and 90 days, amenorrhea if they hadn't had one in more than 90 days, and normal if their cycles lasted between 25 and 35 days. Among the biochemical indicators analyzed were biological parameters such as serum insulin, total cholesterol, triacylglycerol, high-density lipoprotein cholesterol, low-density lipoprotein, and total cholesterol.

Statistical analysis

The Statistical Package for Social Sciences (Version 16.0) was used to analyze the data after they were imported into Microsoft Excel. Means and standard deviations were used to express continuous variables, and percentages were used to express categorical variables. Comparing anthropometric traits and biological markers between women with regular menstrual periods, oligomenorrhea and amenorrhea was done using analysis of variance. Spearman correlation coefficient was applied to see the strength of correlation of obesity with menstrual irregularities based on age and the anthropometric parameters. A p-value (<0.05) was considered to be statistically significant.

RESULTS

Table I displays the anthropometric characteristics of obese women with and without regular menstrual periods. Of 100 women, 66 (66.00%) had normal menstrual cycles, 22 (22.00%) had oligomenorrhea, and 12 (12.00%) had amenorrhea. According to the findings, 34 women (34.0%) had irregular menstruation. The mean age of women who have oligomenorrhea (age 22), amenorrhoea (12), and normal menstrual cycle (age 66) is (29.82±5.63), (28.86±5.87), and (30.08±5.81) years, respectively. Women with oligomenorrhea (79.84±6.60) (kg), normal menstrual cycle (76.15±7.19) (kg), and amenorrhoea (80.83±8.86) (kg) had higher average weights (kg). Similarly, women with amenorrhoea (92.88±6.84) (cm), oligomenorrhea (88.81±6.02) (cm), and normal menstrual cycles (80.65±4.62) (cm) had the largest average waist circumference (WC). The same is true for hip circumference (cm), where women with normal menstrual cycles (91.54±4.94) (cm), oligomenorrhea (94.42±8.37) (cm), and amenorrhoea (98.58±9.95) (cm) had the greatest average HC. Women who experienced irregular menstruation, such as oligomenorrhea (33.69±1.32) and amenorrhoea (34.92±1.32), had higher body mass indices (BMIs). The waist-hip ratio (WHR) is estimated to be 0.88±0.03 (kg/m2) in women with regular menstrual cycles and higher in those with oligomenorrhea (0.89±0.06) and amenorrhoea (0.89±0.07). Women with amenorrhoea had the greatest diastolic blood pressure (mm/hg) (87.58±15.58) (mm/hg), whereas women with regular menstrual cycles have normal systolic blood pressure (mm/hg) (120.39±11.69) (mm/hg). The overall blood pressure of women with regular menstrual cycles was 120.39±11.69/84.69±8.93 (mm/hg), which is considered normal. The age of menarche, measured in years, is highest in women with normal menstrual cycles (12.59±1.21), lowest in amenorrhoea (11.58±1.38), and lowest in oligomenorrhea (12.27±1.42) (years). No discernible differences are observed in age, blood pressure, or BMI. Additionally, the results based on age at menarche, weight (kg), WC, HC, and WHR indicated statistically significant outcomes.

According to Table II, women with regular or irregular menstrual periods and obesity are associated with different biochemical indicators. Therefore, oligomenorrhea (101.41±21.09) (mg/dL) and amenorrhoea (104.67±18.33) (mg/dL) were associated with greater levels of glucose intolerance in women with irregular menstruation. When comparing women with normal menstrual cycles (118.21±20.04) to those with oligomenorrhea (124.42±32.07) (mg/dL), it was shown that triglycerides were considerably greater in women with amenorrhoea (135.75±36.17) (mg/dL). Women with irregular menstrual cycles had higher basal insulin concentrations. This is particularly true for those with amenorrhoea (22.06±10.86) (μU/dL), oligomenorrhea (17.10±8.97) (μU/dL), and normal menstrual periods (14.69±6.43) (μU/dL). There was no difference in HDL, LDL, or total cholesterol levels according to menstrual irregularity. Triglycerides, basal insulin levels, and glucose intolerance all exhibit statistically significant results. Table III examined the degree to which menstrual abnormalities and obesity are correlated. The results indicated a direct relationship between WHR and amenorrhoea (*rho*=0.04950) and oligomenorrhea (*rho*=0.04939). Additionally, there is a strong positive link between blood pressure and irregular menstruation, such as amenorrhoea and oligomenorrhea.

DISCUSSION

According to research, irregular menstruation is highly correlated with obesity. More specifically, class 2 obese women (BMI 30.0-39.9 kg/m2) are more likely to experience oligomenorrhea and amenorrhea. A study conducted by Souza et al. [49] assessed fifty-seven women who had class III obesity, or morbid obesity (≥40 kg/m2). This type of obesity can lead to menstrual dysfunctions such as amenorrhea or oligomenorrhea [26-29,38,47]. WHR and BMI are

anthropometric assessments that indicate how much body fat a person has. WHR is more suggestive of abdominal fat deposition, which has been linked to diabetes mellitus and hypertension and is more hazardous; an increase in these parameters is a sign of obesity [50-52]. Numerous factors, including hormone flux, underlying medical conditions, and body mass as determined by weight and BMI, have been found to affect menstrual irregularity and flow[50,53-55]. A disrupted hormonal balance may cause aberrant menstrual patterns, which in turn may mediate the risk of hypertension[56,57]. Since androgens can raise blood pressure and help with the etiology of hypertension, they can both help prevent cardiovascular diseases (CVDs) such as hypertension by acting as vasodilators [56-60]. Furthermore, some well-established risk factors for irregular menstruation—such as age, smoking, stress, weight, family history, and pregnancy history—also increase the likelihood that obese women may develop hypertension [61-64]. Additionally, the incidence of hypertension in obese women with and without irregular menstruation was demonstrated in the current study.

A comparison of biochemical markers between obese women with normal menstrual cycles, oligomenorrhea, and amenorrhea is presented in Table II. Obesity is closely linked to menstrual abnormalities and unfavorable hormonal profiles[49,56,57,65]. Research has demonstrated that women with oligomenorrhea or amenorrhoea had much higher blood glucose concentrations; these findings are supported by studies conducted by Shen *et al.*[66]and Klein *et al.*[67]. Results showed that blood glucose levels were associated with irregular menstrual periods and obesity. This finding led us to speculate—a theory previously advanced by others—that obesity, while not the cause of PCOS, may facilitate its phenotypic manifestation in women who are predisposed to the illness by resulting in insulin resistance and hyperinsulinemia[44,68,69,70,71]. In our investigation, women with oligomenorrhea and amenorrhoea had higher insulin levels than women with normal menstrual cycles, a finding previously observed in studies by Shim *et al.*[68], Ko*et al.*[69], Itriyeva[70], and Jalil*et al.*[71]. As a result of hyperinsulinemia, increased androgen synthesis may negatively impact the menstrual cycle and decrease the likelihood of conception[27,72-76]. In the current study, reproductive rates decreased when fat levels rose in response to an increase in insulin disruption. Additionally, Seif*et al.*[77] found that insulin and androgens affect steroid levels in the ovarian stroma, contributing to issues with ovulation and unpredictable menstruation. Moreover, hyperinsulinemia and high lipid levels prevent the production of LH and FSH, which alter menstrual periods [74,78-80].Additionally, the current study demonstrated a favorable relationship between oligomenorrhea and amenorrhoea and blood pressure, weight, and WHR (Table 3). Sheela *et al.*[81]discovered that oligomenorrhea is most commonly associated with a BMI over 25 and that greater obesity grades increase the risk of irregular periods. Additionally, a positive correlation between the menstrual profile and BMI was found[50,82-84]. Oligomenorrhea and other menstrualabnormalities are common in obese women. Similar to the current study, a study Mustaqeem*et al.*[36]found that irregular menstrual periods were experienced by 64.44% of individuals with increased WHR.

CONCLUSION

This study advances our knowledge of the relationship between obesity and menstrual problems in women. Retaining a healthy weight helps reduce the likelihood of irregular menstruation and the gynecologic issues associated with obesity.

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Table 1. Anthropometric characteristics of obese women with and without regular menstrual cycles.

Variables	Regular Menstrual Cycle (n=66)	Oligomenorrhea (n=22)	Amennorrhea (12)	p* value (Analysis of variance)
Age (years)	29.82±5.63	28.86±5.87	30.08±5.81	0.76850
Height (cm)	154.66±6.45	153.84±5.91	152.06±6.70	0.00004
Weight (kg)	76.15±7.19	79.84±6.60	80.83±8.86	0.03421
BMI (kg/m^2)	31.77±1.50	33.69±1.32	34.92±1.32	0.42630
Waist circumference (cm)	80.65±4.62	88.81±6.02	92.88±6.84	< 0.00001
Hip circumference (cm)	91.54±4.94	94.42±8.37	98.58±9.95	0.00285
Waist Hip Ratio (kg/m^2)	0.88±0.03	0.89±0.06	0.89±0.07	0.55703
Blood Pressure Diastolic (mm Hg)	84.69±8.93	82.05±10.24	87.58±15.58	0.31999
Blood Pressure Systolic (mm Hg)	120.39±11.69	117.59±15.83	119.08±18.52	0.70738
Age at Menarche (Years)	12.59±1.21	12.27±1.42	11.58±1.38	0.00452

Table 2. Biochemical markers of obese women with and without regular menstrual cycles

Variables	Regular Menstrual Cycle (n=66)	Oligomenorrhea (n=22)	Amennorrhea (12)	*p* value (Analysis of variance)
Glucose (mg/dL)	91.53±17.40	101.41±21.09	104.67±18.33	0.02236
Triglycerides (mg/dL)	118.21±20.04	124.42±32.07	135.75±36.17	0.04609
HDL Cholesterol (mg/dL)	54.14±8.84	50.55±10.29	55.08±12.24	0.27761
LDL Cholesterol (mg/dL)	120.42±4.94	117.73±20.94	124.83±28.40	0.65130
Total Cholesterol (mg/dL)	180.92±22.06	178.95±23.93	182.58±33.12	0.90983
Insulin (µU/dL)	14.69±6.43	17.10±8.97	22.06±10.86	0.01073

Table 3. Spearman correlation coefficient of obesity with menstrual irregularities.

Variables	Oligomenorrhea (22)		Amenorrhea (12)	
	R-value	**p-value**	**R-value**	**p-value**
Weight (kg)	0.67988	0.00050	0.83363	0.00075
Waist circumference(cm)	0.06563	0.77168	0.75657	0.00440
Hip circumference(cm)	0.04980	0.82580	0.75657	0.00440
WHR	0.42374	0.04939	0.57701	0.04950
Diastolic BP (mm of Hg)	0.06423	0.77642	0.74211	0.00572
Systolic BP (mm of Hg)	0.08871	0.69462	0.77193	0.00327

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RESEARCH ARTICLE

Randomized Controlled Clinical Trial of *Triphala* based Compound on Childhood Overweight and Obesity – A Study Protocol

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ABSTRACT

Obesity implies excessive fat and not merely excess body weight. Can be corelated to *Sthoulya* in Ayurveda, which is characterised by excess accumulation of *Medas* (adipose tissue) and is described under two domains like a disorder due to excess accumulation of *Kapha* which is a body humor and due to over nourishment. In children the major symptoms that affect their health are excessive sleep, lethargy and excessive hunger. *Ayurveda* has options to correct the metabolism for *Sthoulya*. *Triphala Churna* (combination of three herbs) is a widely available formulation indicated for *Sthoulya.* This study investigates the efficacy of Ayurveda interventions, specifically *Triphala churna* and *Bhavitha triphala churna (*processed *triphala churna)* in Childhood overweight and Obesity. 40 subjects, of 10-16 years with overweight and Class I obesity according criteria of WHO, of either gender, with no other systemic illness will be randomized into two groups. The intervention is two arm where *Triphala* powder will be administered as processed and plain, i.e., trial and standard groups. The primary outcome measure will be the comparative efficacy of the trial and standard drugs in the objective parameters like weight, and subjective parameters like hunger, on 14th, 24th, 48th and 56th days of study. The secondary outcome will be the comparison of the efficacies on the lipid parameters on 0th and 46th day. Trial Registration (CTRI 2023/07/055149), prospectively registered on July 12th, 2023. Childhood overweight and obesity, has the potential to lead to many secondary diseases in adulthood. Ayurveda classifies this condition as *Sthoulya* and focuses on metabolism correction. This study aims to describe potential role of Ayurveda in correction of childhood obesity or overweight. The reduction in the subjective and objective parameters is expected from this study on 48th day.

Keywords: Ayurveda, Childhood Overweight and Obesity, *Triphala*

INTRODUCTION

Sthoulya is a condition described under *Shleshmananatmajavyadhi,* [1] *Santarpananimittaja vyadhi* [2] (condition as a consequence of caused due to over nourishment) and *Atibrimhana Nimittaja vyadhi* (condition caused as consequence of over excess nutrition) [3]. It is described as *Upachita Shareeratva* (condition where in there is appearance of large or big body parts) [4] and is characterized by excess accumulation of *Medas.* There are many *lakshana* (symptoms) of *Sthoulya* [5] *as* mentioned in Ayurveda , of which a few symptoms that are commonly found in children are *Atinidra* (excess sleep) , *Alasya* (lethargy), *AyaseShwasa* (difficulty in breathing) and *Atikshudha* (excess hunger). The clinical symptomatology of *Sthoulya* is similar to that of Overweight and Obesity in contemporary science, which has been defined as, a body mass index of 23kg/m^2 and 27kg/m^{2}respectively. (Indian cutoffs after 2 years of age, which is between 85th to 95thpercentile) [6]. Enlargement of fat cell in its size; or an increase in number of fat cells; or both, leads to abnormal growth of adipose tissue which is known as obesity. In such condition, body fat is extensively accumulated under the skin and around certain organs such as belly, breasts, thighs [7].

According to a study in 2021, the prevalence of overweight and obesity among school children in Mysuru, Karnataka showed that there was 3.86% of obesity and 12.27%of overweight [8]. A recent study conducted 2021, in school children of Mysuru, Karnataka revealed significant differences in variables such as body weight and BMI, before and after lockdown. Post lockdown the BMI increased among all the participants from 17.32 to 17.80 kg/m^2 ($p<0.001$). The study also depicted that obesity has a proportional impact on the children's quality of life (QOL) [9]. In a recent study done in Rishikesh, Uttarakhand, in the year 2021, it was found that 6.8% of adolescents were obese and that about 17.1% were overweight [10] These studies give enough proof for the prevalence of overweight and obesity among children even in adolescent age group. Some of the common complications of childhood obesity, if left unattended are Obstructive sleep apnea, Asthma, Acanthosis nigricans, Polycystic ovarian syndrome and Psychological problems like Anxiety, Low self-esteem and Worsening school performance [11]. Contemporary science has a multidisciplinary approach in the management of obesity, like lifestyle modification, regular meal timings and at least 7-8 hours of sleep at night [12].

Ayurveda also describes multi model therapy including diet, medicine and life style modifications for *Sthoulya*. Some of the *internal medications* indicated for *Sthoulya* are having *Acacia catechu* Willd, *Terminalia chebula* Retz, *Emblica officinalis* Gaertn as their ingredients [14]. Usage of *Triphala* and *Madhu* have been specifically mentioned in *Sthoulya Chikitsa.* [14] *Triphala* triturated in the *Kwatha* (aqueous extraction) of *Khadira* and *Asana,* consumed for 1 month reduces *Sthoulya.* It has been specifically mentioned for children [15].

MATERIALS AND METHODS

Patients, of both genders, will be selected from the pediatric OPD and IPD of department of *pediatrics* JSS Ayurveda Medical Hospital, Mysuru, special health camps and other referrals. The study will include children fulfilling the inclusion criteria (Table no:1). The study was given the ethical clearance from the Institute of Ethics Committee (IEC)-JSSAMC/1198/2022-2023.

The collected data presented in the form of tables will be considered for drawing conclusion of the study.

Primary objectives
To compare the efficacy of the trial drug with that of standard drug on the subjective.

Secondary Objectives:
To compare the efficacy of trial and standard drugs on Lipid parameters.

Sample calculation: as it is a PG dissertation work the sample size of 40 was planned.

GROUPING: Grouping of the subjects: 2 groups containing 20 subjects each.

The patients will be mainly diagnosed on the BMI cut-offs as per the IAP (Table no: 2). An elaborate proforma will be filled containing clinical history as well as complete general and physical examination of the patients.

Investigations: Lipid profile will be conducted in every patient. Before and after the treatment.

Drugs: Ingredients of *Bhavitha Triphala churna* are depicted in (table no: 3)

Method of preparation of *Bhavitha Triphala Churna (trial drug)* and *Triphala Churna (Standard drug)*
The drugs of the trial intervention were procured from the NKCA pharmacy, Mysuru. The three herbs *Triphala (Hareetaki, Vibhitaki* and *Amalaki)* were taken in an equal ration (1:1:1). The decoction of Khadira sara and Asana were prepared and the powder of *Triphala* was soaked in the prepared decoction in the night for 7-8 hours and dried the next day, repeating this process consecutively for 7 days. Then the trial drug was packed in the air tight containers.
The standard drug was prepared by mixing the herbal powders in the equal ration (1:1:1) and mixed in airtight containers.

Source of drug: from NKCA pharmacy, Mysuru
Intervention: is depicted in table no:4
All the patients will be followed up after 1 month of completion of the study.

Criteria for assessment: the results of the medicine will be assessed on the basis of clinical signs and symptoms mentioned in *Ayurveda* classics. Functional capacity will also be assessed and laboratory investigations will be repeated at the end of the treatment schedule. All the signs and symptoms will be given scoring pattern depending upon severity as below.

Subjective parameters
Gatra Dourgandhya, Alasya, Ayaseshwasa, Svedadhikya, Atipipasa, Atikshudha, Nidradhikya. Will be assessed on 0th day, 14th day, 28th day and 46th day and after one month of the completion of the study for all the subjects.

Objective parameters
Anthropometry (BMI, Weight, Skin fold thickness, Mid upper arm circumference, Abdominal circumference) was assessed on the same time as subjective parameters assessment.
Lipid profile will be conducted before and after the treatment i.e., on the 0th day and 46th day for all the subjects.

Statistical analysis: Paired 't' Test, Unpaired 't' Test, Wilcoxon Sign Rank Test and Man Whitney U Test are the statistical tests that are utilized.

Results: results will be collected and analysed based on the changes in subjective and objective parameters before and after the intervention.

DISCUSSION

Childhood obesity can be due to either constitutional factors (due to the environmental factors like genetically modified food, increased estrogen content in the food articles) or due to the pathology of some other systemic condition like obesity due to endocrine cause like Cushing Syndrome, GH deficiency or due to genetic syndromes like Prader Willi, Carpenter syndromes etc. The pathological cause of obesity is only seen in <1% of childhood obesity cases.
Status of Childhood Obesity: prevalence of childhood obesity in India is 8.4%, while the prevalence of childhood overweight is 12.4%. [21]

Status of therapy for obesity: According to contemporary science the recommended drugs are Metformin (approved in Type 2 DM) after 8 years of age and Oralistat (Gastric lipase inhibitor that decreases fat absorption), approved after 12 years of age.
Certain measures that include Regular meals, including breakfast, 45 minutes of regular moderate to vigorous physical activity and screen time below 1 hour daily, Avoidance of snacking, inactivity, and screen exposure while eating, avoid rigorous dieting. [6]

According to the ayurveda the condition is caused as the result of the excess accumulation of *Medas* (adipose tissue) in the body, hence the protocol is developed for reducing the *Medas* that include internal medications that have the ingredients like *Acacia catechu,* Willd., *Terminalia chebula* Retz., *Terminalia belerica* Roxb. that have the antihyperglycemic, anti-inflammatory, anti-hyperlipidemic actions.

Role of *Triphala* in obesity: *Triphala*, an Ayurveda's polyherbal formulation, has shown promising pharmacological actions in managing obesity. Research has highlighted *Triphala's* potential to reduce weight, body fat, and circumferential measures. Additionally, its prebiotic effects on gut microbiota promote the growth of beneficial bacteria while inhibiting pathogenic species.[22] Furthermore, *Triphala* has also exhibited anti-obesity effects by lowering inflammation and oxidative stress, reducing adipocyte size, modulating gene expression related to lipid metabolism, and restoring monoamine levels [23] Moreover, incorporating in obesity treatment has shown significant reductions has also led to improvements in insulin levels, lipid profiles, and anti-oxidant status.[24] The components of the formulation exhibit antihyperlipidemic, antihyperglycemic, and anti-oxidant properties, which help disrupt the pathogenesis of obesity and lessen the burden of related diseases.[25]
In view of the Drop outs or any withdrawal subjects, enrollment of additional 5 subjects were planned for each group.

EXPECTED RESULTS

The change in the subjective parameters like difficulty in breathing, excessive sleep, lethargy is expected and objective parameter like weight and lipid parameters like Triglycerides and Total Cholestrol is expected. As per the previous research data, there are no any serious adverse reactions was reported. Hence, in this study Adverse reaction of the medications is not expected.

CONCLUSION

Childhood overweight and obesity can lead to many complicated conditions in the adulthood like PCOD, Obstructive Sleep Apnea, reduced energy levels. The obese children are more likely to be obese even in their adulthood because of the pathogenesis inducing gut microbiota. *Triphala* provides good gut microbiota that is efficient in correction of the metabolism and also stops the growth of the harmful bacteria. This study will be conducted in 40 subjects, with the 2 groups, making 20 subjects in each group. Calculating the medication dose according to the age of the subject, the standard and trial drugs will be administered twice a day before food for a period of 6 weeks.

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Table No: 1 Inclusion Exclusion Criteria

Inclusion criteria	Exclusion criteria
1. Subjects from 10-16 years	1. known case of endocrine disorders like hypothyroidism and cushings syndrome.
2. Subjects of either gender	2. Drug induced obesity
3. Obesity caused due to exogenous factors like over-eating, poor health	3. Systemic disorders like Juvenile Diabetes Mellitus 4. Syndromes like Cushing's, Prader willi
4. Bmi of 23kg/$m^2$and 27 kg/m^2 (body weight between 85th – 95th percentile)	
5. Having symptoms mentioned in *Brihat trayee (Charaka Samhitha, Ashtanga Hridaya)*	
6. Parents and subjects ready to sign consent and assent forms respectively	

Table 2: Depicting BMI extension for study

BMI levels	Grading
BMI* of 85th (23kg/m^2)	Overweight
BMI of 95th (27kg/m^2)	Obesity

Table 3: Depicting the Ingredients of trial and standard drugs:

a. Trial drug ingredients

Sl.no	Ingredients /phytochemicals and its action	Botanical name / toxicity studies
1.	*Asana* phytoconstituents (including pterosupin, pterostilbene, liquirtigenin, isoliquiritigenin, epicatechin, kinoin, kinotannic acid, kino-red beta-eudesmol, carsupin, marsupol, marsupinol) which have anti-inflammatory and anti-hyperlipidemic actions [16]	*Pterocarpus marsupium*Roxb.
2.	*Khadira* Which have the phytoconstituents like (protocatechuic acid, taxifolin, epicatechin, epigallocatechin, catechin, epicatechin gallate, procyanidin, phloroglucin, aldobiuronic acid, gallic acid, D-galactose, afzelchin gum, L-arabinose, D-rhamnose, and quercetin) that have antihyperlipidemic, anti-inflammatory, anti-oxidant actions [17]	*Acacia catechu* Willd.
	Hareetaki contain (chebulic acid, chebulinic acid, and chebulaginic acid) that have anti-inflammatory, anti-diabetic and anti-oxidant actions [18]	*Terminalia chebula* Retz.
4.	*Vibhitaki* contains (ethanolic extract) that has hepatoprotective activity, anti-inflammatory, anti-diabetic and anti-oxidant actions [19]	*Terminalia belerica* Roxb.
5.	*Amalaka* contain phytoconstituents like (quercetin and flavonoids (phyllantine, phyllantidine), gallic acid, ascorbic acid and hydrolyzable tannins (emblicanin A and B) that have anti-oxidant, anti-inflammatory actions. [20]	*Emblica officinalis* Gaertn.

b)Ingredients of standard drug:

Sl.no	Drug	Botanical Name
1.	Hareetaki	*Terminalia chebula* Retz.
2.	Vibhitaki	*Terminalia belerica* Roxb.
3.	Amalaki	*Emblica officinalis* Gaertn.

* Phytoconstituents are not mentioned in the standard drug table since they are already mentioned in the trial drug table. Because the standard drug contains 3 ingredients of the trial drug.

Table no: 4 Intervention given to two groups

Drug	*Group A*	*Group B*
Route of administration	Oral	Oral
Duration	6 weeks	6 weeks
Aushadha sevana kala	Twice a day before food	Twice a day before food
Dosage	3-6 gm	3-6 gm
Anupana	*Madhu*	*Madhu*

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RESEARCH ARTICLE

New Perceptions on Soft Locally Closed Sets in Soft Topological Spaces

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ABSTRACT

The article presents a detailed exploration of a novel form of closed sets and its corresponding continuous maps, defined over soft J^Cclosed sets in soft topological spaces. The study compares these sets with soft closed sets and soft J^Cclosed sets, analysing their properties in great depth. Additionally, the article introduces the concept of soft locally J^Ccontinuous maps and compares them with other types of continuous maps, providing a thorough understanding of their properties and behaviour. The study also investigates the nature and behaviour of these maps in various contexts and delves into some characteristics and properties of these concepts. The article provides a comprehensive analysis of these novel concepts and their implications in soft topology.

Keywords: Soft mapping, Soft locally J^Cclosed set, Soft locally J^Cclosed* set, Soft locally J^Cclosed** set, Soft locally J^Ccontinuous map.

AMS Classification: 54A40, 03E72, 54D05, 54C05, 54C10

INTRODUCTION

The field of Soft Set has made significant progress since its inception in 1999.Initially, proposed by Molodtov D[9] to address uncertainty in a parametric way, researchers have contributed to this field with their findings and discoveries, resulting in numerous developments in the subject. In 2002, P. K. Maji et al.[7] introduced several basic terms on Soft Sets. Subsequently, N. Cagman et al.[3] initiated a Soft Topology on Soft Set, defining a soft topological space, followed by Shabir M and Naz M[10], who proposed fundamental definitions in soft topological space. Other researchers have introduced new concepts such as soft mappings by P. Majumdar and S. K. Samanta[8] and soft continuous mapping by Aras and Sonmez[2]. Ali. H. Kocaman and N. Tozlu[1] proposed soft locally closed sets and decomposition of soft continuity in 2015. In previous studies, the concept of soft J^Cclosed set and the soft J^Copen set[6] was introduced. This study introduces a new form of closed setsand its continuous maps known as the soft locally J^Cclosed set and soft locally J^Ccontinuous map are introduced. These sets are defined over soft J^Cclosed sets in soft topological spaces. The study compares these sets with soft closed sets and soft J^Cclosed sets and delves into their properties in great detail. One of the major focuses of the study is on the properties of the union, intersection, and complement of soft locally J^Cclosed sets, soft locally J^Cclosed* sets, and soft locally J^Cclosed** sets. The article investigates these properties in depth,providing a thorough analysis of their characteristics and behaviors. Furthermore, the article introduces the notion of soft locally J^Ccontinuous maps, comparing them with soft continuousand soft J^Ccontinuous maps. The study investigates the properties of these maps in detail, exploring their relationship with other types of continuous maps and their behavior in various contexts. This study represents a significant contribution to the field of Soft Set and provides valuable insights into the properties and behaviour of various sets and maps. We representsoft topology as ST space throughout this article.

PRELIMINARIES

Definition 2.1[9] A **S-set** M_A on the universe G is defined by the set of ordered pairs $M_A = \{(g, m_a(g)): g \in E \text{ and } m_a(x) \in P(G)\}$, where $m_a: A \to P(G)$ such that $m_a(g) = \phi$ for all $g \notin A$. Hence m_a is called an approximate function of the S-set M_A. The value of m_a may be arbitrary, some of them may be empty, some may have non empty intersection.

Definition 2.2[3] Consider r be a collection of S-sets over G with a fixed set E of parameters.Then, r is called a ST on G if

1. $\tilde{\phi}\ \tilde{G} \in r$.
2. The union of any number of S-sets in r belongs to r.
3. The intersection of any two S-sets in r belongs to r.

The triplet (G, r_E) is called **ST space** over G. The members of r are called **S-open** sets in G and complements of them are called **S-closed** sets in G.

Definition 2.3[8] Consider $SS(G)_E$ and $SS(H)_K$ be families of s-sets, $u: G \to H$ and $v: E \to K$. Then the mapping $m_{uv}: SS(G)_E \to SS(H)_K$ is described as

1. Let $(A_E) \in SS(G)_E$. Then $m_{uv}(A_E) = (m(A), v(E))$ is a s-set in $SS(H_K)$ such that $\bigcup_{x \in v^{-1}(y) \cap P} u(A(x))$, $v^{-1}(y) \cap P \neq \phi\ m_{uv}(A)(y) = \{\ \phi,$ otherwise

2. Let $(B_K) \in SS(Y)_K$. Then $m^{-1}(B_K) = (m^{-1}(B), v^{-1}(K))$ is a s-set in $SS(G)_E$ such that

$$m_{uv}^{-1}(B)(x) = \begin{cases} u^{-1}\left(B(v(x))\right), v(x) \in K \\ \phi, \text{ otherwise} \end{cases}.$$

Definition 2.4[1] A **S-locally closed set** is a s- subset (A_E) of a ST space (G, r_E) if $(X_E) = (Y_E) \tilde{\cap} (Z_E)$ where (Y_E) is a s-open set and (Z_E) is a s-closed set in $\tilde{G}$

Definition 2.5[6] A **S-J^cclosed set** is s-subset (Y_E) of a s ST space (G, r_E) if $Scl^*(Y_E) \tilde{\subseteq} U_E)$ when-ever $(Y_E) \tilde{\subseteq} U_E)$ and (U_E) is s-semi*open set. $SJ^cC(G)$ represents the collection of all S-J^cclosed sets.

Definition 2.6[6]: A **S-J^copen set** is a s- subset (Y_E) of a ST space (G, r_E) if it's complement is S-J^cclosed set and noted by $SJ^cO(G)$.

Definition 2.7 A mapping $m_{uv}: SS(G)_E \to SS(H)_K$ is said to be

1. **S-continuous [2]** if $m^{-1}(B_K)$ is s-open set in (G, r_E) for each one of the s-open set (B_K) in (H, σ_K).
2. **S-locally continuous[1]** if $m^{-1}(B_K)$ is s-locally closed set in $\tilde{G}$ for each one of the s- open set (B_K) in $\tilde{H}$
3. **S-J^ccontinuous[6]** if $m^{-1}(X_K)$ is S-J^cclosed set in (G, r_E) for each one of thes-closed set (X_K) in (H, σ_K).

S-LOCALLY J^cCLOSED SET

Definition 3.1: Consider $(A_E) \tilde{\subseteq} (G, r_E)$. (A_E) is known as **S-locally J^cclosed set** if $(A_E) = (D_E) \tilde{\cap} (F_E)$ where (D_E) is a S-J^copen set and (F_E) is a S-J^cclosed set in $\tilde{G}$ It is indicated by $SJ^cLC(G, r_E)$.

Definition 3.2: Consider $(B_E) \tilde{\subseteq} (G, r_E)$. (B_E) is known as **S-locally J^cclosed* set** if $(B_E) = (X_E) \tilde{\cap} (Y_E)$ where (X_E) is a s-J^copen set and (Y_E) is a s-closed set in $\tilde{G}$ It is indicated by $SJ^cLC^*(G, r_E)$.

Definition 3.3: Consider $(V_E) \tilde{\subseteq} (G, r_E)$. (V_E) is known as **S-locally J^cclosed** set** if $(V_E) = (H_E) \tilde{\cap} (I_E)$ where (H_E) is a s-open set and (I_E) is a S-J^cclosed set in $\tilde{G}$ It is indicated by $SJ^cLC^{**}(G, r_E)$.

Example 3.4: Consider $G = \{\alpha, \beta\}$, $E = \{e_1, e_2\}$, $r = \{\tilde{G}\tilde{\phi}Q_{E1}, Q_{E2}, Q_{E3}, Q_{E4}, Q_{E5}, Q_{E6}, Q_{E7}, Q_{E8}\}$ where $Q_1(e_1) = \{\alpha\}, Q_1(e_2) = \tilde{\phi}$ $Q_2(e_1) = \{\beta\}$, $Q_2(e_2) = \tilde{\phi}$ $Q_3(e_1) = \{\alpha, \beta\}, Q3(e2) = \tilde{\phi}$, $Q4(e1) = \{\alpha\}, Q4(e2) = \{\alpha\}$, $Q5(e1) = \{\alpha\}, Q5(e2) = \{\beta\}$, $Q6(e1) = \{\beta\}$, $Q_6(e_2) = \{\alpha\}$, $Q_7(e_1) = \{\alpha, \beta\}$, $Q_7(e_2) = \{\alpha\}$, $Q_8(e_1) = \{\alpha, \beta\}$, $Q_8(e_2) = \{\beta\}$. A s-subset (U_E)={$(e_1, \beta), (e_2, \alpha)$} is S-locally J^cclosed set, (V_E)={$(e_1, \alpha), (e_2, \alpha)$} is s-locally JCclosed* set and $(WE) = \{(e1, \beta), (e2, \tilde{\phi})\}$ is S-locally JC closed** set.

Theorem 3.5

1. All s-open set and s-closed set in (G, r_E) are S-locally J^cclosed set.
2. All s-locally closed set is S-locally J^cclosed, S-locally J^cclosed*, S-locally J^cclosed**.

Proof: The evidence is clearly visible.

Theorem 3.6: If (G, rE) is a ST space and

1. $(X_E)\tilde{\in}J^cC(G, r_E) \Longrightarrow (X_E)\tilde{\in}J^cLC(G, r_E)$
2. $(X_E)\tilde{\in}J^cO(G, r_E) \Longrightarrow (X_E)\tilde{\in}J^cLC(G, r_E)$
3. $(X_E)\tilde{\in}J^cLC^*(G, r_E) \Longrightarrow (X_E)\tilde{\in}J^cLC(G, r_E)$
4. $(X_E)\tilde{\in}J^cLC^{**}(G, r_E) \Longrightarrow (X_E)\tilde{\in}J^cLC(G, r_E)$

Proof

The proof of (1) and (2) is conspicuous.

1. Consider (X_E) is a S-locally J^cclosed* in (G, r_E), since all s-closed sets are S- J^cclosed set. Therefore, $(X_E) = (\beta_E)\tilde{\cap}(\delta_E)$ where (β_E) is a S-J^copen set and (δ_E) is a S-J^cclosed set. Hence, $(X_E)\tilde{\in}J^cLC(G, r_E)$.
2. Consider (X_E) is a S-locally J^cclosed** in (G, r_E), since all s-open sets are S-J^copenset. Therefore, $(O_E) = (\lambda_E)\tilde{\cap}(\theta_E)$ where (λ_E) is a S-J^copen set and (θ_E) is a S- J^cclosed set. Hence, $(X_E)\tilde{\in}J^cLC(G, r_E)$.

Remark 3.7: Theorem 3.6 doesn't always work the other way around. For instance, consider $G = \{1,2\}$, $E = \{e_1, e_2\}$, $r = \{\tilde{G}\tilde{\phi}H_E\}$ where $H(e_1) = \{1,2\}, H(e_2) = \tilde{\phi}$ A s-subset $(T_E)=\{(e_1, 1,2), (e_2, \phi)\}$ is S-locally J^cclosed set in (G, r_E) but not S-J^cclosed set as well as

$(A_E)=\{(e_1, 1), (e_2, 1,2)\}$ is S-locally closed set but not S-J^copen set. Also, a s-subsets $(P_E) = \{(e_1, 1), (e_2, 2)\}$ and $(Q_E) = \{(e_1, 2), (e_2, 1)\}$ are S-locally J^cclosed set but not S- locally J^cclosed* set and S-locally J^cclosed** set.

Theorem 3.8: Suppose a s-subset (B_E) is S-locally J^cclosed set in (G, r_E) and (D_E) is S- J^copen or s-closed set, then $(B_E)\tilde{\cap}(D_E)$ is S-locally J^c closed set in (G, r_E).

Proof: Consider (B_E) is S-locally J^cclosed set in (G, r_E). Then $(B_E) = (X_E)\tilde{\cap}(Y_E)$ where (X_E) is S-J^copen set and (Y_E) is S-J^cclosed set. Suppose (D_E) is S-J^copen set, $(J_E) = (X_E)\tilde{\cap}(D_E)$ is S-J^copen set. Therefore, the s-intersection of (B_E) and (D_E) is $(X_E)\tilde{\cap}(Y_E)\tilde{\cap}(D_E) = (J_E)\tilde{\cap}(Y_E)$. Hence, the s-intersection of (B_E) and (D_E) is S-locally J^cclosed set in (G, r_E). Suppose (D_E) is s-closed set, $(K_E) = (D_E)\tilde{\cap}(Y_E)$ is S-J^cclosed set. Therefore, $(B_E)\tilde{\cap}(D_E) = (X_E)\tilde{\cap}(K_E)$. Hence, $(B_E)\tilde{\cap}(D_E)$ is S-locally J^cclosed set in (G, r_E).

Theorem 3.9: Suppose a s-subset (P_E) is S-locally J^cclosed** set in (G, r_E) and (Q_E) is s- open or s-closed set, then $(P_E)\tilde{\cap}(Q_E)$ is S-locally J^cclosed** set in (G, r_E).

Proof: Consider (P_E) is S-locally J^cclosed** set in (G, r_E). Then $(P_E) = (T_E)\tilde{\cap}(S_E)$ where (T_E) is s-open set and (S_E) is S-J^cclosed set. Suppose (Q_E) is s-open set, $(W_E) = (T_E)\tilde{\cap}(Q_E)$ is s-open set. Therefore, $(P_E)\tilde{\cap}(Q_E) = (W_E)\tilde{\cap}(S_E)$. Hence, $(P_E)\tilde{\cap}(Q_E)$ is S-locally J^cclosed** set in (G, r_E). Suppose (Q_E) is s-closed set, $(V_E) = (Q_E)\tilde{\cap}(S_E)$ is S-J^cclosed set. Therefore, $(P_E)\tilde{\cap}(Q_E) = (T_E)\tilde{\cap}(V_E)$. Hence, $(P_E)\tilde{\cap}(Q_E)$ is S-locally J^cclosed** set in (G, r_E).

Remark 3.10:

1. Each S-locally J^cclosed set is the intersection of a S-J^copen and S-J^cclosed set.
2. The complement of S-locally J^cclosed set in (G, r_E) is S-locally J^cclosed.
3. Finite union of S-locally J^cclosed sets need not be S-locally J^cclosed in (G, r_E).

Example 3.11: Consider $G = \{\mu, \nu\}$, $E = \{e_1, e_2\}$, $r = \{\tilde{G}, \tilde{\phi}, R_{E1}, R_{E2}, R_{E3}\}$ where $R_1(e_1) = \tilde{\phi} R_1(e_2) = \{\mu\}$, $R_2(e_1) = \tilde{\phi} R_2(e_2) = \{\nu\}$, $R_3(e_1) = \tilde{\phi} R_3(e_2) = \{\mu, \nu\}$. A s- subset $(A_E) = \{(e_1, \mu, \nu), (e_2, \mu)\}$ is S-locally J^cclosed set in (G, r_E) and its complement of (A_E) is $\{(e_1, \tilde{\phi}), (e_2, \nu)\}$ which is S-J^cclosed set in (G, r_E). Also $\tilde{\cup}(A_E)$ is not S-locally J^cclosed set in (G, r_E).

Theorem 3.12: The intersection of two S-locally J^cclosed* sets in (G, r_E) is S-locally J^cclosed*.

Proof: Consider $(J_E), (K_E)$ be two S-locally J^cclosed* sets in (G, r_E). Then $(J_E) = (1_E) \tilde{\cap} (2_E)$ and $(K_E) = (3_E) \tilde{\cap} (4_E)$ where (1_E), (3_E) are S-J^copen set and (2_E), (4_E) are s-closed set. Since intersection of S-J^copen set is S-J^copen set and intersection of s-closed set is s-closed set. Therefore, $(J_E) \tilde{\cap} (K_E)$ is S-locally J^cclosed*.

Theorem 3.13: Consider $(C_E), (D_E)$ be any two separated S-locally J^cclosed* subsets of (G, r_E) then $(C_E) \tilde{\cup} (D_E) \tilde{\in} SJ^c LC^*(G, r_E)$.

Proof: Consider (C_E), (D_E) be two S-locally J^cclosed* subsets of (G, r_E). Then there exists a S-J^copen sets $(0_E), (1_E)$ such that $(C_E) = (0_E) \tilde{\cap} (2_E)$ and $(D_E) = (1_E) \tilde{\cap} (3_E)$. Take $(A_E) = (0_E) \tilde{\cap} (3_E)^c$ and $(B_E) = (1_E) \tilde{\cap} (2_E)^c$, therefore (A_E) and (B_E) are S-J^copen sets and $(A_E) \tilde{\cup} (B_E)$ is S-J^copen in (G, r_E). Clearly $(C_E) = (A_E) \tilde{\cap} (2_E)$, $(D_E) = (B_E) \tilde{\cap} (3_E)$, $(A_E) \tilde{\cap} (3_E) = \tilde{\phi}$ and $(B_E) \tilde{\cap} (2_E) = \tilde{\phi}$ Consequently, $(C_E) \tilde{\cup} (D_E) = [(A_E) \tilde{\cup} (B_E)] \tilde{\cap} [(2_E) \tilde{\cup} (3_E)]$. Hence, $(C_E) \tilde{\cup} (D_E)$ is S-locally J^cclosed* set in (G, r_E).

Theorem 3.14: A s-subset (Y_E) of (G, r_E) is S-locally J^cclosed if and only if $(Y_E) = (\alpha_E) \tilde{\cap} cl(Y_E)$ where (α_E) is a S-J^copen set.

Proof: Consider (Y_E) be a S-locally J^cclosed set in (G, r_E). Therefore, $(Y_E) = (\alpha_E) \tilde{\cap} (3_E)$ where (α_E) is a S-J^copen set and (3_E) be a S-J^cclosed set in G. $Scl(Y_E) = Scl((\alpha_E) \tilde{\cap} (3_E)) \tilde{\subset} Scl(\alpha_E) \tilde{\cap} Scl(3_E) = Scl(\alpha_E) \tilde{\cap} (3_E)$. Since $Scl(Y_E) \tilde{\subset} (3_E)$, then $(Y_E) \tilde{\subset} (\alpha_E) \tilde{\cap} Scl(Y_E) \tilde{\subset} (\alpha_E) \tilde{\cap} (3_E) = (Y_E)$. Hence, $(Y_E) = (\alpha_E) \tilde{\cap} cl(Y_E)$.

Conversely, suppose $(Y_E) = (\alpha_E) \tilde{\cap} cl(Y_E)$ where (α_E) is a S-J^copen set. Since, $Scl(Y_E)$ is s- closed set in G and each s-closed set are S-J^cclosed set. Then (Y_E) is a S-locally J^cclosed set.

Theorem 3.15: A s-subset (T_E) of (G, r_E) is S-locally J^cclosed** if and only if $(T_E) = (5_E) \tilde{\cap} cl(T_E)$ where (5_E) is a s-open set.

Proof: Consider (T_E) be a S-locally J^cclosed** set in (G, r_E). Then (T_E) is s-intersection of (5_E) and (6_E) where (5_E) is a s-open set and (6_E) be a S-J^cclosed set in G. $cl(T_E) = cl((5_E) \tilde{\cap} (6_E)) \tilde{\subset} cl(5_E) \tilde{\cap} cl(6_E) = cl(5_E) \tilde{\cap} (6_E)$. Since $cl(T_E) \tilde{\subset} (6_E)$, therefore $(T_E) \tilde{\subset} (5_E) \tilde{\cap} cl(T_E) \tilde{\subset} (5_E) \tilde{\cap} (6_E) = (T_E)$. Hence, $(T_E) = (5_E) \tilde{\cap} cl(T_E)$.

Conversely, suppose $(T_E) = (5_E) \tilde{\cap} cl(T_E)$ where (5_E) is a s-open set. Since, $cl(T_E)$ is s- closed set in G and each s-closed set are S-J^cclosed set. Therefore, (T_E) is a S-locally J^cclosed** set.

S-$J^c Lc$-CONTINUOUS

Definition 4.1: A mapping $m_{uv}: SS(G)_E \rightarrow SS(H)_K$ is said to be S-$J^c Lc$-continuous (S-$J^c Lc^*$-continuous, S-$J^c Lc^{**}$-continuous) if $m_{uv}^{-1}(B_K)$ is S-locally J^cclosed set (S-J^clocally

closed*, S-J^Clocally closed**) in (G, r_E) for each s-open set (B_K) in (H, σ_K).

Example 4.2: Consider $G = \{x_1, x_2\}, E = \{e_1, e_2\}$, $r = \{\tilde{\phi}, \tilde{G}, (F_{E1}), (F_{E2}), (F_{E3})\}$ where $F_1(e_1) = \{x_2\}, F_1(e_2) = \tilde{\phi} F_2(e_1) = \tilde{\phi} F_2(e_2) = \{x_1\}$, $F_3(e_1) = \{x_2\}, F_3(e_2) = \{x_1\}$ and $H = \{y_1, y_2\}$, $K = \{k_1, k_2\}$, $\sigma = \{\tilde{\phi}, \tilde{H}, (S_{K1}), (S_{K2})\}$ where $S_1(k_1) = \tilde{\phi}$ $S_1(k_2) = \{y_1\}$, $S_2(k_1) = \{y_1\}$, $S_2(k_2) = \{y_1\}$. Define $\mu : G \to H$ and $\nu : E \to K$ as $\mu(x_1) = y_1, \mu(x_2) = y_2$ and $\nu(e_1) = k_1, \nu(e_2) = k_2$. Let $m_{\mu\nu}: SS(G)_E \to SS(H)_K$ be a s-mapping where (S_{K1}) be a s-open set in $\tilde{H}$ then $m^{-1}(S) = \{(e, \tilde{\phi}), (e, y)\}$ is S-locally J^Cclosed set, S-J^Clocally closed* set, S-J^Clocally closed** set in $\tilde{G}$. Therefore the mapping $m_{\mu\nu}: SS(G)_E \to SS(H)_K$ is S-$J^C Lc$-continuous, S-$J^C Lc^*$-continuous, S-$J^C Lc^{**}$-continuous.

Theorem 4.3: Consider (G, r_E) and (H, σ_K) be a ST space and the mapping $m_{uv}: SS(G)_E \to SS(H)_K$.

1. If m_{uv} is S-locally continuous then it is S-$J^C Lc$-continuous.
2. If m_{uv} is S-locally continuous then it is S-$J^C Lc^*$-continuous.
3. If m_{uv} is S-locally continuous then it is S-$J^C Lc^{**}$-continuous

Proof: Consider m_{uv} is S-locally continuous, (T_E) is a s-open set in $SS(H)_K$. Then $m^{-1}(T_E)$ is S-locally closed in $SS(G)_E$. By theorem 3.5, $m^{-1}_{uv}(T_E)$ is S-J^Clocally closed in $SS(G)_E$.
Hence the mapping m_{uv} is S-$J^C Lc$-continuous

Remark 4.4: S-$J^C Lc$-continuous, S-$J^C Lc^*$-continuous and S-$J^C Lc^{**}$-continuous are not S-locally continuous.

Example 4.5: Consider $G = \{i, j\}$, $E = \{e_1, e_2\}$, $r = \{\tilde{\phi}, \tilde{G}, (J_{E1}), (J_{E2})\}$ where $J_1(e_1) = \{j\}$, $J_1(e_2) = \{j\}, J_2(e_1) = \{i, j\}, J_2(e_2) = \{j\}$ and $H = \{a, b\}$, $K = \{k_1, k_2\}$, $\sigma = \{\tilde{\phi}, \tilde{H}, (S_{K1}), (S_{K2})\}$ where $S_1(k_1) = \{a\}$, $S_1(k_2) = \tilde{\phi}$ $S_2(k_1) = \{a\}$, $S_2(k_2) = \{b\}$,. Define $\mu : G \to H$ and $\nu : E \to K$ as $\mu(x) = a, \mu(y) = b$ and $\nu(e_1) = k_1, \nu(e_2) = k_2$. Let $m_{\mu\nu}: SS(G)_E \to SS(H)_K$ be a s-mapping where (S_{K2}) be a s-open set in $\tilde{H}$ then $m^{-1}_{\mu\nu}(S_{K2}) = \{(e_1, x), (e_2, y)\}$ is S-locally J^Cclosed set, S-locally J^Cclosed* set, S-locally J^Cclosed** set in $\tilde{G}$. Therefore the mapping $m_{\mu\nu}: SS(G)_E \to SS(H)_K$ is S-$J^C Lc$-continuous, S-$J^C Lc^*$- continuous, S-$J^C Lc^{**}$-continuous. But $m^{-1}(S)$ is not S-locally closed set in $\tilde{G}$. Hence it is not S-Lc-continuous.

Theorem 4.6: Consider the two ST spaces (G, r_E) and (H, σ_K) also the mapping $m_{uv}: SS(G)_E \to SS(H)_K$. If m_{uv} is S-J^Ccontinuous then it is S-$J^C Lc$-continuous

Proof: Suppose m_{uv} is S-J^Ccontinuous, (Z_K) is a s-open set in $SS(H)_K$. Then $m^{-1}(Z_K)$ is S- J^Copen set in $SS(G)_E$. By theorem 3.6, $m^{-1}_{uv}(Z_K)$ is S-J^Clocally closed set in $SS(G)_E$.
Therefore, m_{uv} is S-$J^C Lc$-continuous.

Theorem 4.7: Consider the two ST spaces (G, r_E) and (H, σ_K) also the mapping $m_{uv}: SS(G)_E \to SS(H)_K$. If m_{uv} is S-J^Ccontinuous then it is S- $J^C Lc^{**}$-continuous

Proof: Consider m_{uv} is S-J^ccontinuous, (J_K) is a s-open set in $SS(H)_K$. Then $m^{-1}(J_K)$ is S- J^copen set in $SS(G)_E$. By theorem 3.6, $m-1(J_{uv\ K})$ is S-JClocally closed** set in $SS(G)_E$ Hence,

muv is S-$JCLc{*}{*}$-continuous

Theorem 4.8: Consider the mapping $m_{uv}: SS(G)_E \to SS(H)_K$. If m_{uv} is S-J^cLc^*-continuousthen it is S-J^cLc-continuous.

Proof: Consider (Q_K) be a s-open set in $SS(H)_K$. Then $m^{-1}(Q_K)$ is S-J^clocally closed* set in $SS(G)_E$, since m_{uv} is S-J^cLc^*-continuous. Also by theorem 3.6, $m^{-1}(Q_K)$ is S-J^clocally closed set in $SS(G)_E$. Hence, m_{uv} is S-J^cLc-continuous.

Theorem 4.9: Consider the mapping $m_{uv}: SS(G)_E \to SS(H)_K$ is S-J^cLc-continuous and $n_{uv}: SS(H)_K \to SS(W)_R$ is s-continuous. Then $m_{uv} \circ n_{uv}: SS(G)_E \to SS(W)_R$ is S-J^cLc-continuous

Proof: Consider (O_R) is a s-open set in $SS(W)_R$. Then $n^{-1}(O_R)$ is s-open set in $SS(H)_K$ because n_{uv} is s-continuous. Also, $m^{-1}(n^{-1}(O\ R))$ is S-J^clocally closed set in $SS(G)$, because m_{uv} is S-J^cLc-continuous. Hence, $m_{uv} \circ n_{uv}$ is S-J^cLc-continuous.

Theorem 4.10: Consider the mapping $m_{uv}: SS(G)_E \to SS(H)_K$ is S-J^cLc^*-continuous (S- J^cLc^{**}-continuous) and $n_{uv}: SS(H)_K \to SS(W)_R$ is s-continuous. Then $m_{uv} \circ n_{uv}: SS(G)_E \to SS(W)_R$ is S-J^cLc^*-continuous (S-J^cLc^{**}-continuous).

Proof: Consider (D_R) as a s-open set in $SS(W)_R$. Now, since n_{uv} is s-continuous, $n^{-1}(D_R)$ is s-open set in $SS(H)_K$. $\therefore m^{-1}(n^{-1}(D\ ))$ is S-J^clocally closed* set (S-J^clocally closed** set) in $SS(G)_E$, because m_{uv} is S-J^cLc^*-continuous (S-J^cLc^{**}-continuous). Hence, $m_{uv} \circ n_{uv}$ is S-J^cLc^*-continuous (S-Lc^{**}-continuous).

CONCLUSION

This research constitutes a significant contribution to the field of ST space by introducing innovative concepts and perspectives. The findings provide a comprehensive understanding of the interrelationships between different types of closed sets and continuous maps in ST space. The results may have practical implications for various domains, including data analysis, artificial intelligence, and machine learning. The study demonstrates an impressive level of expertise and knowledge in the area of ST space and its applications, showcasing the author's competence in the field

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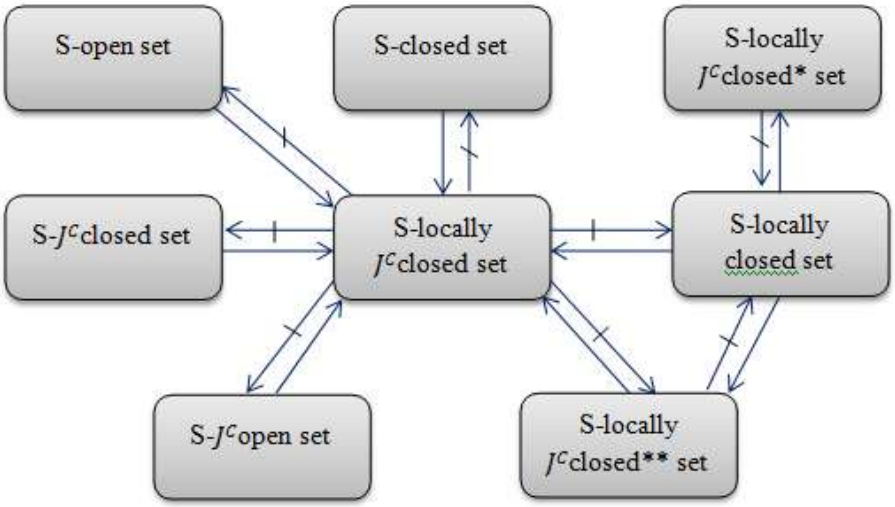


Figure 1: S-locally J^cclosed set

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RESEARCH ARTICLE

Interval Valued Secondary k-Kernel Symmetric Intuitionistic Fuzzy Matrices

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ABSTRACT

The characterization of interval valued(IV) secondary k- kernel symmetric (ks)Intuitionistic fuzzy matrices have been examined in this study. It is discussed how IV s-k ks, s-ks, IV k-ks, and IVks matrices relate to one another. We establish the necessary and sufficient criteria for IV s-k ks Intuitionisticfuzzy matrices.

Keywords: Interval valued Intuitionistic Fuzzy matrix, ks IV Intuitionistic fuzzy matrix,s-k-ks IV Intuitionistic fuzzy matrix.

INTRODUCTION

Matrices are crucial in many fields of research in science and engineering. The traditional matrix theory is unable to address problems involving numerous kinds of uncertainties. .Thomason [14] has study Convergence of powers of a fuzzy matrix. Fuzzy matrices are used to solve certain kinds of issues. Many researchers have since completed numerous works. Only membership values are addressed by fuzzy matrices. These matrices cannot handle values that are not membership. Khan, Shyamal, and Pal [11] introduced intuitionistic fuzzy matrices (IFMs) for the first time. Several properties on IFMs have been studied in Khan and Pal [6].Atanassov [1,2,3] has discussed Intuitionistic Fuzzy Sets Theory and Applications, Intuitionistic fuzzy sets and Operations over interval-valued intuitionistic fuzzy sets. .Hashimoto has studied Canonical form of a transitive matrix. Kim and Roush [5] have studied Generalized fuzzy matrices. Pal, Khan and and Shyamal have characterize Intuitionistic fuzzymatrices. Lee [7] has studied

Secondary Skew Symmetric, Secondary Orthogonal Matrices. Hilland Waters [8] have analyze Onk-Realandk-Hermitian matrices. Meenakshi [9] has studied Fuzzy Matrix: Theory and Applications. Meenakshi and JayaShree [10] have studied Onk-kernel symmetricmatrices. Meenakshi and Krishanmoorthy [11] have characterize On Secondary k-Hermitian matrices. Madhumangal Pal and Susanta Khan[16] have studied Interval-Valued Intuitionistic Fuzzy Matrices Meenakshi and JayaShree [12] have studied On K –range symmetricmatrices. Jaya shree [13] has studied Secondary κ-Kernel Symmetric Fuzzy Matrices. Shyamal and Pal [14] Interval valued Fuzzy matrices. Meenakshi and Kalliraja [15] Regular Interval valued Fuzzy matrices.But, practically it is difficult to measure the membership or non-membership value as a point .So, we consider the membership value as an interval and also in the case of non-membership values, it is not selected as a point, it can be considered as an interval .Here, we introduce the Secondary k-Kernel Symmetric Intuitionistic Fuzzy Matrices and introduce some basic operators on IVIFMs.

Notations

P^T = Transpose of the matrix P
P^+= Moore-penrose inverse of P
R(P) = Row space of P
C(P) = Column space of P
N(P) =Null space of P

PRELIMINARIES AND DEFINITIONS

Definition: 2.1 Interval-valued intuitionistic fuzzy matrix (IVIFM): An interval valued intuitionistic fuzzy matrix (IVIFM) P of order m×n is defined as $P = [x_{ij},<p_{ij\mu},p_{ijv}>]_{m\times n}$ where $p_{ij\mu}$ and p_{ijv} are both the subsets of [0,1] which are denoted by $p_{ij\mu} = [p_{ij\mu L},p_{ij\mu U}]$ and $p_{ijv} = [p_{ijvL},p_{ijvU}]$ which maintaining the condition $0\leq p_{ij\mu U} + p_{ijvU} \leq 1, 0\leq p_{ij\mu L} + p_{ijvL} \leq 1$,$0 \leq p_{\mu L} \leq p_{\mu U} \leq 1$, $0 \leq p_{vL} \leq p_{vU} \leq 1$ for i = 1,2,⋯,m and j = 1,2,⋯,n.

Example 2.1 Let $P = \begin{bmatrix} <[0.2,0.2],[0.3,0.3]> & <[0.2,0.3],[0.3,0.4]> \\ <[0.2,0.3],[0.3,0.4]> & <[0.2,0.2],[0.3,0.3]> \end{bmatrix}$,

$$P_L = \begin{bmatrix} <0.2,0.2> & <0.3,0.3> \\ <0.2,0.2> & <0.3,0.3> \end{bmatrix}, P_U = \begin{bmatrix} <0.2,0.3> & <0.3,0.4> \\ <0.3,0.2> & <0.4,0.3> \end{bmatrix}$$

Upper Limit IFM

Preliminaries 2.1

If $\kappa(x)=(x_{k[1]}, x_{k[2]}, x_{k[3]},\ldots, x_{k[n]})\in F_{n\times 1}$ for $x = x_1, x_2,..,x_n \in F_{[1\times n]}$, where K is involuntary, The corresponding permutation matrix is satisfied using the following.

(P.2.1) $KK^T = K^T K = I_n$, $K = K^T$, $K^2 = I$

By the definition of V ,

and $R(x) = Kx$

(P.2.2)

$V = V^T$, $VV^T = V^T V = I_n$ and $V^2 = I$

(P.2.3) $R([P_{\mu L}, P_{vL}]) = R([P_{\mu L}, P_{vL}]V)$, $R([P_{\mu L}, P_{vL}]) = R([P_{\mu L}, P_{vL}]_K)$

$R([P_{\mu U}, P_{vU}]) = R([P_{\mu U}, P_{vU}]V)$, $R([P_{\mu U}, P_{vU}]) = R([P_{\mu U}, P_{vU}]_K)$

(P.2.4) $R([P_{\mu L}, P_{vL}]V)^T = R(P[P_{\mu L}, P_{vL}]_T)$, $R(V[P_{\mu L}, P_{vL}])^T = R([P_{\mu L}, P_{vL}]_T V)$

$R([P_{\mu U}, P_{vU}]V)^T = R(V[P_{\mu U}, P_{vU}]_T)$, $R(V[P_{\mu U}, P_{vU}])^T = R([P_{\mu U}, P_{vU}]$

Definition 2.2. For IV Intuitionistic fuzzy matrix P is RS fuzzy matrix iff $R([P_{\mu L}, P_{vL}]) = R([P_{\mu L}, P_{vL}]_T)$ and $R([P_{\mu U}, P_{vU}]) = R([P_{\mu U}, P_{vU}]_T)$.

Interval valued Secondary k-Range symmetric Intuitionistic fuzzy matrix

Definition 3.1. For an Intuitionistic fuzzy matrix $P =< [P_{\mu L}, P_{\mu U}], [P_{vL}, P_{vU}] > \in IVIFM_{nn}$ is an IV s - symmetric fuzzy matrix iff $[P_{\mu L}, P_{vL}] = V[P_{\mu L}, P_{vL}]^T V$ and $[P_{\mu U}, P_{vU}] = V[P_{\mu U}, P_{vU}]^T V$

Definition 3.2 For an Intuitionistic fuzzy matrix $P =< [P_{\mu L}, P_{\mu U}], [P_{vL}, P_{vU}] > \in IVIFM_{nn}$ is an IV s- RS Intuitionistic fuzzy matrix iff $R([P_{\mu L}, P_{vL}]) = R(V[P_{\mu L}, P_{vL}]^T V), R([P_{\mu U}, P_{vU}]) = R(V[P_{\mu U}, P_{vU}]^T V)$

Definition 3.3. For an Intuitionistic fuzzy matrix $P =< [P_{\mu L}, P_{\mu U}], [P_{vL}, P_{vU}] > \in IVIFM_{nn}$ is an IV s-k- RS fuzzy matrix iff $R([P_{\mu L}, P_{vL}]) = R(KV[P_{\mu L}, P_{vL}]^T VK)$, $R([P_{\mu U}, P_{vU}]) =$

$R(KV[P_{\mu U}, P_{vU}]^T VK)$

Lemma3.1 For $P =< [P_{\mu L}, P_{vL}], [P_{\mu U}, P_{vU}] >, P^+ =< [P_{\mu L}, P_{vL}]^+, [P_{\mu U}, P_{vU}]^+ >$ exists $\Leftrightarrow (K[P_{\mu L}, P_{vL}])^+$

$, (K[P_{\mu U}, P_{vU}])^+$ exists $\Leftrightarrow (VK[P_{\mu L}, P_{vL}])^+, (VK[P_{\mu U}, P_{vU}])^+$ exists.

Proof: For $P =< [P_{\mu L}, P_{vL}], [P_{\mu U}, P_{vU}] >$, if $[P_{\mu L}, P_{vL}]^+$ exists then $[P_{\mu L}, P_{vL}]^+ = [P_{\mu L}, P_{vL}]^T$ which $[P_{\mu L}, P_{vL}]^T$ is a generalized inverse of $[P_{\mu L}, P_{vL}]$

Consider $[P_{\mu L}, P_{vL}]^+, [P_{\mu U}, P_{vU}]^+$ exists $\Leftrightarrow (K[P_{\mu L}, P_{vL}])^+, (K[P_{\mu U}, P_{vU}])^+$ exists. [*By Lemma* 3.4 *in* [11]]

$\Leftrightarrow (K[P_{\mu L}, P_{vL}])(K[P_{\mu L}, P_{vL}])^T (K[P_{\mu L}, P_{vL}]), (K[P_{\mu U}, P_{vU}])(K[P_{\mu U}, P_{vU}])^T (K[P_{\mu U}, P_{vU}])$

$\Leftrightarrow (K[P_{\mu L}, P_{vL}])^+ (K[P_{\mu U}, P_{vU}])^+$ *exists.*

$\Leftrightarrow (VK[P_{\mu L}, P_{vL}])(VK[P_{\mu L}, P_{vL}])^T (VK[P_{\mu L}, P_{vL}]), (VK[P_{\mu U}, P_{vU}])(VK[P_{\mu U}, P_{vU}])^T (VK[P_{\mu U}, P_{vU}])$

$\Leftrightarrow (VK[P_{\mu L}, P_{vL}])^T \in (VK[P_{\mu L}, P_{vL}])\{1\}, (K[P_{\mu U}, P_{vU}])^T \in (VK[P_{\mu U}, P_{vU}])\{1\}$

$\Leftrightarrow \left(VK[P_{\mu L}, P_{vL}]\right)^{+} \left(VK[P_{\mu U}, P_{vU}]\right)^{+}$ *exists.*

Remark :3.1 For $P =< [P_{\mu L}, P_{vL}], [P_{\mu U}, P_{vU}] >, P^{+} =< [P_{\mu L}, P_{vL}]^{+}, [P_{\mu U}, P_{vU}]^{+} >$

exists $\Leftrightarrow \left(KV[P_{\mu L}, P_{vL}]\right)^{+}, \left(KV[P_{\mu U}, P_{vU}]\right)^{+}$ exists.

Lemma3.2. For an Intuitionistic fuzzy matrix $P =< [P_{\mu L}, P_{\mu U}], [P_{vL}, P_{vU}] > \in \text{IVIFM}_{nn}$ is interval valued s-Range symmetric Intuitionistic fuzzy matrix $\Leftrightarrow$ $\text{VP} =< V[P_{\mu L}, P_{vL}], \text{V}[P_{\mu U}, P_{vU}] >$ interval valued Range symmetric Intuitionistic fuzzy matrix $\Leftrightarrow$ $\text{PV} =< [P_{\mu L}, P_{vL}]\text{V}, [P_{\mu U}, P_{vU}]\text{V} >$ is interval valued Range symmetric Intuitionistic fuzzy matrix.

Proof. *An Intuitionistic fuzzy matrix* $P =< [P_{\mu L}, P_{\mu U}], [P_{vL}, P_{vU}] > \in \text{IVIFM}_{nn}$ *is s-RS fuzzy matrix*

$\Leftrightarrow R\left([P_{\mu L}, P_{vL}]\right) = R\left(V[P_{\mu L}, P_{vL}]^{T} V\right)$ *[Definition 3.2]*

$\Leftrightarrow R\left([P_{\mu L}, P_{vL}]\text{V}\right) = R\left([P_{\mu L}, P_{vL}]V\right)^{T}$

$\Leftrightarrow [P_{\mu L}, P_{vL}]\text{V}$ is RS. [By P.2.2]

$\Leftrightarrow R\left(\text{V}[P_{\mu L}, P_{vL}]\text{VV}^{T}\right) = R\left(VV[P_{\mu L}, P_{vL}]^{T} V\right)$

$\Leftrightarrow R\left(\text{V}[P_{\mu L}, P_{vL}]\right) = R\left(\text{V}[P_{\mu L}, P_{vL}]\right)^{T}$

$\Leftrightarrow \text{V}[P_{\mu L}, P_{vL}]$ is RS.

Similar manner

$\Leftrightarrow R\left([P_{\mu U}, P_{vU}]\right) = R\left(V[P_{\mu U}, P_{vU}]^{T} V\right)$

$\Leftrightarrow R\left([P_{\mu U}, P_{vU}]\text{V}\right) = R\left([P_{\mu U}, P_{vU}]V\right)^{T}$

$\Leftrightarrow [P_{\mu U}, P_{vU}]\text{V}$ *is RS.*

$\Leftrightarrow R\left(\text{V}[P_{\mu U}, P_{vU}]\text{VV}^{T}\right) = R\left(VV[P_{\mu U}, P_{vU}]^{T} V\right)$

$\Leftrightarrow R\left(\text{V}[P_{\mu U}, P_{vU}]\right) = R\left(\text{V}[P_{\mu U}, P_{vU}]\right)^{T}$

$\Leftrightarrow \text{V}[P_{\mu U}, P_{vU}]$ is RS.

Therefore, $VP =< V[P_{\mu L}, P_{vL}], V[P_{\mu U}, P_{vU}] >$ is an interval valued symmetric.

Remark 3.1. If P is interval valued s-k-symmetric, then $[P_{\mu L}, P_{vL}]$ =KV $[P_{\mu L}, P_{vL}]$ TVK, and A_U =KVA^T_UVK, indicating that it is interval valued (IV) s-k-RS Intuitionistic fuzzy matrix, then R($[P_{\mu L}, P_{vL}]$) = R(KV $[P_{\mu L}, P_{vL}]$ TVK), R($[P_{\mu U}, P_{vU}]$) = R(KV $[P_{\mu U}, P_{vU}]$ TVK).We note that s-k-symmetric Intuitionistic fuzzy matrix is s-k-RS Intuitionistic fuzzy matrix.

The opposite isn't always true, though. The example that follows illustrates this V

Example 3.1 Let $K = \begin{bmatrix} <1,0> & <0,1> \\ <0,1> & <1,0> \end{bmatrix}, V = \begin{bmatrix} <0,1> & <1,0> \\ <1,0> & <0,1> \end{bmatrix}$ and $P =< [P_{\mu L}, P_{\mu U}], [P_{vL}, P_{vU}] > \in IVIFM_{nn}$

$$P = \begin{bmatrix} <[0.4,0.4],[0.5,0.5]> & <[0.4,0.5],[0.2,0.4]> \\ <[0.4,0.5],[0.2,0.4]> & <[0.4,0.4],[0.3,0.3]> \end{bmatrix},$$

is an IV symmetric, IV s − κ symmetric and hence therefore IV s − κ RS.

Hence, $P_L = \begin{bmatrix} <0.4,0.4> & <0.4,0.5> \\ <0.4,0.5> & <0.4,0.4> \end{bmatrix}, P_U = \begin{bmatrix} <0.5,0.5> & <0.2,0.4> \\ <0.2,0.4> & <0.3,0.3> \end{bmatrix}$

$$KV = \begin{bmatrix} <1,0> & <0,1> \\ <0,1> & <1,0> \end{bmatrix} \begin{bmatrix} <0,1> & <1,0> \\ <1,0> & <0,1> \end{bmatrix} = \begin{bmatrix} <0,1> & <1,0> \\ <1,0> & <0,1> \end{bmatrix}$$

$$VK = \begin{bmatrix} <0,1> & <1,0> \\ <1,0> & <0,1> \end{bmatrix} \begin{bmatrix} <1,0> & <0,1> \\ <0,1> & <1,0> \end{bmatrix} = \begin{bmatrix} <0,1> & <1,0> \\ <1,0> & <0,1> \end{bmatrix}$$

$$KVP_L^T VK = \begin{bmatrix} <0,1> & <1,0> \\ <1,0> & <0,1> \end{bmatrix} \begin{bmatrix} <0.4,0.4> & <0.4,0.5> \\ <0.4,0.5> & <0.4,0.4> \end{bmatrix} \begin{bmatrix} <0,1> & <1,0> \\ <1,0> & <0,1> \end{bmatrix} = P_L$$

$$KVP_L^T VK = \begin{bmatrix} <0,1> & <1,0> \\ <1,0> & <0,1> \end{bmatrix} \begin{bmatrix} <0.5,0.5> & <0.2,0.4> \\ <0.2,0.4> & <0.3,0.3> \end{bmatrix} \begin{bmatrix} <0,1> & <1,0> \\ <1,0> & <0,1> \end{bmatrix} = P_U$$

$R(P_L)$= $R(KVP_L^T VK)$

$A = [A_L, A_U]$ is an IV s − κ RS.

Example 3.1. For k = (1,2), $K = \begin{bmatrix} <1,0> & <0,1> \\ <0,1> & <1,0> \end{bmatrix}, V = \begin{bmatrix} <0,1> & <1,0> \\ <1,0> & <0,1> \end{bmatrix}$ and

$P =< [P_{\mu L}, P_{\mu U}], [P_{vL}, P_{vU}] > \in IVIFM_{nn}$ $P = \begin{bmatrix} <[0,0.2],[0,1]> & <[0.2,0.5],[0.2,0.4]> \\ <[0.2,0.5],[0.2,0.4]> & <[0.2,0.2],[0.3,0.4]> \end{bmatrix},$

$$P_U = \begin{bmatrix} <0,1> & <0.2,0.4> \\ <0.2,0.4> & <0.3,0.4> \end{bmatrix},$$

$$KVP_U{}^T VK = \begin{bmatrix} <1,0> & <0,1> \\ <0,1> & <1,0> \end{bmatrix}\begin{bmatrix} <0,1> & <1,0> \\ <1,0> & <0,1> \end{bmatrix}\begin{bmatrix} <0,1> & <0.2,0.4> \\ <0.2,0.4> & <0.3,0.4> \end{bmatrix}$$
$$\begin{bmatrix} <0,1> & <1,0> \\ <1,0> & <0,1> \end{bmatrix}\begin{bmatrix} <1,0> & <0,1> \\ <0,1> & <1,0> \end{bmatrix},$$

$$KVP_U{}^T VK \neq P_U$$

Here $P = KP^T{}_U K$

Therefore P is symmetric IFM, κ –symmetric IFM, s- κ -RS IFM but not s- κ –symmetric IFM.

Theorem 3.1. The following conditions are equivalent for $P \in \mathrm{IVIFM}_n$

1. $P =< [\mathrm{P}_{\mu L}, \mathrm{P}_{vL}], [\mathrm{P}_{\mu U}, \mathrm{P}_{vU}] >$ is an IV s − κ RS
2. $\mathrm{KVP} =< KV[P_{\mu L}, P_{vL}], \mathrm{KV}[P_{\mu U}, P_{vU}] >$ is an IV RS
3. $\mathrm{PKV} =< [P_{\mu L}, P_{vL}]KV, [P_{\mu U}, P_{vU}]KV >$ is an IV RS
4. $\mathrm{VP} =< V[P_{\mu L}, P_{vL}], \mathrm{V}[P_{\mu U}, P_{vU}] >$ is an IV k- RS
5. $\mathrm{PK} =< [P_{\mu L}, P_{vL}]\mathrm{K}, [P_{\mu U}, P_{vU}]\mathrm{K} >$ is an IV s- RS
6. P^{T} is an IV s-k kernel symmetric
7. $\mathrm{R}([P_{\mu L}, P_{vL}]) = \left(\mathrm{R}[P_{\mu L}, P_{vL}]^T\ \mathrm{VK}\right), \mathrm{R}([P_{\mu U}, P_{vU}]) = \left(\mathrm{R}[P_{\mu U}, P_{vU}]^T\ \mathrm{VK}\right)$
8. $\mathrm{R}([P_{\mu L}, P_{vL}]^T) = \left(\mathrm{R}[P_{\mu L}, P_{vL}]\mathrm{VK}\right), \mathrm{R}([P_{\mu U}, P_{vU}]^T) = \left(\mathrm{R}[P_{\mu U}, P_{vU}]\mathrm{VK}\right)$
9. $\mathrm{C}(\mathrm{KV}[P_{\mu L}, P_{vL}]) = C\left(\mathrm{KV}[P_{\mu L}, P_{vL}]^T\right)^T, \mathrm{C}(\mathrm{KV}[P_{\mu U}, P_{vU}]) = C\left(\mathrm{KV}[P_{\mu U}, P_{vU}]^T\right)^T$
10. $[P_{\mu L}, P_{vL}] = \mathrm{VK}[P_{\mu L}, P_{vL}]^T VKH_1, [P_{\mu U}, P_{vU}] = \mathrm{VK}[P_{\mu U}, P_{vU}]^T VKH_1 \text{ for } H_1 \in IVIFM$
11. $[P_{\mu L}, P_{vL}] = H_1\,\mathrm{KV}[P_{\mu L}, P_{vL}]^T KV, [P_{\mu U}, P_{vU}] = H_1 K[P_{\mu U}, P_{vU}]^T VK \text{ for } H_1 \in IVIFM$
12. $[P_{\mu L}, P_{vL}]^T = \mathrm{KV}[P_{\mu L}, P_{vL}]KVH_1, [P_{\mu U}, P_{vU}]^T = KV[P_{\mu U}, P_{vU}]VKH_1 \text{ for } H_1 \in IVIFM$
13. $[P_{\mu L}, P_{vL}]^T = H_1\,\mathrm{KV}[P_{\mu L}, P_{vL}]KV, [P_{\mu U}, P_{vU}]^T = H_1 KV[P_{\mu U}, P_{vU}]VK \text{ for } H_1 \in IVIFM$

Proof: (1) iff (2) iff (4)

Let $P =< [\mathrm{P}_{\mu L}, \mathrm{P}_{vL}], [\mathrm{P}_{\mu U}, \mathrm{P}_{vU}] >$ is an IV s − κ RS

Let $[\mathrm{P}_{\mu L}, \mathrm{P}_{vL}]$ is a s − κ RS

$\Leftrightarrow R([\mathrm{P}_{\mu L}, \mathrm{P}_{vL}]) = R(KV[\mathrm{P}_{\mu L}, \mathrm{P}_{vL}]^T VK), \mathrm{R}([\mathrm{P}_{\mu U}, \mathrm{P}_{vU}]) = R(KV[\mathrm{P}_{\mu U}, \mathrm{P}_{vU}]^T VK),$ (By definition 3.3)

$\Leftrightarrow R(KV[\mathrm{P}_{\mu L},\mathrm{P}_{vL}]) = R(KV[\mathrm{P}_{\mu L},\mathrm{P}_{vL}])^T, \mathrm{R}([\mathrm{P}_{\mu U},\mathrm{P}_{vU}]) = R(KV[\mathrm{P}_{\mu U},\mathrm{P}_{vU}])^T$ By (P.2.3)

$\Leftrightarrow$ $\mathrm{KVP} =< KV[P_{\mu L},P_{vL}], \mathrm{KV}[P_{\mu U},P_{vU}] >$ is an IV RS

$\Leftrightarrow \mathrm{VP} =< V[P_{\mu L},P_{vL}], \mathrm{V}[P_{\mu U},P_{vU}] >$ is an IV κ- RS

As a conclusion (1) iff (2) iff (4) is true

(1) iff (3) iff (5)

Let $P =< [\mathrm{P}_{\mu L},\mathrm{P}_{vL}],[\mathrm{P}_{\mu U},\mathrm{P}_{vU}] >$ is an IV s − κ RS

$\Leftrightarrow R([\mathrm{P}_{\mu L},\mathrm{P}_{vL}]) = R(KV[\mathrm{P}_{\mu L},\mathrm{P}_{vL}]^T VK), \mathrm{R}([\mathrm{P}_{\mu U},\mathrm{P}_{vU}]) = R(KV[\mathrm{P}_{\mu U},\mathrm{P}_{vU}]^T VK),$ [By Definition 3.3]

$\Leftrightarrow R(KV[\mathrm{P}_{\mu L},\mathrm{P}_{vL}]) = R(KV[\mathrm{P}_{\mu L},\mathrm{P}_{vL}])^T, \mathrm{R}(KV[\mathrm{P}_{\mu U},\mathrm{P}_{vU}]) = R(KV[\mathrm{P}_{\mu U},\mathrm{P}_{vU}])^T,$ By (P.2.3)

$\Leftrightarrow R(VK(KV[\mathrm{P}_{\mu L},\mathrm{P}_{vL}])) = R((VK)[\mathrm{P}_{\mu L},\mathrm{P}_{vL}]^T VK(VK)^T)$,

$\mathrm{R}(VK(KV[\mathrm{P}_{\mu U},\mathrm{P}_{vU}])) = R((VK)[\mathrm{P}_{\mu U},\mathrm{P}_{vU}]^T VK(VK)^T)$

$\Leftrightarrow R([\mathrm{P}_{\mu L},\mathrm{P}_{vL}]KV) = R([\mathrm{P}_{\mu L},\mathrm{P}_{vL}]KV)^T, \mathrm{R}([\mathrm{P}_{\mu U},\mathrm{P}_{vU}]KV) = R([\mathrm{P}_{\mu U},\mathrm{P}_{vU}]KV)^T$ [By Lemma. 2.2]

$\Leftrightarrow PKV = \left[[\mathrm{P}_{\mu L},\mathrm{P}_{vL}]KV,[\mathrm{P}_{\mu U},\mathrm{P}_{vU}]KV\right]$ is an IV RS

$\Leftrightarrow PK = \left[[\mathrm{P}_{\mu L},\mathrm{P}_{vL}]K,[\mathrm{P}_{\mu U},\mathrm{P}_{vU}]K\right]$ is an IV s- RS

As a conclusion (1) $\Leftrightarrow$ (3) $\Leftrightarrow$ (5) is true

(2) $\Leftrightarrow$ (9)

$KVA = \left[KV[\mathrm{P}_{\mu L},\mathrm{P}_{vL}], KV[\mathrm{P}_{\mu U},\mathrm{P}_{vU}]\right]$ is an interval valued RS

$\Leftrightarrow R\left(KV[\mathrm{P}_{\mu L},\mathrm{P}_{vL}]\right) = R\left(\left(KV[\mathrm{P}_{\mu L},\mathrm{P}_{vL}]\right)^T\right), \mathrm{R}\left(KV[\mathrm{P}_{\mu U},\mathrm{P}_{vU}]\right) = R\left(\left(KV[\mathrm{P}_{\mu U},\mathrm{P}_{vU}]\right)^T\right)$

$\Leftrightarrow C\left(KV[\mathrm{P}_{\mu L},\mathrm{P}_{vL}]\right)^T = R\left(KV[\mathrm{P}_{\mu L},\mathrm{P}_{vL}]\right), \mathrm{R}\left(KV[\mathrm{P}_{\mu U},\mathrm{P}_{vU}]\right)^T = R\left(KV[\mathrm{P}_{\mu U},\mathrm{P}_{vU}]\right)$ (2) $\Leftrightarrow$ (9) is true

(2) $\Leftrightarrow$ (7)

is an IV RS $KVP = \left[KV[\mathrm{P}_{\mu L},\mathrm{P}_{vL}], KV[\mathrm{P}_{\mu U},\mathrm{P}_{vU}]\right]$

$\Leftrightarrow R\left(KV[\mathrm{P}_{\mu L},\mathrm{P}_{vL}]\right) = R\left(\left(KV[\mathrm{P}_{\mu L},\mathrm{P}_{vL}]\right)^T\right), \mathrm{R}\left(KV[\mathrm{P}_{\mu U},\mathrm{P}_{vU}]\right) = R\left(\left(KV[\mathrm{P}_{\mu U},\mathrm{P}_{vU}]\right)^T\right)$

$\Leftrightarrow R\left([\mathrm{P}_{\mu L},\mathrm{P}_{vL}]\right) = R\left(\left(KV[\mathrm{P}_{\mu L},\mathrm{P}_{vL}]\right)^T\right), \mathrm{R}\left([\mathrm{P}_{\mu U},\mathrm{P}_{vU}]\right) = R\left(\left(KV[\mathrm{P}_{\mu U},\mathrm{P}_{vU}]\right)^T\right)$

$\Leftrightarrow R\left([\mathrm{P}_{\mu L},\mathrm{P}_{vL}]\right) = R\left([\mathrm{P}_{\mu L},\mathrm{P}_{vL}]^T VK\right), \mathrm{R}\left([\mathrm{P}_{\mu U},\mathrm{P}_{vU}]\right) = R\left([\mathrm{P}_{\mu U},\mathrm{P}_{vU}]^T VK\right)$

As a conclusion (2) $\Leftrightarrow$ (7) is true

(3) $\Leftrightarrow$ (8)

$PVK = \left[[\mathrm{P}_{\mu L},\mathrm{P}_{vL}]VK,[\mathrm{P}_{UL},\mathrm{P}_{vU}]VK\right]$

$\Leftrightarrow R\left([\mathrm{P}_{\mu L},\mathrm{P}_{vL}]VK\right)=R\left(\left([\mathrm{P}_{\mu L},\mathrm{P}_{vL}]VK\right)^{T}\right),\mathrm{R}\left([\mathrm{P}_{\mu U},\mathrm{P}_{vU}]VK\right)=R\left(\left([\mathrm{P}_{\mu U},\mathrm{P}_{vU}]VK\right)^{T}\right)$

$\Leftrightarrow R\left([\mathrm{P}_{\mu L},\mathrm{P}_{vL}]VK\right)=R\left([\mathrm{P}_{\mu L},\mathrm{P}_{vL}]\right)^{T},\mathrm{R}\left([\mathrm{P}_{\mu U},\mathrm{P}_{vU}]VK\right)=R\left([\mathrm{P}_{\mu U},\mathrm{P}_{vU}]\right)^{T}$ As a conclusion (3) $\Leftrightarrow$ (8) is true

(1) $\Leftrightarrow$ (6)

Let $P=<[\mathrm{P}_{\mu L},\mathrm{P}_{vL}],[\mathrm{P}_{\mu U},\mathrm{P}_{vU}]>$ is an IV s − κ RS

$\Leftrightarrow R([\mathrm{P}_{\mu L},\mathrm{P}_{vL}])=R(KV[\mathrm{P}_{\mu L},\mathrm{P}_{vL}]^{T}VK),\mathrm{R}([\mathrm{P}_{\mu U},\mathrm{P}_{vU}])=R(KV[\mathrm{P}_{\mu U},\mathrm{P}_{vU}]^{T}VK),$ (By definition 3.3)

$\Leftrightarrow (KVP)^{T}=(KV[\mathrm{P}_{\mu L},\mathrm{P}_{vL}],KV[\mathrm{P}_{\mu U},\mathrm{P}_{vU}])^{T}$ is an IV RS

$\Leftrightarrow R(KV[\mathrm{P}_{\mu L},\mathrm{P}_{vL}])=R\left((KV[\mathrm{P}_{\mu L},\mathrm{P}_{vL}])^{T}\right),\mathrm{R}([\mathrm{P}_{\mu U},\mathrm{P}_{vU}])=R\left((KV[\mathrm{P}_{\mu U},\mathrm{P}_{vU}])^{T}\right)$

$\Leftrightarrow P^{T}VK=([\mathrm{P}_{\mu L},\mathrm{P}_{vL}]VK,[\mathrm{P}_{\mu U},\mathrm{P}_{vU}]VK)$ is an IV RS

$\Leftrightarrow P^{T}=\left([\mathrm{P}_{\mu L},\mathrm{P}_{vL}]^{T},[\mathrm{P}_{\mu L},\mathrm{P}_{vL}]^{T}\right)$ is an interval valued s − κ RS

As a conclusion (1) $\Leftrightarrow$ (6) is true

(1) $\Leftrightarrow$ (12) $\Leftrightarrow$ (11)

Let $P=<[\mathrm{P}_{\mu L},\mathrm{P}_{vL}],[\mathrm{P}_{\mu U},\mathrm{P}_{vU}]>$ is an IV s − κ RS

Consider $[\mathrm{P}_{\mu L},\mathrm{P}_{vL}]$ is a s − κ RS

$\Leftrightarrow R([\mathrm{P}_{\mu L},\mathrm{P}_{vL}])=R(KV[\mathrm{P}_{\mu L},\mathrm{P}_{vL}]^{T}VK),\mathrm{R}([\mathrm{P}_{\mu U},\mathrm{P}_{vU}])=R(KV[\mathrm{P}_{\mu U},\mathrm{P}_{vU}]^{T}VK),$ (By definition 3.3)

$\Leftrightarrow R([\mathrm{P}_{\mu L},\mathrm{P}_{vL}]^{T})=C(\mathrm{KV}[\mathrm{P}_{\mu L},\mathrm{P}_{vL}]VK),\mathrm{R}([\mathrm{P}_{\mu U},\mathrm{P}_{vU}])^{T}=C(\mathrm{KV}[\mathrm{P}_{\mu U},\mathrm{P}_{vU}]VK)$

$\Leftrightarrow [\mathrm{P}_{\mu L},\mathrm{P}_{vL}]^{T}=KV[\mathrm{P}_{\mu L},\mathrm{P}_{vL}]VK,[\mathrm{P}_{\mu U},\mathrm{P}_{vU}]^{T}=KV[\mathrm{P}_{\mu U},\mathrm{P}_{vU}]\mathrm{VK}$ (By Theorem 2.3)

$\Leftrightarrow [\mathrm{P}_{\mu L},\mathrm{P}_{vL}]=H_{1}\,\mathrm{KV}[\mathrm{P}_{\mu L},\mathrm{P}_{vL}]^{T}VK,[\mathrm{P}_{\mu U},\mathrm{P}_{vU}]=H_{1}KV[\mathrm{P}_{\mu U},\mathrm{P}_{vU}]^{T}\ \mathrm{VK}\ \text{for}\ H_{1}\in IVIFM$ By (P.2.3)

As a conclusion (1) $\Leftrightarrow$ (12) $\Leftrightarrow$ (11) is true

Therefore, (1) $\Leftrightarrow$ (10) $\Leftrightarrow$ (11) is true

(2) $\Leftrightarrow$ (13) $\Leftrightarrow$ (10)

$\Leftrightarrow \mathrm{KVP}=<KV[P_{\mu L},P_{vL}],\mathrm{KV}[P_{\mu U},P_{vU}]>$ is an IV RS

$\Leftrightarrow \mathrm{VP}=<V[P_{\mu L},P_{vL}],\mathrm{V}[P_{\mu U},P_{vU}]>$ is an IV κ- RS

$\Leftrightarrow R(\mathrm{V}[\mathrm{P}_{\mu L},\mathrm{P}_{vL}])=R(K\left(\mathrm{V}[\mathrm{P}_{\mu L},\mathrm{P}_{vL}]\right)^{T}K),N([\mathrm{P}_{\mu U},\mathrm{P}_{vU}])=R(V\left(\mathrm{V}[\mathrm{P}_{\mu U},\mathrm{P}_{vU}]\right)^{T}K),$

$R([\mathrm{P}_{\mu L},\mathrm{P}_{vL}])=R([\mathrm{P}_{\mu L},\mathrm{P}_{vL}]^{T}VK),N([\mathrm{P}_{\mu U},\mathrm{P}_{vU}])=R([\mathrm{P}_{\mu U},\mathrm{P}_{vU}]^{T}VK),$

$\mathrm{C}([\mathrm{P}_{\mu L},\mathrm{P}_{vL}])^{T}=C(\mathrm{KV}[\mathrm{P}_{\mu L},\mathrm{P}_{vL}]),\mathrm{C}([\mathrm{P}_{\mu U},\mathrm{P}_{vU}])^{T}=R(\mathrm{KV}[\mathrm{P}_{\mu U},\mathrm{P}_{vU}]^{T}),$ [By Definition 3.3]

$([\mathrm{P}_{\mu L},\mathrm{P}_{vL}])^{T}=HKV[\mathrm{P}_{\mu L},\mathrm{P}_{vL}],([\mathrm{P}_{\mu U},\mathrm{P}_{vU}])^{T}=H\,\mathrm{KV}[\mathrm{P}_{\mu U},\mathrm{P}_{vU}]\ \ for\ H\in IFIFM$

$([\mathrm{P}_{\mu L},\mathrm{P}_{vL}])^T = H_1 KV[\mathrm{P}_{\mu L},\mathrm{P}_{vL}]\mathrm{KV}, ([\mathrm{P}_{\mu U},\mathrm{P}_{vU}])^T = H_1\,\mathrm{KV}[\mathrm{P}_{\mu U},\mathrm{P}_{vU}]KV$

$[\mathrm{P}_{\mu L},\mathrm{P}_{vL}] = VK[\mathrm{P}_{\mu L},\mathrm{P}_{vL}]^T\,\mathrm{VK}\,H_1, [\mathrm{P}_{\mu U},\mathrm{P}_{vU}] = VK[\mathrm{P}_{\mu U},\mathrm{P}_{vU}]^T\,\mathrm{VK}\,H_1$

As a conclusion (2) $\Leftrightarrow$ (13) $\Leftrightarrow$ (10) are true. As a result, the Theorem is valid.

The above statement can be reduced to the equivalent requirement that a matrix be an IV s-RS for K = I in particular.

Corollary:3.1 The following statements are equivalent for $P \in \mathrm{IVIFM}_{nn}$

1. $P =< [\mathrm{P}_{\mu L},\mathrm{P}_{vL}],[\mathrm{P}_{\mu U},\mathrm{P}_{vU}] >$ is an IV s- RS
2. $VP =< V[\mathrm{P}_{\mu L},\mathrm{P}_{vL}],\mathrm{V}[\mathrm{P}_{\mu U},\mathrm{P}_{vU}] >$ is an IV RS
3. $PV =< [\mathrm{P}_{\mu L},\mathrm{P}_{vL}]\mathrm{V},[\mathrm{P}_{\mu U},\mathrm{P}_{vU}]\mathrm{V} >$ is an IV RS
4. $P^T =< [\mathrm{P}_{\mu L},\mathrm{P}_{vL}]^T,[\mathrm{P}_{\mu U},\mathrm{P}_{vU}]^T >$ is an IV s - RS
5. $R\left([\mathrm{P}_{\mu L},\mathrm{P}_{vL}]\right) = R\left([\mathrm{P}_{\mu L},\mathrm{P}_{vL}]^T V\right), \mathrm{R}\left([\mathrm{P}_{\mu U},\mathrm{P}_{vU}]\right) = R\left([\mathrm{P}_{\mu U},\mathrm{P}_{vU}]^T V\right)$
6. $R\left([\mathrm{P}_{\mu L},\mathrm{P}_{vL}]^T\right) = R\left([\mathrm{P}_{\mu L},\mathrm{P}_{vL}]V\right), \mathrm{R}\left([\mathrm{P}_{\mu U},\mathrm{P}_{vU}]^T\right) = R\left([\mathrm{P}_{\mu U},\mathrm{P}_{vU}]\mathrm{V}\right)$
7. $C\left(\mathrm{KV}[\mathrm{P}_{\mu L},\mathrm{P}_{vL}]\right) = C\left(\mathrm{V}[\mathrm{P}_{\mu L},\mathrm{P}_{vL}]\right)^T, \mathrm{C}\left(\mathrm{KV}[\mathrm{P}_{\mu U},\mathrm{P}_{vU}]\right) = C\left(\mathrm{V}[\mathrm{P}_{\mu U},\mathrm{P}_{vU}]\right)^T$
8. $[P_{\mu L},P_{vL}] = \mathrm{V}[P_{\mu L},P_{vL}]^T VH_1, [P_{\mu U},P_{vU}] = \mathrm{V}[P_{\mu U},P_{vU}]^T VH_1 \text{ for } H_1 \in IVIFM$
9. $[P_{\mu L},P_{vL}] = H_1\,\mathrm{V}[P_{\mu L},P_{vL}]^T V, [P_{\mu U},P_{vU}] = H_1\,\mathrm{V}[P_{\mu U},P_{vU}]^T V \text{ for } H_1 \in IVIFM$
10. $[P_{\mu L},P_{vL}]^T = \mathrm{V}[P_{\mu L},P_{vL}]VH_1, [P_{\mu U},P_{vU}]^T = V[P_{\mu U},P_{vU}]VH_1 \text{ for } H_1 \in IVIFM$
11. $[P_{\mu L},P_{vL}]^T = H_1\,\mathrm{V}[P_{\mu L},P_{vL}]V, [P_{\mu U},P_{vU}]^T = H_1 V[P_{\mu U},P_{vU}]V \text{ for } H_1 \in IVIFM$

Theorem 3.2. For $P =< [\mathrm{P}_{\mu L},\mathrm{P}_{vL}],[\mathrm{P}_{\mu U},\mathrm{P}_{vU}] >$ then any two of the conditions below imply the other

1. $P =< [\mathrm{P}_{\mu L},\mathrm{P}_{vL}],[\mathrm{P}_{\mu U},\mathrm{P}_{vU}] >$ is an IV κ- RS
2. $P =< [\mathrm{P}_{\mu L},\mathrm{P}_{vL}],[\mathrm{P}_{\mu U},\mathrm{P}_{vU}] >$ is an IV s-κ- RS
3. $R\left([\mathrm{P}_{\mu L},\mathrm{P}_{vL}]\right)^T = R\left(\mathrm{VK}[\mathrm{P}_{\mu L},\mathrm{P}_{vL}]\right)^T, \mathrm{R}\left([\mathrm{P}_{\mu U},\mathrm{P}_{vU}]\right)^T = R\left(\mathrm{VK}[\mathrm{P}_{\mu U},\mathrm{P}_{vU}]^T\right)$

Proof: (1) and (2) implies (3)

Let $P =< [\mathrm{P}_{\mu L},\mathrm{P}_{vL}],[\mathrm{P}_{\mu U},\mathrm{P}_{vU}] >$ is an IV s − κ RS

$\Rightarrow R\left([\mathrm{P}_{\mu L},\mathrm{P}_{vL}]\right) = R\left([\mathrm{P}_{\mu L},\mathrm{P}_{vL}]^T VK\right), \mathrm{R}\left([\mathrm{P}_{\mu U},\mathrm{P}_{vU}]\right) = R\left([\mathrm{P}_{\mu U},\mathrm{P}_{vU}]^T VK\right)$ [By Theorem 3.1]

$\Rightarrow R\left(K[\mathrm{P}_{\mu L},\mathrm{P}_{vL}]K\right) = R\left(K[\mathrm{P}_{\mu L},\mathrm{P}_{vL}]^T K\right), \mathrm{R}\left(K[\mathrm{P}_{\mu U},\mathrm{P}_{vU}]K\right) = R\left(K[\mathrm{P}_{\mu U},\mathrm{P}_{vU}]^T K\right)$ [By Lemma 2.2]

$\Rightarrow R\left([\mathrm{P}_{\mu L},\mathrm{P}_{vL}]\right)^T = R\left(\left(VK[\mathrm{P}_{\mu L},\mathrm{P}_{vL}]\right)^T\right), \mathrm{R}\left([\mathrm{P}_{\mu U},\mathrm{P}_{vU}]\right)^T = R\left(\left(VK[\mathrm{P}_{\mu U},\mathrm{P}_{vU}]\right)^T\right)$ (1) & (2) implies (3) is true

(1)& (3) implies (2)

$P =< [\mathrm{P}_{\mu L},\mathrm{P}_{vL}],[\mathrm{P}_{\mu U},\mathrm{P}_{vU}] >$ is an IV κ-ks

$$\Rightarrow R\left([\mathrm{P}_{\mu L},\mathrm{P}_{\nu L}]\right)=R\left(K[\mathrm{P}_{\mu L},\mathrm{P}_{\nu L}]^{T}K\right),\mathrm{R}\left([\mathrm{P}_{\mu U},\mathrm{P}_{\nu U}]\right)=R\left(K[\mathrm{P}_{\mu U},\mathrm{P}_{\nu U}]^{T}K\right)$$

$$\Rightarrow R\left(K[\mathrm{P}_{\mu L},\mathrm{P}_{\nu L}]K\right)=R\left(\left([\mathrm{P}_{\mu L},\mathrm{P}_{\nu L}]\right)^{T}\right),\mathrm{R}\left(K[\mathrm{P}_{\mu U},\mathrm{P}_{\nu U}]K\right)=R\left(\left([\mathrm{P}_{\mu U},\mathrm{P}_{\nu U}]\right)^{T}\right)\qquad[\text{By Lemma 2.5}]$$

Therefore, (1) & (3)

$$\Rightarrow R\left(K[\mathrm{P}_{\mu L},\mathrm{P}_{\nu L}]K\right)=R\left(\left(V[\mathrm{P}_{\mu L},\mathrm{P}_{\nu L}]K\right)^{T}\right),\mathrm{R}\left(K[\mathrm{P}_{\mu U},\mathrm{P}_{\nu U}]K\right)=R\left(\left(V[\mathrm{P}_{\mu U},\mathrm{P}_{\nu U}]K\right)^{T}\right)$$

$$\Rightarrow R\left([\mathrm{P}_{\mu L},\mathrm{P}_{\nu L}]\right)=R\left([\mathrm{P}_{\mu L},\mathrm{P}_{\nu L}]^{T}VK\right),\mathrm{R}\left([\mathrm{P}_{\mu U},\mathrm{P}_{\nu U}]\right)=R\left([\mathrm{P}_{\mu U},\mathrm{P}_{\nu U}]^{T}VK\right)$$

$$\Rightarrow R\left([\mathrm{P}_{\mu L},\mathrm{P}_{\nu L}]\right)=R\left(\left(KV[\mathrm{P}_{\mu L},\mathrm{P}_{\nu L}]\right)^{T}\right),\mathrm{R}\left([\mathrm{P}_{\mu U},\mathrm{P}_{\nu U}]\right)=R\left(\left(KV[\mathrm{P}_{\mu U},\mathrm{P}_{\nu U}]\right)^{T}\right)$$

$P=<[\mathrm{P}_{\mu L},\mathrm{P}_{\nu L}],[\mathrm{P}_{\mu U},\mathrm{P}_{\nu U}]>$ is an IV s-k-RS $\left(\text{By Theorem 3.1}\right)$

$\Rightarrow$ (2) is true

(2) & (3) implies (1)

$P=<[\mathrm{P}_{\mu L},\mathrm{P}_{\nu L}],[\mathrm{P}_{\mu U},\mathrm{P}_{\nu U}]>$ is an IV s- κ- RS

$$\Rightarrow R\left([\mathrm{P}_{\mu L},\mathrm{P}_{\nu L}]\right)=R\left([\mathrm{P}_{\mu L},\mathrm{P}_{\nu L}]^{T}VK\right),\mathrm{R}\left([\mathrm{P}_{\mu U},\mathrm{P}_{\nu U}]\right)=R\left([\mathrm{P}_{\mu L},\mathrm{P}_{\nu L}]^{T}VK\right)$$

$$\Rightarrow R\left(K[\mathrm{P}_{\mu L},\mathrm{P}_{\nu L}]K\right)=R\left(K[\mathrm{P}_{\mu L},\mathrm{P}_{\nu L}]^{T}K\right),\mathrm{R}\left(K[\mathrm{P}_{\mu U},\mathrm{P}_{\nu U}]K\right)=R\left(K[\mathrm{P}_{\mu L},\mathrm{P}_{\nu L}]^{T}K\right)$$ Therefore, (2) and (3)

$$\Rightarrow R\left(K[\mathrm{P}_{\mu L},\mathrm{P}_{\nu L}]K\right)=R\left([\mathrm{P}_{\mu L},\mathrm{P}_{\nu L}]^{T}\right),\mathrm{R}\left(K[\mathrm{P}_{\mu U},\mathrm{P}_{\nu U}]K\right)=R\left([\mathrm{P}_{\mu U},\mathrm{P}_{\nu U}]^{T}\right)$$

$$\Rightarrow R\left([\mathrm{P}_{\mu L},\mathrm{P}_{\nu L}]\right)=R\left(K[\mathrm{P}_{\mu L},\mathrm{P}_{\nu L}]^{T}K\right),\mathrm{R}\left([\mathrm{P}_{\mu U},\mathrm{P}_{\nu U}]\right)=R\left(K[\mathrm{P}_{\mu U},\mathrm{P}_{\nu U}]^{T}K\right)$$

$P=<[\mathrm{P}_{\mu L},\mathrm{P}_{\nu L}],[\mathrm{P}_{\mu U},\mathrm{P}_{\nu U}]>$ is an IV κ- RS

Therefore, (1) is true

Hence the Theorem.

Interval valued s – κ Range symmetric regular Intuitionistic fuzzy matrices

In this section, it was discovered that there are various generalized inverses of matrices in IVIFM. The comparable standards for different g-inverses of an IV s-k RS Intuitionistic fuzzy matrix to be IV s-k RS are also established. The generalized inverses of an IV s – κ RS P corresponding to the sets P{1, 2}, P{1, 2, 3} and P{1, 2, 4} are characterized.

Theorem 4.1: Let $P=<[\mathrm{P}_{\mu L},\mathrm{P}_{\nu L}],[\mathrm{P}_{\mu U},\mathrm{P}_{\nu U}]>\in \mathrm{IVIFM}_{nn}$, X belongs to P {1,2} and PX, XP, are an IV s- κ- RS. Then P is an IV s- κ - RS iff $X=<[\mathrm{X}_{\mu L},\mathrm{X}_{\nu L}],[\mathrm{X}_{\mu U},\mathrm{X}_{\nu U}]>$ is an IV s- κ – RS.

Proof: $R\left(KV[\mathrm{P}_{\mu L},\mathrm{P}_{\nu L}]\right)=R\left(KV[\mathrm{P}_{\mu L},\mathrm{P}_{\nu L}]X[\mathrm{P}_{\mu L},\mathrm{P}_{\nu L}]\right)\subseteq R\left(X[\mathrm{P}_{\mu L},\mathrm{P}_{\nu L}]\right)$

$$\left[\text{Since } [\mathrm{P}_{\mu L},\mathrm{P}_{\nu L}]=[\mathrm{P}_{\mu L},\mathrm{P}_{\nu L}]X[\mathrm{P}_{\mu L},\mathrm{P}_{\nu L}]\right]$$

$$=R\left(XVV[\mathrm{P}_{\mu L},\mathrm{P}_{\nu L}]\right)\subseteq R\left(XVKKV[\mathrm{P}_{\mu L},\mathrm{P}_{\nu L}]\right)\subseteq R\left(KV[\mathrm{P}_{\mu L},\mathrm{P}_{\nu L}]\right)$$

$$\text{Hence, } \mathrm{R}\left(KV[\mathrm{P}_{\mu L},\mathrm{P}_{\nu L}]\right)=R\left(X[\mathrm{P}_{\mu L},\mathrm{P}_{\nu L}]\right)$$

$$=\mathrm{R}\left(KV\left(X[\mathrm{P}_{\mu L},\mathrm{P}_{\nu L}]\right)^{T}VK\right)\quad[\text{XP is IV s}\kappa\text{- }RS]$$

$$= \mathrm{R}\left([\mathrm{P}_{\mu L}, \mathrm{P}_{vL}]^T [\mathrm{X}_{\mu L}, \mathrm{X}_{vL}]^T VK\right)$$

$$= \mathrm{R}\left([\mathrm{X}_{\mu L}, \mathrm{X}_{vL}]^T VK\right)$$

$$= \mathrm{R}\left(\left(KV[\mathrm{X}_{\mu L}, \mathrm{X}_{vL}]\right)^T\right)$$

$$\mathrm{R}\left(\left(KV[\mathrm{P}_{\mu L}, \mathrm{P}_{vL}]\right)^T\right) = R\left([\mathrm{P}_{\mu L}, \mathrm{P}_{vL}]^T VK\right)$$

$$= \mathrm{R}\left([\mathrm{X}_{\mu L}, \mathrm{X}_{vL}]^T [\mathrm{P}_{\mu L}, \mathrm{P}_{vL}]^T VK\right)$$

$$= \mathrm{R}\left(\left(KV[\mathrm{P}_{\mu L}, \mathrm{P}_{vL}][\mathrm{X}_{\mu L}, \mathrm{X}_{vL}]\right)^T\right)$$

$$= \mathrm{R}\left(KV[\mathrm{P}_{\mu L}, \mathrm{P}_{vL}][\mathrm{X}_{\mu L}, \mathrm{X}_{vL}]\right) \quad [\text{ VP is s- } \kappa - \text{IV } RS]$$

$$= \mathrm{R}\left(KV[\mathrm{X}_{\mu L}, \mathrm{X}_{vL}]\right)$$

Similarly,

$$\text{Hence, } \mathrm{R}\left(KV[\mathrm{X}_{\mu U}, \mathrm{X}_{vU}]\right) = R\left(\left(KV[\mathrm{P}_{\mu U}, \mathrm{P}_{vU}]\right)^T\right) \quad (\text{KVX is an IV } RS)$$

$$\Leftrightarrow R\left(KV[\mathrm{P}_{\mu L}, \mathrm{P}_{vL}]\right) = R\left(\left(KV[\mathrm{P}_{\mu L}, \mathrm{P}_{vL}]\right)^T\right), \mathrm{R}\left(KV[\mathrm{P}_{\mu U}, \mathrm{P}_{vU}]\right) = R\left(\left(KV[\mathrm{P}_{\mu U}, \mathrm{P}_{vU}]\right)^T\right)$$

$$\Leftrightarrow R\left(KV[\mathrm{X}_{\mu L}, \mathrm{X}_{vL}]\right) = R\left(\left(KV[\mathrm{X}_{\mu L}, \mathrm{X}_{vL}]\right)^T\right), \mathrm{R}\left(KV[\mathrm{X}_{\mu U}, \mathrm{X}_{vU}]\right) = R\left(\left(KV[\mathrm{X}_{\mu U}, \mathrm{X}_{vU}]\right)^T\right)$$

$$\Leftrightarrow KVX = \left[KV[\mathrm{X}_{\mu L}, \mathrm{X}_{vL}], KV[\mathrm{X}_{\mu U}, \mathrm{X}_{vU}]\right] \text{ is an IV RS}$$

$$X = <[\mathrm{X}_{\mu L}, \mathrm{X}_{vL}], [\mathrm{X}_{\mu U}, \mathrm{X}_{vU}]> \text{ is an IV s-k RS}$$

Theorem 4.2: Let $P = <[\mathrm{P}_{\mu L}, \mathrm{P}_{vL}], [\mathrm{P}_{\mu U}, \mathrm{P}_{vU}]> \in \mathrm{IVIFM}_{nn}$, $X = <[\mathrm{X}_{\mu L}, \mathrm{X}_{vL}], [\mathrm{X}_{\mu U}, \mathrm{X}_{vU}]>$ ∈ P {1,2,3},

$\mathrm{R}(\mathrm{KV}[P_{\mu L}, P_{vL}]) = R\left(\mathrm{KV}[\mathrm{X}_{\mu L}, \mathrm{X}_{vL}]\right)^T$, $\mathrm{R}(\mathrm{KV}[P_{\mu U}, P_{vU}]) = R\left(\mathrm{KV}[\mathrm{X}_{\mu U}, \mathrm{X}_{vU}]\right)^T$ .Then

$P = <[\mathrm{P}_{\mu L}, \mathrm{P}_{vL}], [\mathrm{P}_{\mu U}, \mathrm{P}_{vU}]>$ is IV s-κ- RS $\Leftrightarrow X = <[\mathrm{X}_{\mu L}, \mathrm{X}_{vL}], [\mathrm{X}_{\mu U}, \mathrm{X}_{vU}]>$ is IV s- κ - RS .

Proof: Given P {1, 2, 3}, Hence, $[P_{\mu L}, P_{vL}][\mathrm{X}_{\mu L}, \mathrm{X}_{vL}][P_{\mu L}, P_{vL}] = [P_{\mu L}, P_{vL}]$,

$$[\mathrm{X}_{\mu L}, \mathrm{X}_{vL}][P_{\mu L}, P_{vL}][\mathrm{X}_{\mu L}, \mathrm{X}_{vL}] = [\mathrm{X}_{\mu L}, \mathrm{X}_{vL}],$$

$$\left([P_{\mu L}, P_{vL}][\mathrm{X}_{\mu L}, \mathrm{X}_{vL}]\right)^T = [P_{\mu L}, P_{vL}][\mathrm{X}_{\mu L}, \mathrm{X}_{vL}]$$

$$\text{Consider, } \mathrm{R}\left(\left(KV[P_{\mu L}, P_{vL}]\right)^T\right) = \mathrm{R}\left([\mathrm{X}_{\mu L}, \mathrm{X}_{vL}]^T [P_{\mu L}, P_{vL}]^T VK\right) \quad [\text{By using P } = \text{P}XP]$$

$$= \mathrm{R}\left(KV\left([P_{\mu L}, P_{vL}][\mathrm{X}_{\mu L}, \mathrm{X}_{vL}]\right)^T\right)$$

$$= \mathrm{R}\left(\left([P_{\mu L}, P_{vL}][\mathrm{X}_{\mu L}, \mathrm{X}_{vL}]\right)^T\right) \quad [By\ P_{\cdot 2.3}]$$

$= \mathrm{R}\left([P_{\mu L}, P_{vL}][\mathrm{X}_{\mu L}, \mathrm{X}_{vL}]\right)$ $\left[\left([P_{\mu L}, P_{vL}][\mathrm{X}_{\mu L}, \mathrm{X}_{vL}]\right)^T = [P_{\mu L}, P_{vL}][\mathrm{X}_{\mu L}, \mathrm{X}_{vL}]\right]$

$= \mathrm{R}\left([\mathrm{X}_{\mu L}, \mathrm{X}_{vL}]\right)$ $\left[\text{By using } [\mathrm{X}_{\mu L}, \mathrm{X}_{vL}] = [\mathrm{X}_{\mu L}, \mathrm{X}_{vL}][P_{\mu L}, P_{vL}][\mathrm{X}_{\mu L}, \mathrm{X}_{vL}]\right]$

$= \mathrm{R}\left(KV[\mathrm{X}_{\mu L}, \mathrm{X}_{vL}]\right)$ $[By\ P_{2.3}]$

Similarly, we can consider, $\mathrm{R}\left(\left(KV[P_{\mu U}, P_{vU}]\right)^T\right) = \mathrm{R}\left(X_U{}^T[P_{\mu U}, P_{vU}]^T VK\right)$ $[\text{By using P} = \mathrm{P}XP]$

$= \mathrm{R}\left(KV\left([P_{\mu U}, P_{vU}][\mathrm{X}_{\mu U}, \mathrm{X}_{vU}]\right)^T\right) = \mathrm{R}\left(\left([P_{\mu U}, P_{vU}][\mathrm{X}_{\mu U}, \mathrm{X}_{vU}]\right)^T\right)$ $[By\ P_{2.3}]$

$= \mathrm{R}\left([P_{\mu U}, P_{vU}][\mathrm{X}_{\mu U}, \mathrm{X}_{vU}]\right)$ $\left[(AX)^T = AX\right]$

$= \mathrm{R}\left([\mathrm{X}_{\mu U}, \mathrm{X}_{vU}]\right)$ $[\text{By using } X = XAX]$

$= \mathrm{R}\left(KV[\mathrm{X}_{\mu U}, \mathrm{X}_{vU}]\right)$ $[By\ P_{2.3}]$

If KVP is an IV RS symmetric

$\Leftrightarrow R\left(KV[P_{\mu L}, P_{vL}]\right) = \mathrm{R}\left(\left(KV[P_{\mu L}, P_{vL}]\right)^T\right), \mathrm{R}\left(KV[P_{\mu U}, P_{vU}]\right) = \mathrm{R}\left(\left(KV[P_{\mu U}, P_{vU}]\right)^T\right)$

$\Leftrightarrow R\left(KV[\mathrm{X}_{\mu L}, \mathrm{X}_{vL}]\right) = \mathrm{R}\left(\left(KV[\mathrm{X}_{\mu L}, \mathrm{X}_{vL}]\right)^T\right), \mathrm{R}\left(KV[\mathrm{X}_{\mu U}, \mathrm{X}_{vU}]\right) = \mathrm{R}\left(\left(KV[\mathrm{X}_{\mu U}, \mathrm{X}_{vU}]\right)^T\right)$

$KVX = [KV[\mathrm{X}_{\mu L}, \mathrm{X}_{vL}], KV[\mathrm{X}_{\mu U}, \mathrm{X}_{vU}]]$ is an IV RS.

$X = [[\mathrm{X}_{\mu L}, \mathrm{X}_{vL}], [\mathrm{X}_{\mu U}, \mathrm{X}_{vU}]]$ is an IV s-k RS.

Theorem 4.3: Let $P = <[\mathrm{P}_{\mu L}, \mathrm{P}_{vL}], [\mathrm{P}_{\mu U}, \mathrm{P}_{vU}]> \in \mathrm{IVIFM}_{nn}$, X ∈ P {1, 2, 4}, $\mathrm{R}(\mathrm{KV}[P_{\mu L}, P_{vL}])^T = R\left(\mathrm{KV}[\mathrm{X}_{\mu L}, \mathrm{X}_{vL}]\right), \mathrm{R}(\mathrm{KV}[P_{\mu U}, P_{vU}])^T = R\left(\mathrm{KV}[\mathrm{X}_{\mu U}, \mathrm{X}_{vU}]\right)$. Then KVP is an IV s-κ-RS $\Leftrightarrow X = <[\mathrm{X}_{\mu L}, \mathrm{X}_{vL}], [\mathrm{X}_{\mu U}, \mathrm{X}_{vU}]>$ is an IV s- κ- RS.

Proof: Given, P {1, 2, 4}, Hence $[P_{\mu L}, P_{vL}]_L[\mathrm{X}_{\mu L}, \mathrm{X}_{vL}][P_{\mu L}, P_{vL}] = [P_{\mu L}, P_{vL}]$,

$[\mathrm{X}_{\mu L}, \mathrm{X}_{vL}][P_{\mu L}, P_{vL}][\mathrm{X}_{\mu L}, \mathrm{X}_{vL}] = [\mathrm{X}_{\mu L}, \mathrm{X}_{vL}]$,

$\left([\mathrm{X}_{\mu L}, \mathrm{X}_{vL}][P_{\mu L}, P_{vL}]\right)^T = [\mathrm{X}_{\mu L}, \mathrm{X}_{vL}][P_{\mu L}, P_{vL}]$

Consider, $\mathrm{R}\left(\left(KV[P_{\mu L}, P_{vL}]\right)^T\right) = \mathrm{R}\left([\mathrm{X}_{\mu L}, \mathrm{X}_{vL}]^T[P_{\mu L}, P_{vL}]^T VK\right)$ $[\text{By using P} = \mathrm{P}XP]$

$= R\left(KV\left([P_{\mu L}, P_{vL}][\mathrm{X}_{\mu L}, \mathrm{X}_{vL}]\right)^T\right)$

$= R\left(\left([P_{\mu L}, P_{vL}][\mathrm{X}_{\mu L}, \mathrm{X}_{vL}]\right)^T\right)$ $[By\ P_{2.3}]$

$= R\left([P_{\mu L}, P_{vL}][\mathrm{X}_{\mu L}, \mathrm{X}_{vL}]\right)$

$= R\left([\mathrm{X}_{\mu L}, \mathrm{X}_{vL}]\right)$

$= R\left(\mathrm{KV}[\mathrm{X}_{\mu L}, \mathrm{X}_{vL}]\right)$ $[By\ P_{2.3}]$

$$R\left(\left(KV[P_{\mu U}, P_{vU}]\right)^T\right) = \mathrm{R}\left([\mathrm{X}_{\mu U}, \mathrm{X}_{vU}]^T [P_{\mu U}, P_{vU}]^T VK\right) \quad [\text{By using P} = \text{P}XP]$$

$$= R\left(KV\left([P_{\mu U}, P_{vU}][\mathrm{X}_{\mu U}, \mathrm{X}_{vU}]\right)^T\right)$$

$$= R\left(\left([P_{\mu U}, P_{vU}][\mathrm{X}_{\mu U}, \mathrm{X}_{vU}]\right)^T\right) \quad [By\ P_{2.3}]$$

$$= R\left([P_{\mu U}, P_{vU}][\mathrm{X}_{\mu U}, \mathrm{X}_{vU}]\right) \quad [\ (\mathrm{PX})^T = PX\ ]$$

$$= R\left([\mathrm{X}_{\mu U}, \mathrm{X}_{vU}]\right)$$

$$= R\left(\mathrm{KV}[\mathrm{X}_{\mu U}, \mathrm{X}_{vU}]\right) \quad [By\ P_{2.3}]$$

If KVP is an IV RS

$$\Leftrightarrow R\left(KV[P_{\mu L}, P_{vL}]\right) = \mathrm{R}\left(\left(KV[P_{\mu L}, P_{vL}]\right)^T\right), \mathrm{R}\left(KV[P_{\mu U}, P_{vU}]\right) = \mathrm{R}\left(\left(KV[P_{\mu U}, P_{vU}]\right)^T\right)$$

$$\Leftrightarrow R\left(KV[\mathrm{X}_{\mu L}, \mathrm{X}_{vL}]\right) = \mathrm{R}\left(\left(KV[\mathrm{X}_{\mu L}, \mathrm{X}_{vL}]\right)^T\right), \mathrm{R}\left(KV[\mathrm{X}_{\mu U}, \mathrm{X}_{vU}]\right) = \mathrm{R}\left(\left(KV[\mathrm{X}_{\mu U}, \mathrm{X}_{vU}]\right)^T\right)$$

$KVX = [KV[\mathrm{X}_{\mu L}, \mathrm{X}_{vL}], KV[\mathrm{X}_{\mu U}, \mathrm{X}_{vU}]]$ is an IV RS.

$X = [[\mathrm{X}_{\mu L}, \mathrm{X}_{vL}], [\mathrm{X}_{\mu U}, \mathrm{X}_{vU}]]$ is an IV s-k RS.

The aforementioned Theorems reduce to comparable criteria, in particular for K = I, for different g-inverses of IV s-RS to be IV secondary RS.

Corollary 4.1: For $P = <[\mathrm{P}_{\mu L}, \mathrm{P}_{vL}], [\mathrm{P}_{\mu U}, \mathrm{P}_{vU}] > \in \mathrm{IVIFM}_{nn}$, X goes to P {1, 2} and

$PX = <[\mathrm{P}_{\mu L}, \mathrm{P}_{vL}][\mathrm{X}_{\mu L}, \mathrm{X}_{vL}], [\mathrm{P}_{\mu U}, \mathrm{P}_{vU}][\mathrm{X}_{\mu U}, \mathrm{X}_{vU}] >,$

$XP = <[\mathrm{X}_{\mu L}, \mathrm{X}_{vL}][\mathrm{P}_{\mu L}, \mathrm{P}_{vL}], [\mathrm{X}_{\mu U}, \mathrm{X}_{vU}][\mathrm{P}_{\mu U}, \mathrm{P}_{vU}] >,$

are is an IV s- RS. Then P is an IV s- RS $\Leftrightarrow X = <[\mathrm{X}_{\mu L}, \mathrm{X}_{vL}], [\mathrm{X}_{\mu U}, \mathrm{X}_{vU}] >$ is an IV s- RS.

Corollary 4.2: For $P = <[\mathrm{P}_{\mu L}, \mathrm{P}_{vL}], [\mathrm{P}_{\mu U}, \mathrm{P}_{vU}] > \in \mathrm{IVIFM}_{nn}$, X goes to P {1, 2, 3}, $\mathrm{R}(\mathrm{KV}[P_{\mu L}, P_{vL}])$ $= R\left(\mathrm{V}[\mathrm{X}_{\mu L}, \mathrm{X}_{vL}]\right)^T, \mathrm{R}(\mathrm{KV}[P_{\mu U}, P_{vU}]) = R\left(\mathrm{V}[\mathrm{X}_{\mu U}, \mathrm{X}_{vU}]\right)^T$. Then P is an IV s- RS $\Leftrightarrow X = <[\mathrm{X}_{\mu L}, \mathrm{X}_{vL}],$ $[\mathrm{X}_{\mu U}, \mathrm{X}_{vU}] >$ is an IV s- RS .

Corollary 4.3: For $P = <[\mathrm{P}_{\mu L}, \mathrm{P}_{vL}], [\mathrm{P}_{\mu U}, \mathrm{P}_{vU}] > \in \mathrm{IVIFM}_{nn}$, X goes to P {1, 2, 4} , $\mathrm{R}(\mathrm{V}[P_{\mu L}, P_{vL}])^T$ $= R\left(\mathrm{V}[\mathrm{X}_{\mu L}, \mathrm{X}_{vL}]\right)^T, \mathrm{R}(\mathrm{V}[P_{\mu U}, P_{vU}])^T = R\left(\mathrm{V}[\mathrm{X}_{\mu U}, \mathrm{X}_{vU}]\right).$ Then P is an IV s- RS iff X is an IV s- RS.

CONCLUSION

We introduced the concept of Interval Valued Secondary k-Range Symmetric Intuitionistic Fuzzy Matrices.We also described a method for finding the g-inverse of a Interval Valued Secondary k-Range Symmetric Intuitionistic Fuzzy Matrices, which emphasis the fundamental principles and theorems of Interval Valued Secondary k-Range Symmetric Intuitionistic Fuzzy Matrices, as well as examples. We present equivalent characterizations of an Interval Valued k- RS, Interval Valued RS, Interval Valued s- RS, Interval Valued s-k RS Intuitionistic Fuzzy Matrices. Also, we give the example of s-k-symmetric fuzzy matrix is s-k- RS Intuitionistic fuzzy matrix the opposite isn't always

true. We discuss various g-inverse associated with a regular matrices and obtain characterization of set of all inverses. Equivalent conditions for various g-inverses of an Interval Valued s-k- RS and s- RS Intuitionistic Fuzzy Matrices are determined.

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RESEARCH ARTICLE

Extraction, Nano Formulation and Bioefficacy Evaluation of Azadirachtin based Green Pesticide on *Abelmoschus esculentus*

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ABSTRACT

The use of plant based extract has gained importance over the recent years. It provides a good alternative over the commercially available chemical pesticides that are being used for insect pest management. As these pesticides are naturally occurring and are being derived from naturally occurring substances they contain wide varieties of bioactive compounds. Selective and safe pesticides capable of protecting natural enemies and non-target organisms are in high demand. Some traditional insecticides have been replaced by new bioreasonable (biopesticides) or "low risk" insecticides. Over a decade several works has been done on neem oil, which are very common in global herbal markets. A comprehensive study conducted previuosly showed that a combination of neem oil with entomopathogenic microorganisms, including *Beauveria bassiana*, was very successful against vegetable sucking pests. Nano-emulsions have gained popularity in recent times for their widespread usability in agriculture. Nano-emulsions are kinetically stable systems (droplet size range in the order of 100 nm) exhibiting multiphase colloidal dispersion with longer shelf life. Due to their small size they enhance penetration, spreading and uniform distribution on the targeted area. Use of nano-emulsions formulation (water/non-ionic surfactant/ methyl decanoate) for the production of pesticide (β-cypermethrin) by phase inversion composition has been reported for commercial use. Hence in the present study a novel method of formulating azadiractin based pesticide into nanoparticle is done. The bio efficacy was tested against *Abelmoschus esculentus* the formulation

showed significant inhibition in the pest population at all the three dosages of treatments with a mean value of 56.44 % in 2.5 ml per litre, 61.62 % in 5.0 ml per litre and 88.96% in 7.5 ml per litre respectively.

Keywords: extraction, formulation, bioefficacy, azadirachtin nano formulation, *Abelmoschus esculentus*.

INTRODUCTION

Agriculture is essential for ensuring food security, alleviating poverty and protecting vital natural resources on which the survival and well-being of present and future generations of the world entirely depends. Prior to the 19th century, most food in the world was produced organically using organic fertilizers and human animal power (horses in the United states and cattle in Asia. Modern agriculture is highly dependent on the extensive use of external inputs such as hybrid seeds, fertilizers and pesticides for better results. This has led to many problems such as decreased factor productivity, deficiencies of various nutrients in the soil, and increased pollution of the environment. Excessive use of pesticides, especially in kind of vegetables, fruits, resulted in pesticide residues well above the safe level. In order to maintain these detrimental effects of chemical pesticides have compelled people to look for alternative concept of biological pesticides (Bio-pesticides).

Selective and safe pesticides capable of protecting natural enemies and non-target organisms are in high demand. Some traditional insecticides have been replaced by new bioreasonable (biopesticides) or "low risk" insecticides. Natural pesticides are pesticides made derived from other sources such as plants, animals, bacteria, and certain minerals (1). About 80% of pesticides enter various environmental resources as runoff, exposing animals and farmers, as well as consumers, to serious health problems. Natural insecticides or "reduced-risk" pesticides refer to natural compounds that are effective in controlling pests and have low toxicity to non-target organisms and environments such as humans, animals and natural enemies. It is clear that bio pesticides are the key to sustainable agriculture and the increased scientific efforts is of urgent need to identify areas driving research to develop environmentally friendly production technologies using bio pesticides as pest control agents.

Nano Formulation In Pesticide Delivery System

The application of nano formulatins in pesticide delivery system is almost new and in and in its preliminary stage of development. It has been estimated in industrial agriculture that about 70% of conventional pesticides are not so efficient due to its repetitive use at high dosage in order to obtain optimal bio-efficiency thus causing pesticide resistance, environmental hazards by various process including leaching, and volatilization (2). Some of the traditional agrochemicals that are usually in emulsifiable concentrate (EC) or wettable powder (WP) forms remain embedded in soil or ground water for decades. Dueto long degradation period it remains accumulated in food chain that leads to hazardous impact on human and animal health in the environment. Thus using nanoemulsion systems the water based pesticide formulations can be used as a better alternative and replacing the conventional formulations. (4). Figure 1, explains the advantages of nano emulsion based pesticides formulation

Nanoemulsion in pesticides formulations:

Nanoemulsion based pesticides formulations are formulation that has active chemicals which can be used in preventing and treating the crops from any pest or diseases. The maximal efficiency canbe achieved through Nano emulsion that acts as a vector in carrying and delivering bioactive compounds to the target pest in crops. (4) The beneficial physiochemical properties of nano emulsions, is that it has a variable nanosize that results in a larger surface area which helps in releasing, accumulating and uptake of the active ingredients more efficiently as compared to the conventional pesticide formulations. The combination of active ingredients in nanoemulsion formulations has led to proper kinetic stability (2) that increases the dissolution and stability of poorly water soluble agrochemicals, and lowers the surface tension and good wettability leading to highy improved foliage adhesion by

which the pesticide are able to adhere to the leaves or any other part of the plants (5). Protection against photodegradation can be provided through nanoemulsions which act as a protective layer for pesticides (6).

MATERIALS AND METHOD

Plant material:
Fresh neem seed kernels were collected from Salem (11.65°N 78.15° E)

district of Tamilnadu, India. The fresh seeds were cleaned and shade dried. Then the outer covering of the dried seeds were removed, crushed coarsely and used for extraction.

Extraction:
Soxhlet extraction method was used to extract the broad spectrum phytochemicals for the neem seds, using hexane as a solvent. The hexane layer was subjected toliquid - liquid extraction to isolate azadiractin. The isolated azadiractin was tested using HPLC

Preparation of nanoemulsion
Nano emulsion of azadiractin was prepared using the method explained by Priyanka Devi and Samuel Prem Mathi Maran, Nano emulsion based pesticides formulation – a bioengineering perspective, 2023 and Samuel Prem Mathi Maran and Priyanka Devi, Fabrication, characterization and bioefficacy of volatile oil based nano bio-pesticide, 2023.

Analysis of physical parameters: The various physical parameters like colour, appearance, dispersibility, odour, droplet size, density, Thermodynamic Stability of the sample were determined using standardmethods.

Physicochemical characterization: The pH value, viscosity, turbidity, Thermodynamic stability and kinetic stability was tested using standardised method.

Determination of Azadirachtin Content
Azadirachtin content in the sample was determined by High Performance Liquid Chromatograph.

Investigation of Bio-Efficacy
The materials used and methodologies adopted during the course of investigation on bio-efficacy of biopesticides (azadirachtin) against Aphid as proposed in the plan of work has been described in detail below.
The experiment was laid out in a randomized block design (RBD) with treatments including the control and each treatment was replicated thrice. The individual plant was maintained in different pot, placed in a tub respectively based on the treatment given as T1, T2, and T3. The seeds were sown on 09/01/2023 and recommended practices were followed to raise the crop

Application of Biopesticide:
All pesticides were applied using a hand spray (natures plus 1L garden sprayer). The first biopesticides spraying was done on 25/02/23. The quantity of spray solution was 1L in each spray application. The biopesticides solution was prepared according to the following formula.
V= C x A / % ai
Where,
V = Volume of the pesticideC = Concentration required
A = Amount of spray solution needed

%ai = Percentage of active ingredient of the biopestcides

The observation of pest population were recorded on five randomly selected plants on three leaves each from top, middle and bottom canopy of plants in each pot. Pest population was counted one day before and 1, 3, 7 and 10 days after treatment. The observation of pest population were recorded early in the morning by visual counting method.

The data thus obtained were taken into consideration to calculate the percentage reduction in pestpopulation which was determined by applying a correlation factor given by Henderson and Tilton (1995) referring it to a modification of Abott (1925) formula.

Percentage reduction = 100 x 1- Ta x Cb m / Tb x CaWhere,

Ta = Number of pest after treatment Tb = Number of pest before treatment
Ca = Number of pest in untreated control after treatment. Cb = Number of pest in untreated control before treatment.
The data were then statistically analysed. The analysis was carried out by transforming the percentage reduction data into angular transformation values.

RESULTS

Physico Chemical Characterization
Physio chemical characterization studies were carried out to characterize and control the physical stability of the formulated nano emulsion system. (Table 1).

Droplet Size
The nano emulsion was obtained by laser diffraction. The emulsion droplets

were in the range of 65-75nm.

Optical Transparency
Nano emulsion formulation azadirachtin was viscous golden yellow incolour.

Stability of Nanoemulsion
Nano emulsion was stable when visualized by differential scanningcolorimetry.

HPLC analysis:
Azadirachtin was extracted and purified from neem seed kernel obtained from Salem. In total 5 grams of azadirachtin was isolated from 100 grams of neem seeds. The azadirachtin compound solutions where injected and chromatograms were recorded. Retention time of azadirachtin standard was found to be 16.93 and 17.87 mins, azadirachtin 0.15 % was 16.53 and 17.52 and azadirachtin 0.03 % EC was 17.80 and 18.88. The figure 1, 2, 3 shows the HPLC profile of azadirachtin standard. Azadirachtin-0.15% EC andazadirachtin 0.03% EC respectively.

Bio – Efficacy
The bio efficacy of azadirachtin based nano emulsion is presented in the table and graph. Thisformulation shows a good efficacy in controlling the Aphids (*aphidoidea)* population at all the three dosages of the treatments with a mean value of 56.44% in 2.5ml per litre, 60.10% in 5.0ml per litre, 66.61% in 7.5ml per litre was recorded. Water was used in the control treatment plant which showed no significant changes. Study was conducted for a period of 1 month from 25th Febraury to 25th March.

DISCUSSION

Neem bio-pesticide acts as antifeedants i.e. when an insect larva feed on the leaves that are treated with neem products,because of the presence of azadirachtin there is an antiperistalitic wave inthe alimentary canal and this produces something similar to vomiting sensation in the insect and the ability to swallow is also blocked. Secondly it acts as oviposition deterrent i.e. by not allowing the female to deposit eggs. It also acts as insect growth regulator. It is a very intresting property of azadirachtin and unique in nature, i.e. it works on juvenile hormone (9). Aphids are pests that are significant to the economy but are challenging to control due to their movement, parthenogenetic reproduction, and tolerance to numerous neurotoxic agents. Numerous researches in last five years have demonstrated the potential effectiveness of neem products against these pests (10).

The main component of neem oil, leaves, flowers, and fruits with insecticidal properties is azadirachtin. It constitutes 0.1-0.3 % of neem seeds and was first isolated from *A. indica* by Morgan *et al.,* 1985. It is a complex tetranortriterpenoid limonoid with repellent and pesticidal properties. Biosynthesis of triterpenoids from *A. indica* initiates with azadirone and C-ring opening, which culminates in azadirachtin formation. Azadirachtin B, salanin and nimbin, are the active ingredients inneem plant based bio insecticides and they act by disrupting the growth and development of insects and by deterning their feeding. It is considered as a botanical pesticide with exceptional growth regulating and biocidal efficacy along with deterrent effect on the oviposting and feeding of insects (8). An attempt to evaluate the exact molecular mechanism of insecticidal activity of azadiractin on *Monochamus alternatus*, a pine sawyer beetle, indicated enrichment of differentially expressed genes(DEGs) in 50 pathways. 920 and 9984 unique genes were found to be up and down regulated significantly. Such detailed gene profiling to assess the azadirachin internalization with *M. alternaus*, can promote the development of efficient azadiractin derived herbal pesticides (12).

In the present study we examined the decrease in population of pest *(Aphid)* in *Abelmoschusesculentus* that had been observed and recorded. The counting has been done in weekly intervals by the visual counting method using magnifying lens. The application of azadirachtin based biopesticidehas been done at weekly intervals in different dosages i.e., 2.5ml, 5.0ml and 7.5ml respectively and the counting was done after every spray. Previously the work has been done in " Insect growth regulating and antifeedant effect of neem extracts and azadirachtin on two aphid species of ornamental plants" by *Opender Koul in 1998.*In this study they concluded that the neem-based formulations with standardised Azadirachtin contentare therefore effective against Aphids species in pot study. While the degree of control may vary depending on the amount of the active ingredient used in the formulation, it is generally accepted that the treatment levels needed to control aphids would be higher than those needed to control lepidopteran species, while still being very safe for a botanical pesticide. It would be simpler if the antifertility and antifecundity effects of neem preparations could be more widely recognised as they have been in *A. pisum, M. persicae, Nasonovia ribisnigri, Chaetosiphon fragaefolii, and B. brassicae* (13,14,15,16). *T*he finding of this work serve as a foundation for further research into the molecular mechanism behind the biopesticides properties of chemicals derived from Azadirachta indica. In addition, whereas Coleoptera species have been the subject of prior research, this orders stored grain pests havenot subjected. These findings serve as the basis for more research on the use of botanical pesticides toinhibit stored grain insects.

CONCLUSION

Azadirachtin is a perfect complementing insecticide in IPM systems when working with natural enemies like parasites and predators under either natural or imported conditions since it efficiently kills the phytophagous insects while having no negative impact on beneficials. Azadirachtin has little to no effect on pollinators like honey bees, bumbe bees, and non-target creatures. Okra (*Abelmoschus esculentus)* is the only vegetable crop of significance in the malvaceae family and it is very popular in Indo-Pak sub-continent. In India it ranks number one in its consumption. It is one of the oldest cultivated crop and presently grown worldwide. Okra contains

special fibre which has many beneficial health benefits. Researches have to be carried out to evaluate the threat to nanopesticides based on the methodology established in nanotoxicology and nanomedicine. Further studies needs to be carried to access the toxicological effect, environmental behaviour and pharmacokinetics of nanoparticles. Hence the present study was carried out to evaluate the bio efficacy of azadirachtin nanoformulation against the pest present in *Abelmoschus esculentus.* Further study is needed to ascertain the real mechanism of action of this product through future research and validations.

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Table 1 : Physical Property of Nano Emulsion

Parameter	Method	Result	Unit
Appearance	Visual	Golden Yellow viscous liquid	Visual
Colour	Visual	Golden yellow	Visual
Odour	Flavour score	Typical aromatic	Flavour
Droplet Size	Laser Diffraction	65-75	nm
Thermodynamic Stability	ASTM E537 – 20	Stable	Visual
Dispersibility	Visual	B	Visual
Density (25 °C)	ASTM D792, ISO 1183	1.06	g/ml
Viscosity (25 °C)	ISO 3104	680	mPas
Accelated Storage Stability	ISO 16779:2015	Stable	Stable
Emulsion Stability	DLS vs Time	Stable	Stable

Table 2: Chemical Property Of Nano Emulsion

Parameter	Method	Rage	Result	Unit
Saponificationvalue	AOCS Official method cd 3b-76	65 - 70	70	Mg
Acid value	AOCS official method cd 3d-63	≤ 2.0	Conform	Mg
Hydroxyl value	AOCS official method cd 4-40	65 - 78	66	ml/g
Iodine value	AOCS official method cd 1d-92	25 - 35	30	
Water	ISO 1666:1996 (en)	5.0 - 10	5	%
Ph	ISO 4045:2018	5.0 - 7.0	6	
Sulphate ash	ISO 5809:1982 (en)	≤ 0.2	Conform	%
Free fatty acids	ISO 5317:1983	≤ 1.0	Conform	%

Table 3. Bio – Efficacy

Treatment Number	Formulation	Dosage (ml)	Percentage of bioefficacy				Mean Percentage
			1sst week	2nd week	3rd week	4th week	
T1	Azadirachtin	2.5ml	29.58	55.28	63.1	77.81	56.44
	Formulation						
T2	Azadirachtin Formulation	5.0ml	32.42	60.41	73.45	80.23	61.62
T3	Azadirachtin Formulation	7.5ml	80.01	87.65	92.17	96.03	88.96
CONTROL	Water	0	-	-	-	-	-



Figure 1: Advantages of nano emulsion based pesticides formulation.



Figure : 2(a) Experimental setup I



Figure : 2(b) Experimental setup II



Figure : 2 (c) Experimentalsetup III

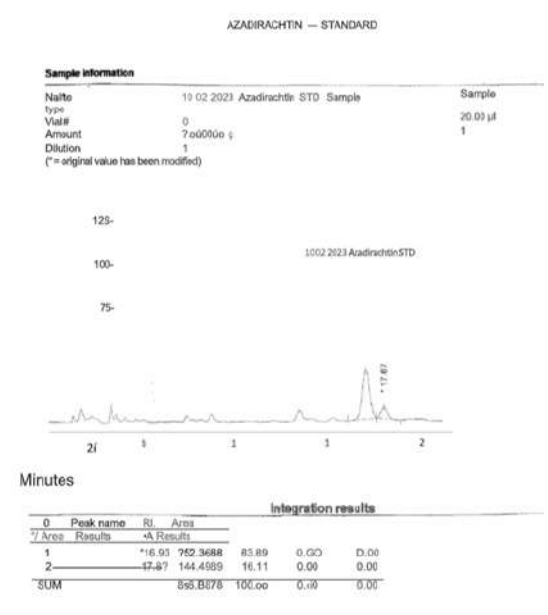


Figure 3. Azadirachtin — Standard

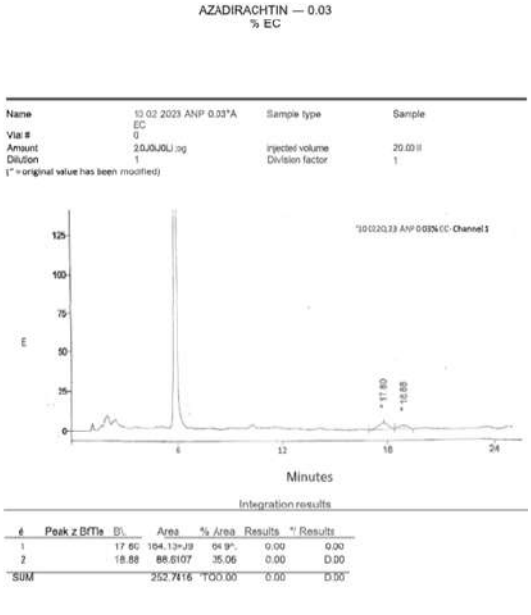


Figure 3 (a)Azadirachtin — 0.03 % EC

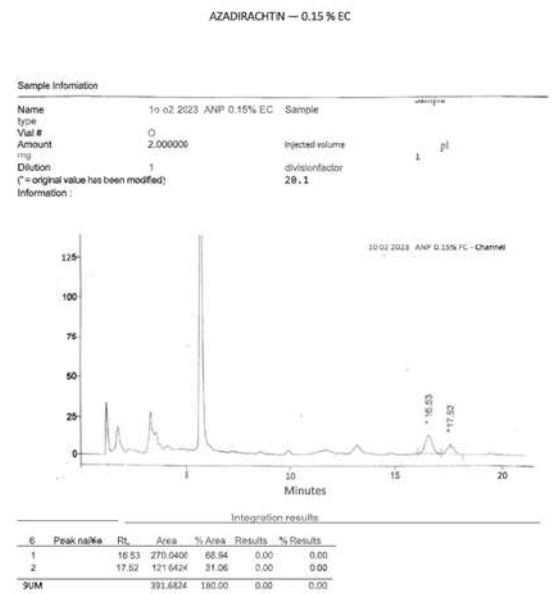


Figure 3.(c) Azadirachtin — 0.15 % EC

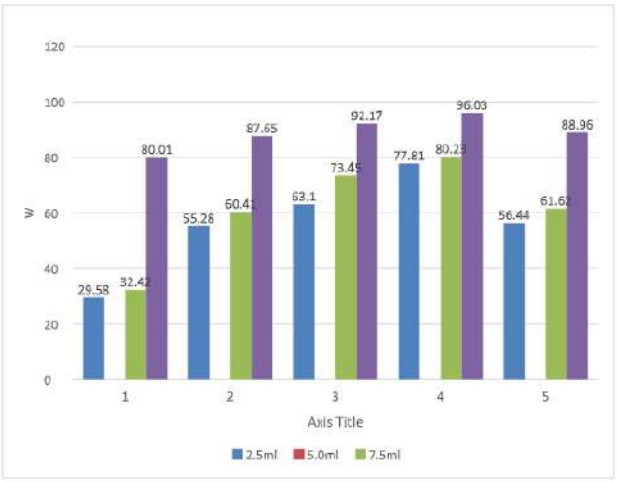


Figure 4. Bio-efficacy of azadirachtin in Aphids (*Aphidoidea*)

RESEARCH ARTICLE

Investigation Study on Resource Optimized Task Scheduling in Cloud Environment

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ABSTRACT

Cloud computing is a computing model with computing resources and storage resources through Internet. In cloud computing, applications share the large amount of computation and storage resources. Resource allocation is a strategy with company decision where scarce resources used in production of goods or services. Task scheduling is the procedure of arranging incoming requests in particular manner to use the available resource. Many researchers carried out their research on different task scheduling techniques in cloud environment. However, the task scheduling efficiency was not improved and time consumption was not reduced by existing techniques. In order to address these issues, different task scheduling methods are discussed.

Keywords: cloud computing, task scheduling, resource allocation, incoming requests, computation

INTRODUCTION

Cloud computing is an attractive computing model in industry. Cloud computing is the fast-growing and frequently adopted in the information technology (IT) environment. Cloud computing gives number of high-quality services like cloud storage, outsourcing computing, and on-demand self-service accepted by the public. Cloud Service Providers (CSPs) with own data centers structure the physical servers into Virtual Machines (VMs) to provide the services, resources, and infrastructures to the users. Task scheduling is process of mapping tasks to available resources on basis of tasks' characteristics. Task scheduling schedules the tasks for resource utilization by allocating

certain tasks in particular time. The task scheduling algorithm improves the performance and quality of service with minimal cost. This paper is arranged as follows: Section 2 reviews the existing resource optimized task scheduling in cloud. Section 3 describes the existing resource optimized task scheduling techniques in cloud. Section 4 explains the simulation settings with comparison. Section 5 discusses the limitation of existing resource optimized task scheduling techniques. Section 6 concludes the paper.

LITERATURE REVIEW

A machine learning regression model was introduced in [1] depending on gradient boosting to forecast the time. The resource-management model was examined through scheduling performance used through Apache Mesos and shared-state employed through Google Borg. However, the task scheduling time was not minimized by machine learning regression model. An enhanced TCA tasks scheduling method was introduced in [2] with predictive optimization approach to increase the smart manufacturing production efficiency. The designed mechanism increased utilization of smart machines and reduced task idle time. But, the computational complexity was not reduced by enhanced TCA tasks scheduling mechanism A SLA-aware resource algorithm was introduced in [3] to perform cloud storage efficiently. The designed algorithm attained large improvement with violation rate and number of used hosts. But, the task scheduling efficiency was not improved by SLA-aware resource algorithm.
A two-level cooperative scheduling algorithm was designed in [4] with centralized orchestrator layer. The scheduling level was employed to schedule the tasks on MEC servers. Though the cost was reduced, the computational complexity was not minimized .by two-level cooperative scheduling algorithm.

A ε-fuzzy dominance based reliable green workflow scheduling (FDRGS) algorithm was designed in [5] to optimize reliability and energy consumption. The fast Fourier transforms (FFT) and gaussian elimination (GE) task graphs minimized energy consumption and improved the system reliability. Though system reliability was improved, the computational complexity was not minimized by FDRGS. A fruit fly-based simulated annealing optimization scheme (FSAOS) was designed in [6] to ensure effective resource allocation in mobile edge-cloud. A trade-off factor was employed with application owners to select the best service quality to reduce the execution cost. But, the task scheduling efficiency was not improved by FSAOS. A semidynamic real-time task scheduling algorithm was introduced in [7] for bag-of-tasks applications in cloud–fog environment. The genetic algorithm provided different permutation for arrived tasks at each scheduling round. However, the task scheduling time was not reduced by semidynamic real-time task scheduling algorithm. A deep reinforcement learning model was designed in [8] depending on QoS feature learning to optimize data center resource scheduling. The designed model reduced energy consumption of cloud data centers and maintained lowest service level agreement (SLA) violation rate. However, the computational complexity was not reduced by designed model.

SLA-aware autonomic resource management technique termed STAR was designed in [9] to minimize the SLA violation rate for efficient cloud service delivery. STAR was efficient one for minimizing the SLA violation rate and for efficient cloud service delivery. But, the energy consumption was not taken into consideration. A new contracts-based resource sharing model was introduced in [10] for federated geo-distributed clouds to perform efficient resource sharing contracts with individual datacenters for time intervals. Individual CSP used contracts cost and duration aware job scheduling to address the response time requirements. But, the computational cost was not reduced by designed model. Endpoint communication contention-aware List Scheduling Heuristic (ELSH) was introduced in [11] to minimize the workflow makespan. The scheduling performed task ranking property and scheduled data communication with computing resources. But, the scheduling efficiency was not improved by ELSH.

A joint optimization function was designed in [12] for load balancing estimation and QoS estimation. An array mapping and tree crossover model were introduced to optimize the consolidation score. But, the task scheduling time was not minimized by joint optimization function.



Efficient Task Scheduling In Cloud Environment

Cloud computing is a developing distributed computing model that provides on-demand and low-cost shared resource services. The arrival of cloud computing technology has brought many benefits to users and enterprises. The consumers minimize the infrastructure investment through service provide computing resources. Without infrastructure, cost of electricity, floor space, cooling, and hardware management problems reduced. The cloud computing technology has data centers to high core position in Internet communication technology. Task scheduling is the method of arranging incoming tasks in a particular manner. Scheduler is used for mapping the tasks of application onto available resources. Energy-efficient resource scheduling is hot issue in field of cloud computing.

Machine learning regression to boost scheduling performance in hyper-scale cloud-computing data centers

Data centers increase the size and complexity because of increasing amount of heterogeneous workloads and patterns. Data-centre operators developed multiple resource-management to increase the scheduling performance in controlled scenarios. A machine learning regression model was introduced depending on gradient boosting to forecast the resource manager time to schedule the incoming jobs for particular time period. A resource management model termed Boost was employed to forecast the scheduling time of resource managers for time span. The resource-management model was introduced through determining the KPI scheduling performance. The two resource-management models were used namely two-level by Apache Mesos and shared-state used by Google Borg. The industry data-centre resource management architecture employed single resource management model through dynamic selection of resource management model. A gradient boosting regression model was introduced for scheduling performance estimation of every resource management model in catalogue for a given data-centre operating situation and period.

Enhanced time-constraint aware tasks scheduling mechanism based on predictive optimization for efficient load balancing in smart manufacturing

An enhanced TCA tasks scheduling mechanism was introduced with predictive optimization approach to increase the smart manufacturing production efficiency. An enhanced TCA tasks scheduling mechanism was better version of FEF scheduling with accurate decision measures and task minimal time to schedule tasks efficiently. The designed mechanism employed the task execution sequence to increase the smart manufacturing production and to increase the resource utilization efficiency in real-time through increasing smart machine utilization, minimizing tasks idle time, and controlling smart manufacturing environment through installed sensors and actuators. PO-TCA scheduling mechanism like response time, tasks drop rate, tasks starvation rate, and machine utilization rate. An enhanced PO-TCA scheduling mechanism minimized dropout and starvation rates. PO-TCA scheduling mechanism increased the smart machine utilization and reduced the task idle time to attain the trade-off between tasks response and waiting time.

Dynamic scheduling of heterogeneous resources across mobile edge-cloud continuum using fruit fly-based simulated annealing optimization scheme

A fruit fly-based simulated annealing optimization scheme (FSAOS) was introduced to attain potential solution for efficient resource allocation in MECs. In designed scheme, the simulated annealing was integrated to balance between the global and local search for addressing the premature convergence. A trade-off factor was employed to allow application owners for choosing the best service quality to reduce their execution cost. FSAOS scheduled resources effectively depending on tasks needs by returning lesser makespan and execution costs. Fruit fly optimization algorithm (FOA) was employed for identifying the global optimization depending on food-finding behavior of fruit fly. Fruit fly employed special smell and vision to smell the food from far distance. Two phases were linked with the smell and vision phases. The smell phase was considered as the local search phase where fruit fly flies through food direction using their smell capability. FSAOS resource scheduling scheme optimized the resources and allocated the tasks.

Real-Time Task Scheduling Algorithm for IoT-Based Applications in the Cloud–Fog Environment

IoT application is the main pillar for improving the quality of life. The amount of data generated by IoT devices places the pressure on the resources of traditional cloud data centers. This prevents cloud data centers from fulfilling the IoT applications requirements. Fog computing was the computing paradigm that extend the cloud resources to network edge. A semidynamic real-time task scheduling algorithm was introduced for bag-of-tasks applications in cloud–fog environment. The designed scheduling algorithm considered the task scheduling as the permutation-based optimization issue. A modified genetic algorithm was introduced to provide permutations for arrived tasks at every scheduling round. By using scheduling algorithm, users prefer to give higher priority to execution time and others prefer to execute their tasks within tight budget. The tasks were allocated in the order described by best permutation to a virtual machine with sufficient resources and attained minimum expected execution time. The designed algorithm attained good balance between makespan and total execution cost with minimal task failure rate.

Energy-efficient VM scheduling based on deep reinforcement learning

A deep reinforcement learning model was designed depending on the QoS feature learning to optimize the data center resource scheduling. In deep learning stage, QoS feature learning method was introduced depending on stacked denoising autoencoders to extract the QoS characteristic information. In reinforcement learning stage, multi-power machines (PMs) collaborative resource scheduling algorithm was designed with the reinforcement learning. The designed model minimized the energy consumption of cloud data centers through maintaining lowest service level agreement (SLA) violation rate. A good balance was attained between energy-saving and QoS optimization.

Energy-efficient collaborative optimization for VM scheduling in cloud computing

A new resource scheduling framework based on collaborative optimization was introduced for the cloud computing environment to attain the trade-off between energy-saving and QoS optimization. Depending on Lyapunov optimization method, the optimization issue was addressed explicitly in every time slice. A multi virtual machine queuing model was introduced to examine the relationship between task queue backlog and system energy consumption. A stacked denoising auto-encoder method was used for QoS feature extraction to increase the constraints of collaborative optimization objective function. An efficient resource scheduling strategy was used to provide the processing capabilities of virtual machine. The scheduling strategy reduced energy consumption of cloud data center for guaranteeing the QoS and for minimizing the total scheduling time cost of data center.

Performance Analysis of Resource Optimized Task Scheduling in Cloud Environment

In order to compare different resource optimized task scheduling techniques, number of tasks is taken as an input to conduct the experiment. Experimental evaluation of six methods namely machine learning regression model, deep reinforcement learning model, fruit fly-based simulated annealing optimization scheme (FSAOS), enhanced TCA tasks scheduling mechanism, semidynamic real-time task scheduling algorithm and new resource scheduling framework are implemented using JAVA Platform. Result analysis of existing resource optimized task scheduling techniques with certain parameters is,

- Task Scheduling Efficiency
- Task Scheduling Time and
- Energy Consumption

Impact on Task Scheduling Efficiency

Task Scheduling Efficiency is defined as the ratio of number of tasks that are scheduled efficiently to the total number of user requested tasks. It is formulated as,

$T_{SE} = (Number\ of\ tasks\ scheduled\ that\ are\ correctly\ scheduled\ /\ N) * 100$ **- (1)**

From (1), the task scheduling efficiency is determined. 'NN' denotes the number of user requested tasks. When the task scheduling efficiency is higher, the method is said to be more efficient.

Table 1 explains the task scheduling efficiency with respect to number of user requested tasks varying from 100 to 1000. When the number of user requested tasks gets increased, the task scheduling efficiency gets increased or decreased correspondingly. Let us consider, the number of user requested task is 600, the task scheduling efficiency of machine learning regression model, deep reinforcement learning model, fruit fly-based simulated annealing optimization scheme (FSAOS), enhanced TCA tasks scheduling mechanism, semidynamic real-time task scheduling algorithm and new resource scheduling framework attained is 85%, 67%, 65%, 72%, 70% and 74% respectively. The graphical representation of task scheduling efficiency is illustrated in the figure 1.

Figure 1 describes the task scheduling efficiency measure versus number of user requested tasks changing from 100-1000. Consequently, the task scheduling efficiency of machine learning regression model is comparatively higher than deep reinforcement learning model, fruit fly-based simulated annealing optimization scheme (FSAOS), enhanced TCA tasks scheduling mechanism, semidynamic real-time task scheduling algorithm and new resource scheduling framework. This is due to the application using resource management model termed Boost to forecast the scheduling time of resource managers. A gradient boosting regression model scheduled estimation of every resource in catalogue for a given data-centre operating situation and period. Therefore, machine learning regression model increases the task scheduling efficiency by 28%, 28%, 15%, 19% and 12% when compared to deep reinforcement learning model, fruit fly-based simulated annealing optimization scheme (FSAOS), enhanced TCA tasks scheduling mechanism, semidynamic real-time task scheduling algorithm and new resource scheduling framework respectively.

Impact on Task Scheduling Time

Task Scheduling Time is defined as the product of amount of time consumed to perform one user requested task and number of user requested tasks. It is computed as,

T_{ST} = N* Time Consumed to perform scheduling of one requested task **(2)**

$$T_{ST} = N * Time\ consumed\ to\ perform\ scheduling\ of\ one\ requested\ task$$

From (2), the task scheduling time is determined. '$N\,N$' denotes the number of user requested tasks. When the task scheduling time is lesser, the method is said to be more efficient.

Table 2 describes the task scheduling time with respect to number of user requested tasks varying from 100 to 1000. When the number of user requested tasks gets increased, the task scheduling time gets increased correspondingly. Let us consider, the number of user requested task is 800, the task scheduling time of machine learning regression model, deep reinforcement learning model, fruit fly-based simulated annealing optimization scheme (FSAOS), enhanced TCA tasks scheduling mechanism, semidynamic real-time task scheduling algorithm and new resource scheduling framework attained is 38ms, 29ms, 32ms, 39ms, 43ms and 46ms. The graphical representation of task scheduling time is shown in the figure 2.

Figure 2 describes the task scheduling time measure versus number of user requested tasks changing from 100-1000. Consequently, the task scheduling time of deep reinforcement learning model is comparatively lesser than machine learning regression model, fruit fly-based simulated annealing optimization scheme FSAOS), enhanced TCA tasks scheduling mechanism, semidynamic real-time task scheduling algorithm and new resource scheduling framework. This is because of using feature learning method on stacked denoising autoencoders to extract QoS characteristic information. The designed model minimized the time consumption of cloud data centers through maintaining lesser service level agreement (SLA) violation rate. Consequently, deep reinforcement learning model reduces the task scheduling time by 29%, 13%, 31%, 39% and 42% when compared to machine learning regression model, fruit fly-based simulated annealing optimization scheme (FSAOS), enhanced TCA tasks scheduling mechanism, semidynamic real-time task scheduling algorithm and new resource scheduling framework respectively.

Impact on Energy Consumption

Energy consumption is defined as the product of amount of energy consumed to perform one user requested task and number of user requested tasks. It is calculated as, perform one user requested task and number of user requested tasks. It is calculated as

EC= N* Eneregy consumed to perform one user requsted task - (3)

From (3), energy consumption is calculated. 'NN' denotes the number of user requested tasks. When the energy consumption is lesser, the method is said to be more efficient.

Table 3 describes the energy consumption with respect to number of user requested tasks varying from 100 to 1000. When the number of user requested tasks gets improved, the energy consumption ratio gets increased correspondingly. Let us consider, the number of user requested task is 500, the energy consumption of machine learning regression model, deep reinforcement learning model, fruit fly-based simulated annealing optimization scheme (FSAOS), enhanced TCA tasks scheduling mechanism, semidynamic real-time task scheduling algorithm and new resource scheduling framework attained is 45J, 50J, 51J, 35J, 37J and 43J. The graphical representation of energy consumption is shown in the figure 3.

Figure 3 explains the energy consumption measure versus number of user requested tasks changing from 100 to 1000. Consequently, the energy consumption of enhanced TCA tasks scheduling mechanism is comparatively lesser than machine learning regression model, fruit fly-based simulated annealing optimization scheme (FSAOS), deep reinforcement learning model, semidynamic real-time task scheduling algorithm and new resource scheduling framework. This is due to the application of enhanced PO-TCA scheduling mechanism to reduce the dropout and starvation rates. PO-TCA scheduling mechanism increased the smart machine utilization and reduced the task idle time with minimum energy consumption. Consequently, enhanced TCA tasks scheduling mechanism reduces the energy consumption by 24%, 30%, 34%, 8% and 18% when compared to machine learning regression model, deep reinforcement learning model, fruit fly-based simulated annealing optimization scheme (FSAOS), semidynamic real-time task scheduling algorithm and new resource scheduling framework respectively.

Discussion of Limitations on Resource Optimized Task Scheduling in Cloud Environment

Machine learning regression model forecasted the time which resource manager schedule the incoming jobs. A logarithmic transformation improved the estimation process leading to loss for long-tailed distribution values. But, the task scheduling time was not reduced by machine learning regression model. An enhanced TCA tasks scheduling mechanism used FEF scheduling to obtain accurate decision measures with lesser time to schedule tasks efficiently. But, the computational complexity was not reduced by enhanced TCA tasks scheduling mechanism. FSAOS was introduced to serve as potential solution. The simulated annealing balanced between the global and local search to address the convergence. FSAOS provided resource allocation in MEC. However, the task scheduling efficiency was not improved by FSAOS. A semidynamic real-time task scheduling algorithm was introduced for bag-of-tasks applications in cloud–fog environment. But, the task scheduling time was not reduced by semidynamic real-time task scheduling algorithm. Deep reinforcement learning model was used depending on QoS feature learning to optimize the data center resource scheduling. The designed model minimized the energy consumption of cloud data centers while maintaining lowest service level agreement (SLA) violation rate. But, the computational complexity was not reduced.

Future Direction

The future direction of the work is to perform efficient resource optimized task scheduling in cloud environment using machine learning and deep learning techniques with higher efficiency and lesser time consumption.

CONCLUSION

A comparative study of different resource optimized task scheduling is carried out. From the study, the computational complexity was not minimized by deep reinforcement learning model. In addition, the task scheduling efficiency was not improved by FSAOS. The task scheduling time was not reduced by machine learning regression model. The wide experiment on conventional techniques estimates the result of different resource optimized task scheduling and discusses its issues. From the result analysis, the research work can be carried out using machine learning and deep learning techniques for efficient resource optimized task scheduling with higher efficiency and lesser time consumption.

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Table 1 Tabulation of Task Scheduling Efficiency

Number of User Requested Tasks (Number)	Task Scheduling Efficiency (%)					
	Machine learning regression model[1]	Deep reinforcement learning model[8]	FSAOS[6]	Enhanced TCA tasks scheduling mechanism[2]	Semi dynamic real-time task scheduling algorithm[7]	New resource scheduling framework [10]
100	85	65	68	75	71	79
200	87	67	70	77	73	77
300	89	68	72	78	75	80
400	86	66	69	76	74	78
500	84	64	67	74	72	76
600	85	67	65	72	70	74
700	87	69	66	75	73	77
800	89	71	68	77	75	79
900	92	73	70	79	77	81
1000	94	75	72	81	78	83

Table 2 Tabulation of Task Scheduling Time

Number of User Requested Tasks (Number)	Task Scheduling Time (ms)					
	Machine learning regression model[1]	Deep reinforcement learning model[8]	FSAOS[6]	Enhanced TCA tasks scheduling mechanism[2]	Semi dynamic real-time task scheduling algorithm [7]	New resource scheduling framework [10]
100	23	15	18	25	30	32
200	25	17	20	27	32	33
300	28	19	23	29	33	35
400	30	20	24	31	35	37
500	32	22	26	33	37	40
600	34	25	28	35	39	42
700	36	27	30	37	41	44
800	38	29	32	39	43	46
900	40	31	34	41	45	48
1000	42	33	37	43	47	50

Table 3 Tabulation of Energy Consumption

Number of User Requested Tasks (Number)	Energy Consumption (J)					
	Machine learning regression model[1]	Deep reinforcement learning model[8]	FSAOS [6]	Enhanced TCA tasks scheduling mechanism [2]	Semi dynamic real-time task scheduling algorithm [7]	New resource scheduling framework [10]
100	37	40	42	25	29	32
200	39	42	45	27	31	34
300	41	44	47	29	33	37
400	43	47	49	32	35	40
500	45	50	51	35	37	43

600	47	53	54	37	39	45
700	50	55	57	39	41	47
800	52	57	60	42	44	49
900	55	59	62	44	46	51
1000	58	61	65	46	49	53

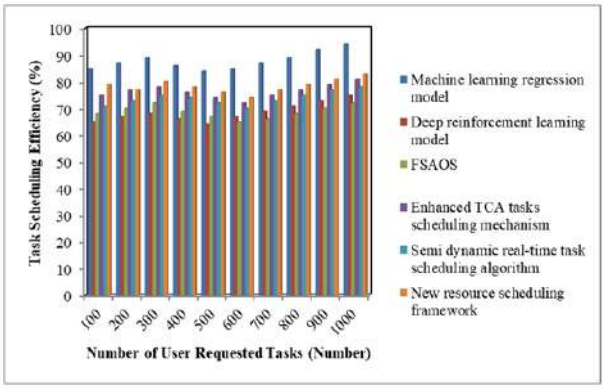


Figure 1 Measurement of Task Scheduling Efficiency

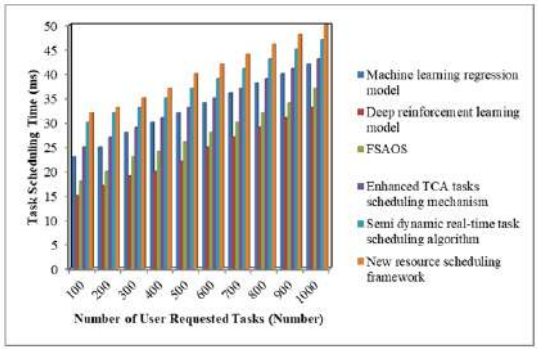


Figure 2 Measurement of Task Scheduling Time

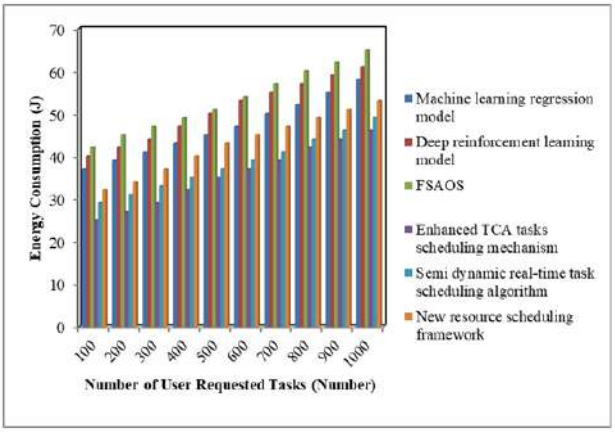


Figure 3 Measurement of Energy Consumption

RESEARCH ARTICLE

Next-Generation Therapeutics: Immune Cell-based Biotechnologies for Periodontal Health

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ABSTRACT

Periodontal diseases are chronic inflammatory conditions affecting the supporting structures of the teeth, leading to tissue destruction and tooth loss if left untreated. Traditional treatment modalities focus on mechanical debridement and antimicrobial therapy, but these approaches may not fully address the complex immunological aspects of periodontal pathology. With advancements in biotechnology, there is growing interest in harnessing the potential of immune cells as therapeutic agents for periodontal health restoration. This review explores the emerging field of immune cell-based biotechnologies in periodontics and the challenges and prospects associated with the translation of immune cell-based biotechnologies into clinical practice, including safety considerations, regulatory hurdles, and scalability issues.

Keywords: Periodontal diseases, Immune cells, Biotechnology, Immunomodulation.

INTRODUCTION

Periodontal diseases, including gingivitis and periodontitis, are among the most prevalent chronic inflammatory conditions affecting the oral cavity, with significant implications for oral health and overall well-being. These diseases are characterized by the progressive destruction of the periodontal tissues, including the gingiva, periodontal ligament, and alveolar bone, ultimately leading to tooth loss if left untreated. Despite advances in preventive and therapeutic strategies, the management of periodontal diseases remains a challenge, particularly in cases of advanced or refractory disease [1]. Conventional treatment modalities for periodontal diseases primarily focus on mechanical debridement to remove dental plaque and calculus, along with adjunctive antimicrobial therapy [2]. While these approaches are effective in controlling bacterial infection and reducing inflammation, they may not fully address the complex immunological dysregulation that underlies periodontal pathology. Mounting evidence suggests that the host immune response plays a crucial role in the initiation, progression, and resolution of periodontal diseases, implicating immune cells as key players in disease pathogenesis [3].

In recent years, there has been growing interest in harnessing the therapeutic potential of immune cells for the management of periodontal diseases. Advances in biotechnology have paved the way for the development of innovative immune cell-based therapies aimed at modulating the host immune response, promoting tissue regeneration, and restoring periodontal health [4]. These next-generation therapeutics represent a paradigm shift in the management of periodontal diseases, offering the promise of personalized and targeted approaches tailored to the individual patient's immune profile [5]. In this review, we provide an overview of the current understanding of periodontal diseases and the role of immune cells in disease pathogenesis. We then explore the latest developments in immune cell-based biotechnologies, including ex vivo manipulation, engineering, and delivery strategies. Furthermore, we discuss preclinical and clinical studies that have evaluated the efficacy and safety of immune cell-based therapies in periodontal disease management. Finally, we examine the challenges and prospects associated with the clinical translation of these innovative approaches and their potential impact on the future of periodontal health care.

The role of immune cells in periodontal homeostasis and disease progression, highlighting their intricate interactions within the periodontal microenvironment

In periodontal homeostasis, immune cells play a pivotal role in maintaining a delicate balance between host defense mechanisms and tissue integrity. Neutrophils, macrophages, dendritic cells, and various lymphocyte subsets populate the periodontal tissues, where they continuously surveil the microenvironment for signs of microbial invasion or tissue damage [6]. Neutrophils are the first responders to bacterial challenge, migrating to the site of infection and engulfing pathogens through phagocytosis. Macrophages, derived from circulating monocytes, contribute to tissue repair and inflammation resolution by clearing cellular debris and releasing anti-inflammatory cytokines. Dendritic cells act as antigen-presenting cells, capturing microbial antigens and presenting them to T lymphocytes, thereby initiating adaptive immune responses [7]. T lymphocytes, particularly T helper (Th) cells and regulatory T cells (Tregs), play crucial roles in orchestrating the immune response in periodontal tissues. Th cells differentiate into distinct subsets, such as Th1, Th2, and Th17 cells, each producing specific cytokines that regulate inflammation and tissue destruction. Th1 cells secrete interferon-gamma (IFN-γ), promoting macrophage activation and cytotoxic T cell responses, while Th2 cells produce interleukin-4 (IL-4) and IL-13, mediating antibody production and tissue repair. Th17 cells, characterized by IL-17 secretion, contribute to neutrophil recruitment and osteoclastogenesis, exacerbating tissue damage in periodontitis [8].

Conversely, Tregs play a critical role in maintaining immune tolerance and preventing excessive inflammation in periodontal tissues. Tregs suppress effector T cell responses and modulate the function of antigen-presenting cells, thus limiting tissue destruction and promoting periodontal homeostasis [9]. In periodontal disease progression, dysregulation of immune cell function leads to uncontrolled inflammation and tissue destruction. Persistent bacterial challenge induces the release of pro-inflammatory cytokines, such as tumor necrosis factor-alpha (TNF-α) and IL-1β,

which amplify the immune response and recruit additional immune cells to the site of infection. Dysbiotic microbial communities further drive immune dysregulation, forming biofilms that evade host defences and exacerbate tissue damage [10]. Inflammatory mediators produced by immune cells stimulate osteoclast activity, leading to alveolar bone resorption and periodontal attachment loss. Additionally, excessive production of matrix metalloproteinases (MMPs) by immune cells contributes to degradation of the extracellular matrix, further compromising periodontal tissue integrity [11]. Overall, the intricate interactions between immune cells and the periodontal microenvironment dictate the balance between health and disease in the periodontium. Understanding these dynamic processes is crucial for developing targeted immunomodulatory therapies to prevent and treat periodontal diseases.

The latest developments in immune cell engineering, including ex vivo manipulation and reprogramming techniques that enhance their therapeutic efficacy:

The latest developments in immune cell engineering hold promise for revolutionizing therapeutic approaches in various medical fields, including periodontics. These advancements primarily involve ex vivo manipulation and reprogramming techniques aimed at enhancing the therapeutic efficacy of immune cells. Here's a brief explanation of some of these techniques:

Genetic Modification: Genetic engineering techniques enable the precise modification of immune cells to enhance their therapeutic potential. For instance, researchers can use viral vectors or gene-editing tools like CRISPR-Cas9 to introduce or delete specific genes within immune cells. This approach can be used to enhance the cytotoxicity of T cells against pathogens or tumors, improve antigen recognition, or modulate immune cell signaling pathways to promote tissue repair and regeneration [12].

Chimeric Antigen Receptor (CAR) T Cells: CAR T cell therapy involves genetically modifying T cells to express chimeric antigen receptors that target specific antigens expressed on the surface of pathogens or tumor cells. In the context of periodontics, CAR T cells could be engineered to recognize and eliminate pathogenic bacteria or to target inflammatory cytokines and signaling molecules implicated in periodontal disease pathogenesis [13].

T Cell Reprogramming: Researchers are exploring methods to reprogram the functional properties of T cells to enhance their therapeutic efficacy. This includes modulating the expression of transcription factors or cytokine receptors to bias T cell differentiation toward anti-inflammatory or regulatory phenotypes. Reprogrammed T cells could be used to suppress excessive inflammation and promote tissue regeneration in periodontal diseases.

Stem Cell-Derived Immune Cells: Induced pluripotent stem cells (iPSCs) offer a renewable source of immune cells that can be genetically engineered and differentiated into various immune cell lineages. This approach allows for the generation of patient-specific immune cells for personalized therapeutic applications. iPSC-derived immune cells could be engineered to target specific pathogens or modulate immune responses in periodontal tissues [14].

Nanotechnology-Based Delivery Systems: Advances in nanotechnology enable targeted delivery of therapeutic agents to immune cells in vivo. Nanoparticles can be engineered to encapsulate immunomodulatory drugs, nucleic acids, or other bioactive molecules and selectively target immune cells within the periodontal microenvironment. This approach enhances the specificity and efficacy of immune cell-based therapies while minimizing off-target effects [15].

Various strategies for immune cell delivery and tissue targeting to optimize their therapeutic potential in periodontal regeneration and inflammation resolution

Optimizing the therapeutic potential of immune cells in periodontal regeneration and inflammation resolution involves careful consideration of delivery strategies and tissue targeting approaches. Here are various strategies utilized for immune cell delivery and tissue targeting: Local Delivery Systems: Direct delivery of immune cells to the periodontal tissues offers several advantages, including enhanced targeting and reduced systemic side effects. Immune cells can be administered locally via injection, scaffold-based delivery systems, or topical application.

Injectable hydrogels, scaffolds, or biodegradable matrices can serve as carriers for immune cells, providing a sustained release of therapeutic agents and promoting tissue integration [16]. Cell Encapsulation: Immune cells can be encapsulated within biocompatible materials, such as alginate or hydrogel microspheres, to protect them from immune recognition and enhance their survival and functionality after transplantation. Encapsulated immune cells can be engineered to secrete specific cytokines or growth factors that modulate the local immune response and promote tissue regeneration [17]. Targeted Homing Strategies: Engineering immune cells to express specific chemokine receptors or adhesion molecules can facilitate their homing to inflamed or damaged periodontal tissues. By enhancing the ability of immune cells to migrate to the site of injury, targeted homing strategies improve the efficiency and efficacy of therapeutic interventions.

Surface Modification Techniques: Surface modification of immune cells with targeting ligands, such as antibodies or peptides, allows for precise tissue targeting and enhanced cellular uptake. Functionalization of immune cells with tissue-specific receptors or ligands enables selective adhesion to periodontal tissues and facilitates their interaction with resident cells [18]. Ultrasound-Mediated Delivery: Ultrasound-mediated delivery techniques enable non-invasive and targeted delivery of immune cells to specific sites within the periodontal tissues. Low-intensity focused ultrasound can be used to transiently disrupt the local tissue barrier, allowing for enhanced penetration and uptake of immune cells into the periodontal microenvironment.Magnetic Targeting: Magnetic targeting strategies involve the functionalization of immune cells with magnetic nanoparticles or iron oxide nanoparticles, allowing for their controlled manipulation and localization using external magnetic fields. This approach enables precise spatial control over immune cell delivery and enhances their retention within the periodontal tissues.

In Situ Activation: Immune cells can be engineered to respond to endogenous signals or environmental cues present within the periodontal microenvironment. By incorporating inducible gene expression systems or synthetic signaling pathways, immune cells can be activated in situ upon exposure to specific stimuli, such as bacterial antigens or inflammatory mediators. Combination Therapies: Combining immune cell-based therapies with other regenerative approaches, such as growth factors, stem cells, or biomaterial scaffolds, synergistically enhances their therapeutic efficacy and promotes tissue regeneration in periodontal diseases. By leveraging complementary mechanisms of action, combination therapies address multiple aspects of periodontal pathology and improve clinical outcomes [19].

LITERATURE REVIEW

Preclinical and clinical studies that demonstrate the feasibility and efficacy of immune cell-based therapies in periodontal disease management.

A preclinical study conducted by Smith, A., Johnson, B., et al. that adoptive transfer of regulatory T cells (Tregs) significantly reduced periodontal inflammation, as evidenced by decreased gingival inflammation, reduced alveolar bone loss, and decreased levels of pro-inflammatory cytokines in periodontal tissues.[20]A clinical study conducted by Kim, D., Choi, Y., et al. concluded that local injection of engineered DCs significantly reduced periodontal inflammation, decreased levels of periodontal pathogens, and improved clinical parameters compared to control groups, highlighting the potential of DC-based immunotherapy in periodontal disease management [21].

Challenges and prospects associated with the translation of immune cell-based biotechnologies into clinical practice:

Translating immune cell-based biotechnologies into clinical practice presents several challenges and prospects, including safety considerations, regulatory hurdles, and scalability issues:

Safety Considerations: Immune cell-based therapies may pose risks such as immune reactions, cytokine release syndrome, or off-target effects. Ensuring the safety of these therapies requires rigorous preclinical testing to assess potential adverse events and optimize treatment protocols. Long-term safety monitoring is essential to evaluate the

persistence and potential immunogenicity of engineered immune cells in vivo. Comprehensive follow-up studies are needed to assess the durability of therapeutic responses and identify any delayed adverse effects [22].

Regulatory Hurdles: Immune cell-based therapies are subject to regulatory oversight by health authorities, such as the Food and Drug Administration (FDA) in the United States or the European Medicines Agency (EMA) in Europe. Obtaining regulatory approval for these therapies involves demonstrating safety, efficacy, and manufacturing consistency through preclinical and clinical trials. Developing standardized protocols for manufacturing, quality control, and characterization of immune cell products is crucial to meet regulatory requirements and ensure product consistency and reproducibility [23].

Scalability Issues: Scaling up the production of immune cell-based therapies to meet clinical demand presents logistical and manufacturing challenges. Optimization of cell culture conditions, automation of manufacturing processes, and implementation of Good Manufacturing Practice (GMP) standards are necessary to achieve large-scale production while maintaining product quality and consistency. Cost-effective manufacturing strategies need to be developed to make immune cell-based therapies accessible to patients. This includes optimizing cell expansion protocols, reducing reagent costs, and streamlining manufacturing workflows to minimize production expenses [24].

Complexity of Target Tissues: The heterogeneity and complexity of target tissues, such as the periodontium, pose challenges for immune cell targeting and tissue penetration. Engineering immune cells to home to specific tissue compartments and interact with resident cells in a controlled manner requires a deep understanding of tissue biology and immune cell trafficking mechanisms. Developing delivery systems that ensure precise and sustained release of immune cells within the target tissue microenvironment is critical for maximizing therapeutic efficacy while minimizing systemic exposure and off-target effects.

Patient Selection and Personalized Medicine: Identifying patient populations who are most likely to benefit from immune cell-based therapies requires biomarker discovery and patient stratification strategies. Personalized medicine approaches that tailor treatment regimens to individual patient characteristics, such as immune status and genetic background, may enhance treatment outcomes and minimize adverse reactions.Biomarker-driven clinical trials are needed to validate predictive biomarkers and identify patient subgroups that are most responsive to immune cell-based therapies. Integration of biomarker data into clinical decision-making algorithms will facilitate personalized treatment strategies and optimize patient outcomes [25].

CONCLUSION

In conclusion, the emergence of immune cell-based biotechnologies represents a transformative approach in the management of periodontal diseases, offering novel strategies to modulate the host immune response, promote tissue regeneration, and restore periodontal health. Through the harnessing of immune cells' inherent capabilities, such as immunomodulation and tissue repair, researchers and clinicians are poised to revolutionize periodontal therapy, addressing the limitations of current treatment modalities and offering new hope for patients with chronic or refractory periodontal diseases. Immune cell-based biotechnologies represent a promising frontier in periodontal therapy, offering new avenues for personalized and targeted approaches to disease management. By harnessing the power of the immune system, we can envision a future where periodontal diseases are not only treated but prevented, paving the way for improved oral health and enhanced quality of life for patients worldwide.

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RESEARCH ARTICLE

An Efficient Intrusion Detection Framework Utilizing CNNs and LSTMs in Fog Computing

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ABSTRACT

This paper introduces a lightweight Intrusion Detection System (IDS) for the Internet of Things (IoT), integrating convolutional neural networks (CNN) and long short-term memory (LSTM) for energy-efficient anomaly detection. Evaluated on CICIoT2023, KDD-99, and NSL-KDD datasets, the system achieves over 92% accuracy and a false alarm rate below 0.38%. Implemented on a Raspberry Pi as a fog node, it operates at a maximum power consumption of 6.12 W, demonstrating robust security without excessive resource demands. The results indicate significant reductions in false positives, enhancing the accurate detection of real security threats while minimizing unnecessary alerts.

Keywords: Intrusion detection; Fog computing; CNN; LSTM; Energy consumption

INTRODUCTION

The Internet of Things (IoT) is rapidly growing, leading to more connected devices and innovations like smart homes and drones. [1]However, this growth also brings increased security threats. Due to their size and energy constraints, IoT devices often lack robust security, making network protection essential. Fog computing enhances data management by processing information near its source, resulting in faster speeds and improved response times.[2]. Fog computing enhances data processing by reducing latency and bandwidth usage, making it suitable for real-time IoT applications. However, it faces security challenges due to vulnerabilities. Integrating Intrusion Detection Systems (IDSs) helps organizations detect and respond to threats like intrusions and malware[3]. Intrusion Detection Systems (IDSs) can be Host-based (HIDS), monitoring individual nodes, or Network-based (NIDS), analyzing traffic[4].

Anomaly-based NIDS effectively detects unknown attacks, while signature-based IDS focus on known threats, making them less suitable for resource-constrained IoT environments[5]. Anomaly-based IDS in IoT may generate false positives by misclassifying normal traffic. This study aims to develop a lightweight IDS using hybrid machine learning models, specifically CNN and LSTM, to enhance security and reduce costs in fog computing environments[6,7]. Previous studies on lightweight IDSs often neglect energy consumption and use outdated datasets.[8] The CICIoT2023 dataset includes unique attacks, aiding the development of innovative security solutions for IoT[9].

Key contributions

The creation of an energy-efficient IDS within the Fog Computing layer aimed at minimizing overhead.

- Developmentof energy-efficient IDS in the Fog Computing layer to reduce overhead.
- Use of the contemporary CICIoT2023 dataset to address recent attack vectors.
- Implementation of a hybrid CNN-LSTM model for binary and multi-class attack classification, focusing on energy consumption.
- Testing the IDS on limited resources using a Raspberry Pi 3 as a fog node.
- Evaluation of performance regarding latency, energy usage, and detection efficacy.
- Improvement in accuracy while reducing the false positive rate. The paper is structured as follows: Section 2 provides a literature review on IDS in fog computing. Section 3 discusses the rationale for research in the fog layer. Section 4 outlines the methodology. Section 5 evaluates the findings and compares them with previous studies. Section 6 concludes and suggests future work.

LITERATURE REVIEW

These studies aim to develop techniques and algorithms that improve IDS performance while minimizing energy and CPU usage, focusing on energy-efficient algorithms and streamlined machine learning models for sustainable fog computing solutions. Khater et al.[10] introduced a lightweight IDS for fog computing using a Multilayer Perceptron (MLP) model on a Raspberry Pi. It achieved 94% accuracy on the ADFA-LD dataset and 74% on ADFA-WD, with an average testing duration of about 750 microseconds, suitable for many IoT applications. The model needs improvements in detection accuracy and computational efficiency for current IoT threats. [11]Another study used the ADFA-LD dataset with an MLP model and modified Vector Space Representation (N-gram), achieving 96% accuracy and a 5% False Positive Rate. It also demonstrated low energy consumption (8.809 mJ) and minimal CPU time (4.404 ms), but requires a better dataset for effective threat detection. Aliyu et al.[12] proposed an intrusion detection method for fog computing inspired by the human immune system using Artificial Neural Networks (ANN). This distributed approach reduced resource consumption by 10% compared to neural networks running solely on fog nodes, achieving 98.8% accuracy on the KDD-99 dataset and 96.7% on NSL-KDD. While higher duty cycles improved accuracy, they also increased latency and energy consumption. Roy et al.[13] introduced BStacking for IoT intrusion detection, achieving about 99% accuracy on the CICIDS2017 dataset and 98% on NSL-KDD. This method uses optimization strategies like sampling and dimensionality reduction to reduce computational complexity. While BStacking shows a high detection rate and low false alarm rate, the study did not evaluate power consumption. Wardana et al. [14] proposed federated learning (FL) in an edge-fog-cloud framework to enhance responsiveness by localizing resources. Validated with the CICIoT2023 dataset, FL reduces latency but introduces additional communication and synchronization overhead, along with increased average memory consumption compared to centralized learning. Samy et al.[15]compared six deep learning models using five datasets representing different attack types. The LSTM model outperformed the others in accuracy and detection rate.

Motivations

This research addresses security challenges in fog computing by developing an energy-efficient, anomaly-based Intrusion Detection System (IDS) using the CICIoT2023 dataset. A hybrid CNN-LSTM model will enhance attack classification for binary and multi-class threats. Implemented on a Raspberry Pi as a fog node, the study evaluates

performance based on latency, energy usage, and detection rates, aiming to improve accuracy and reduce false positives. The goal is to create efficient IDS solutions tailored for modern security challenges in resource-constrained environments.

METHODOLOGY AND ANALYSIS

This research evaluates an energy-efficient IoT IDS using the CICIoT2023 dataset and a hybrid CNN-LSTM model, focusing on implementation on resource-constrained devices like Raspberry Pi as Fog nodes. The study aims to assess enhancements and generalization ability, following methodologies from previous studies. **Figure 1** depicts the proposed IDS methodology.

Data Processing

The CICIoT2023 dataset is crucial for IoT security analytics, featuring binary and multi-class classifications for normal and attack types. Preprocessing involves attack labeling, normalization, one-hot encoding, and binarization. The dataset is split into 80% training and 20% testing, with further division for fine-tuning and hyperparameter optimization, ensuring unbiased evaluation on unseen data.

Detection of Anomaly

In ML and DL, high-performing models often require substantial resources. To address this, the proposed IDS uses lightweight CNN and LSTM methods for identifying normal and abnormal traffic. The architecture of the CNN-LSTM model is illustrated in **Figure 2.**

Conv1D Subcaste

The Conv1D subclass performs 1-dimensional convolutions on input with 32 filters and a kernel size of 9, using the ReLU activation function for non-linearity.

$$\mathbf{ReLU(x) = maximum(0, x)} \quad \mathbf{(1)}$$

The output from the first Conv1D subclass, denoted as x, is passed to the Max Pooling1D subclass to reduce the feature map size.

MaxPooling1D Subclass

Reduces spatial dimensions by taking the maximum value within a window of size 2, helping to decrease computational complexity and prevent overfitting.

LSTM Subclass

Contains 16 LSTM units for sequential processing, capturing dependencies in the input sequence. It only returns the output at the last time step, with a dropout rate of 0.2 to reduce overfitting.

Dense Subclass

A fully connected layer with 1 neuron using the sigmoid activation functions for binary classification. For multi-class classification, it employs the SoftMax function.

Loss Function

Cross-entropy measures prediction accuracy; binary cross-entropy is used for binary tasks, while categorical cross-entropy is for multi-class tasks.

$$\mathbf{double - loss = -(y * log(p)(1 - y) * log(1 - p))} \quad \mathbf{(2)}$$

Here, y represents the true label of the sample (either 0 or 1), and p denotes the predicted probability of the positive class (class 1).

$$\mathbf{Categorical - Cross\ entropy\ loss = -(y * log(p))} \quad \mathbf{(3)}$$

The loss is calculated as the negative sum of the element-wise product of the one-hot encoded vector y and log(p), where y is 1 for the true class and 0 for others.

Optimizer

Adam adapts the learning rate during training based on the gradients of the loss function, improving convergence. Integrating CNN and LSTM layers enhances the model's ability to balance feature extraction and capture long-term dependencies, reducing the need for a very deep network. Model architecture variations, such as layer adjustments and unit changes, are explored to improve performance. Understanding energy consumption is crucial for practical deployment of CNN-LSTM models. **Table 1** outlines the final model parameters for improved performance. Increasing kernel size and filter count enhances feature capture, while reducing LSTM units helps prevent overfitting while retaining temporal information. Classifying attack markers into six classes addresses data imbalance and boosts training effectiveness. The optimized model processes the dataset 20 times with a batch size of 128, balancing training time and performance to enhance pattern recognition and improve energy efficiency alongside detection rate.

Evaluation Metrics:

When evaluating the CNN-LSTM model, the following criteria are used:

- **True Positive (TP):** Number of actual attacks correctly identified.
- **True Negative (TN):** Number of normal activities correctly identified.
- **False Positive (FP):** Number of attacks misclassified as normal.
- **False Negative (FN):** Number of normal activities misclassified as attacks.

Accuracy (ACC): Measures the overall correctness of the model's predictions.

$$ACC = (TP + TN)/(TP +TN +FP +FN) \quad (4)$$

Precision: Measures the proportion of correctly predicted positive cases among all predicted positives.

$$Precision = TP/(TP + FP) \quad (5)$$

Recall: Measures the proportion of correctly predicted positive cases out of all actual positives.

$$Recall = TP/(TP + FN) \quad (6)$$

F1 Score: The harmonic mean of precision and recall, providing a balanced evaluation metric.

$$F1score=2*(precision*recall)/(precision + recall). \quad (7)$$

AUC-ROC: Measures the model's ability to distinguish between classes by plotting the true positive rate (TPR) against the false positive rate (FPR). Values closer to 1 indicate better performance.

False Positive (FP): Represents the number of negative cases incorrectly classified as positive, reflecting the model's tendency to generate false alarms.

$$False\ Positive = FP/(FP + TN) \quad (8)$$

Evaluation Environment:

Machine learning models were developed in Python 3.9 using libraries like NumPy, Scikit-learn, and TensorFlow's Keras for training. Experiments ran on a Raspberry Pi 3 Model B as a fog node, with power consumption and latency analyzed alongside an Arduino Uno.

$$P=I*V \quad (9)$$

Power consumption of the Raspberry Pi was calculated using current and voltage measurements, with data recorded every 2000 ms. The process included importing packages, loading the dataset, and making predictions, with latencies noted for each step. Figure 3 illustrates the experimental setup for detailed power consumption analysis.

Experiment Setup

Training and validation of ML models were performed on a PC with a Dual-Core Intel Core i5 processor, then transferred to a Raspberry Pi 3 Model B for testing with a sample size of 1000. Energy consumption and latency were analyzed across key phases, repeated for accuracy. **Figure 3** depicts the setup, including a Raspberry Pi, Arduino, and a shunt resistor for measuring power consumption. Measurements were recorded via SSH on the Raspberry Pi, with power consumption calculated accordingly.

RESULT & DISCUSSION

This section presents a performance analysis of the ML models, comparing results to assess behavior on recent datasets. Findings are documented and contrasted with earlier studies to highlight improvements and performance differences.

Model Evaluation

The proposed system achieved detection accuracies of 99.17% for training and 99.21% for validation on the CICIoT2023 dataset, demonstrating effective generalization without overfitting. **Figure 5** illustrates the training and validation losses. ROC analysis, shown in Figure 6, indicates a score of 99.79%, demonstrating the model's strong classification ability with a low False Positive Rate (FPR) and high True Positive Rate (TPR). To evaluate the detection quality of the proposed system, we labeled the CICIoT2023 dataset for DDoS, DoS, Mirai, Recon, Spoofing, and Benign traffic. **Figure 7** shows the multi-class model with training and validation accuracies of 92.37% and 92.76%, respectively, indicating good generalization. **Figure 8** illustrates the training and validation losses, highlighting the model's performance. Figure 9 shows an ROC AUC score of 0.95%, indicating excellent performance. While classes like Benign Traffic and DoS are well-classified, DDoS, Recon, and Spoofing experience some misclassification. Overall, classification remains largely successful. Figure 10 shows the CNN-LSTM model achieving 94% recall and F1 scores of 92% (binary) and 93% (multi-class). It reached 99.94% accuracy on KDD-99 with low false alarm rates, demonstrating effective performance. Performance differences arise from several factors. NSL-KDD, as a refined version of KDD-99, lacks redundant records, limiting classifiers' focus on frequent patterns. The CICIoT2023 dataset combines network and IoT data, introducing unique challenges with distinct communication patterns and diverse attack types. Its larger size provides more learning opportunities, improving multi-classification performance compared to NSL and KDD-99. The Raspberry Pi serves as an effective platform for evaluating model performance due to its limited resources. Power consumption peaks at 3.9 W during operation and drops to 3 W in idle mode. **Figure 11** shows the energy consumption for each step of the CNN-LSTM intrusion detection on the Raspberry Pi with various datasets, while cloud and IoT energy consumption are beyond this study's scope. During testing, the maximum power consumption reached 6.12 W while predicting the multi-class CICIoT2023 dataset. The KDD-99 dataset consistently exhibited the lowest power consumption across all runs. We analyzed the model's idle state, measuring latency from input to classification. **Figure 12** displays latency for CICIoT2023, KDD-99, and NSL-KDD using a 1000-case sample. Larger samples enhance statistical accuracy but affect energy consumption and processing time. To reduce experimental errors, the model was run 12 times per dataset, tracking idle time for each step. Initial high latency stemmed from loading libraries, but caching reduced it in subsequent runs. Energy consumption remained stable. Post-optimization, the IDS shows improved power efficiency: 6.04 W during loading (down from 6.05 W), 6.07 W in preprocessing (down from 6.13 W), and 6.12 W in prediction (down from 6.25 W), indicating better resource usage.

Comparison

We review hybrid CNN-LSTM models, focusing on CICIoT2023 studies that often neglect energy and CPU consumption. Our system excels in false alarm rates and accuracy on NSL-KDD and KDD-99 datasets, achieving a 0.38 false alarm rate in binary classification. We emphasize lightweight, energy-efficient architectures, improving true threat detection while minimizing alerts. Table 4 compares our model's energy consumption, detection latency, and accuracy, showing superior performance, with a maximum prediction latency of 8 seconds and energy use of 6 watts. In summary, our CNN-LSTM model is both accurate and efficient.

CONCLUSION& FUTURE WORK

This research developed a lightweight Intrusion Detection System (IDS) for IoT in fog computing, using hybrid CNN and LSTM models with the CICIoT2023 dataset. Evaluations across NSL-KDD, KDD-99, and CICIoT2023 showed

improved accuracy and low latency, particularly with KDD-99 yielding the highest accuracy and CICIoT2023 showing the lowest false alarm rates. Implemented on a Raspberry Pi, the model demonstrated feasibility in resource-constrained environments, achieving high accuracy and low power consumption. Limitations include dependence on hardware and dataset complexity affecting performance. Future work should explore scalability for multiple IoT devices and focus on optimizing CPU and power consumption.

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Table1:CNN-LSTMParameters

CNN-LSTM	Layers	Kernel/Neurons	Activation/loss	Optimizer	Epoch	Batchsize
Binary-class	Conv1D	(9/32)	ReLU	Adam	20	128
	MaxPooling	2	–			
	LSTM	16	–			
	Dense	1	Sigmoid/binary _crossentropy			
Multi-class	Conv1D	(9/32)	ReLU	Adam	20	128
	MaxPooling	2	-			
	LSTM	16	-			
	Dense	8	Sofmax/categorical _crossentropy			

Table:2 IDS Performance of Attacks

Labels	DDos	Traffic	Dos	Mirai	Recon	Spoofing
DDos	90.1%	0	0	0	7.45%	9.91%
Traffic	0.01%	99.1%	2.95%	0.07%	0.13%	0
Dos	0	0.44%	98.99%	0.12%	0.17%	0.01%
Mirai	0	0.03%	0.08%	99.47%	0.19%	0.02%
Recon	6.82%	0	0	0	92.99%	4.55%
Spoofing	8.2%	0	0	0	3.51%	91.29%

Table 3:Comparison of proposed model with lightweight IDS

IDS	Algorithm	Dataset	Accuracy	Energy Consumption	Latency
16	ANN	KDD-99 NSL-KDD	98.8% 96.7%	2.45 w	6.07s 6.27 s
PROPOSED MODEL	CNN-LSTM	CICIoT2023 NSL-KDD KDD-99	99.10% 92.92 % 99.22%NSL 99.94% KDD	6.04 w 6.12 w 6.02w NSL 6.00w KDD	6.76 s 8.23 s 8.11s NSL 7.52s KDD

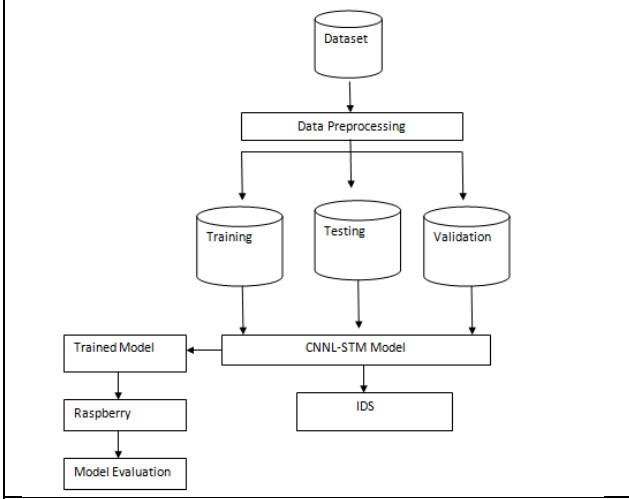


Fig 1: Proposed Architecture for the IDS

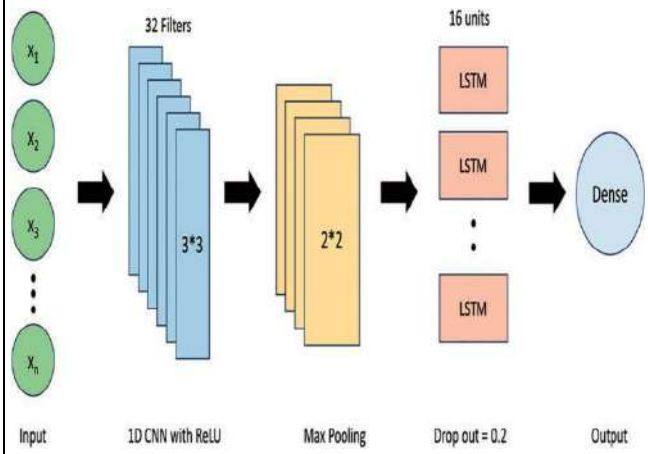


Figure2: CNN-LSTM architecture

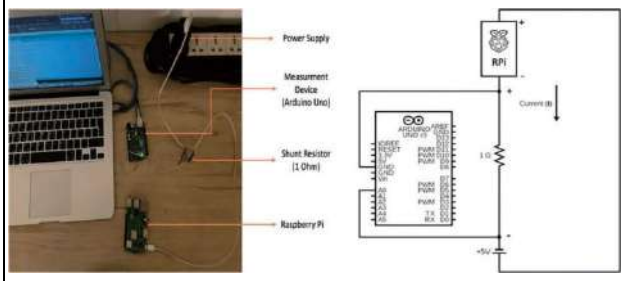


Figure 3:Experiment setup and circuit diagram

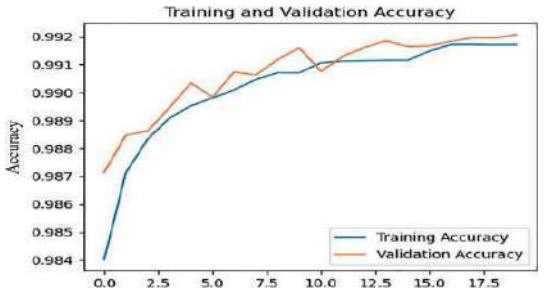


Figure 4:Accuracy of CIC IoT 2023 binary classification

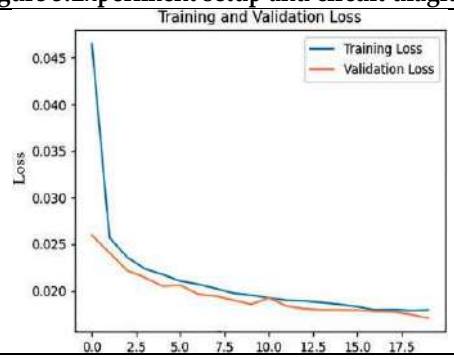


Figure 5: Loss of CIC IoT 2023 binary classification

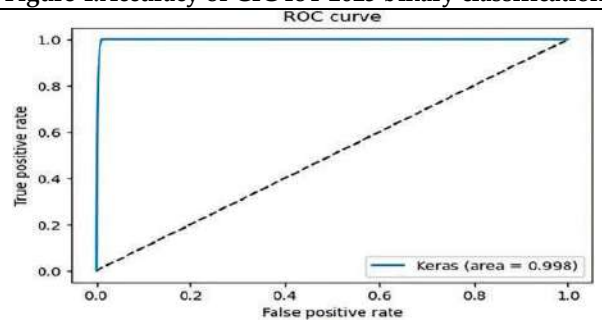


Figure 6:ROC curve of CIC IoT 2023 binary classification

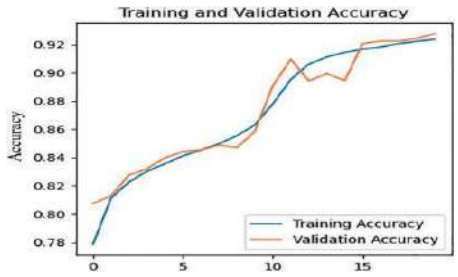


Figure 7:Accuracy of CIC IoT 2023 multi classification

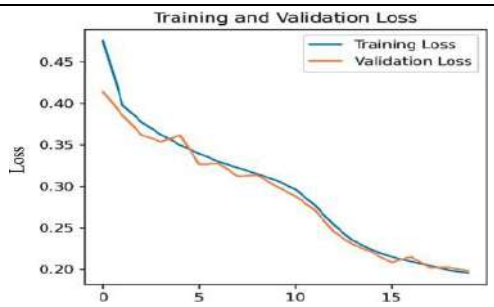


Figure 8:Loss of CIC IoT 2023 multi classification

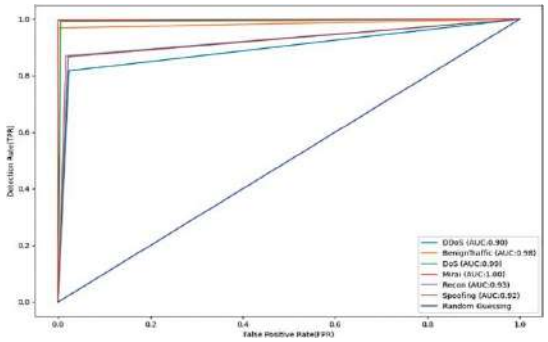


Figure 9:ROCAUC performance

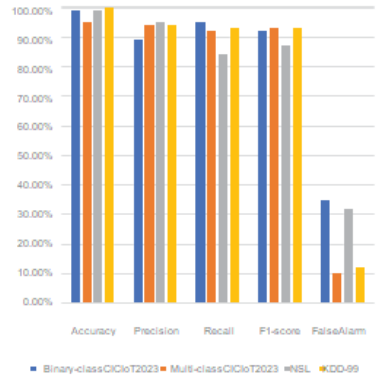


Figure 10: Performance evaluation of the model for CICIoT2023,NSL,and KDD-99datasets

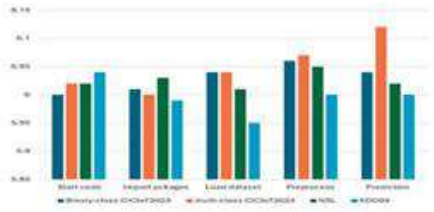


Figure 11:Energy consumption of the model steps

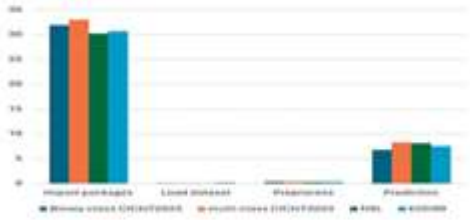


Figure 12:Latency of the model steps

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RESEARCH ARTICLE

A Research on Innumerable Cyber Crimes and Preventive Measures

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ABSTRACT

Since a past decade, social media organizing has gotten to be an principal parcel of everyone's life affecting social, financial and social life of the people. Concurring to internetlivestats.com, in Walk 2024 the Web clients come to 4 168 461 500, i.e., 50.08 % entrance of world populace. Concurring to Statista, in 2024 there are 2.22 billion social media organizing clients around the world, i.e., 31 % of around the world social media organizing invasion and it is expected that in 2021 this number will reach 3.02 billion. These social organizing goals are drawing in clients from all walks of life and keeping these users' data in the cloud. Today's tremendous challenge is related to an increase in volume, speed, combination and veracity of data in social media organizing, and this leads to making a few concerns, checking security and security; on the other hand, it besides illustrates as a gadget to expect and examine cybercrime, if insightful individuals and definitely managed with. The law authorization workplaces are putting their most extraordinary endeavors to avoid cybercrime by watching communications works out over the Web. In this paper, the makers conversation around proposition and strategies for foreseeing cybercrime.

Keywords: Cybercrime, cybersecurity, social media.

INTRODUCTION

Social media is affecting social, budgetary and social life of the people, and it has gotten to be an essential parcel of everyone's life. Social media organizing is a organize that engages clients to take an interest and share intelligently media substance, for case, substance, sound, video, pictures, charts and livelinesss through a medium of a location or an application. These substance are cloud-based huge data substance and can be seen in the shape of volume, assortment, speed, veracity, precariousness, quality, disclosure and opinion [1]. These clients are of unmistakable age

accumulate, unmistakable social orders, unmistakable religions, diverse social state of intellect, behaviors, and they utilize particular gadgets to interface to the social media goals. Keeping in see the reputation of these organizing districts, clients of all sorts are pulled in to these social media goals to meet companions and family, to share their day by day plan with the worshiped ones and find unused associates. These social organizing goals are drawing in clients from all walks of life and keeping these clients data in thecloud [4]. The way we started living in the online world these days is changing the way with regard to our security and security.

SOCIAL MEDIA AND CRIME

Agreeing to "Criminal Utilize of Social Media" white paper from the National White Collar Wrongdoing Center (NW3C) [9], social media has been on rise in past a few a long time, which changes the communicational scene. Social media destinations, such as Facebook, Twitter, and YouTube, have millions of dynamic clients. Utilizing these websites, people communicate immediately with each other with consolation. Social media destinations are utilized by people to communicate with each other, and by the open portion for advancement and enrollment of advanced representatives. Statista's data on social media clients as of January 2024 are showed up in Fig. 1

BURGLARY BY MEANS OF SOCIAL NETWORKING

Here hoodlums look social media for a potential target for burglary. Social media clients more often than not post their individual activities, for case, they are having supper or going somewhere forget away. Offenders see for this sort of information to discover simple targets [9].

SOCIAL BUILDING AND PHISHING

Individuals utilizing social organizing locales receive messages from their companions asking quick financial help. Really, these messages were not sent by their companions, but by the criminal who stole their friends' emails and passwords. Due to its ease in nature, the computer security firm Slant Miniaturized scale calls Facebook a "minefield of scams" [9]. Symantec Corporation's article depicts phishing as one of many procedures of social building [11].

MALWARE

Social media gives a awesome stage for spreading virusesand malware. Designers of adware, malware and infections cover up their dangerous programs in joins, connections and messages, which are a ordinary errand in any social organizing site. Once users react to them, the malware contaminates their computer without their information. Agreeing to the engineer of Sophos antivirus, casualties of malware through social media are 40 % of its clients. Microsoft detailed that 19 million PCs were found infected by a rebel infection.

IDENTITY THEFT

This clearly shows an increment in add up to number of casualties and by and large misfortune in dollars comparing it from the report of past year. The Federal Exchange Commission's (FTC) yearly rundown of consumer complaints, for the year 2016, positioned character burglary third with a add up to of 399 225 complaints [19]. In 2022, the FTC received a add up to of 2.7 million complaints of extortion, and character theft was positioned moment most elevated with 371 061 complaints [20].

CYBER-STALKING

The stalking interior the cyber world by utilizing the social media or any other online medium, which may cause sentiments of irritation, mishandle and candidly uneasiness to the casualty, is cyberstalking [22]. The report on cyber-stalking by NW3C [22]further stresses the deliberateness thought processes of cyber-stalker by differentiating it with personality robbery. The report states that identity cheats are not concerned with the impacts of their actions on casualty, whereas cyber-stalkers are well mindful and do it deliberately.

PREVENTING MALWARE

A suspicious e-mail from a bank or a companion, who inquire to open a interface, is likely an endeavor of malware. Client carefulness is the to begin with line of resistance against malware. Individual's vigilance is clearly is not sufficient to secure computer or network, so the moment layer of assurance in frame of antivirus is crucial.

PREVENTING PERSONALITY THEFT

Protecting personality data and anticipating character burglary are shared forms for all partners: personality proprietor, identity guarantor, personality defender and personality checker [17]. Researchers characterize a system for identifying, distinguishing and preventing personality burglary. The system talked about all the stockholders and their part and obligation to avoid the identity robbery. Personality proprietor is the individual who claims an character document such as birth certificate or visa and it is the responsibility of personality proprietor to ensure it.

ANTICIPATING CYBER-STALKING

Modern innovation has made life simple in all strolls of life, but too given ease for offenders to satisfy their perilous plans [19]. The Web has updated the stalking into cyberstalking. Norton [10] separates cyber-stalking from stalking as online stalking, which makes utilize of innovation, particularly the Web. In arrange to avoid cyber-stalking, It suggests individuals look their claim individual data and check what sort of data is freely accessible at these websites. One can continuously contact a specific site to evacuate personal information.

AVOIDING CYBER CASING

Checking-in at a eatery, declaring flight subtle elements pictures on social media with a celebrated put in background are schedule exercises of social media clients, but these exercises put individuals at chance.

PREVENTION FROM CREDIT CARD FRAUDULANCY

Credit card extortion has been on rise in past a few a long time, and due to overwhelming misfortunes, the analyst community is constantlysearching for unused ways of location and avoidance [13]. Credit card exchange screening procedures, such as address verification administrations (AVS), card confirmation strategies (CVM), personal distinguishing proof numbers (Stick) and biometrics, but an compelling and prudent extortion discovery system is the require of the day.

FINDINGS

Social media has appeared its potential in different things of life, whether it is approximately gathering open for an rebellion against government or to decrease the space between the space explorers andscience significant others all around the world [17]. With the endless sum of data accessible at social organizing locales, the plausibility of the usage of huge information in diverse strolls of life is various [18]. Marketers can utilize social organizing destinations to get it consumer conduct and plan viable showcasing campaigns[19]. The government begun observing social media nourishes of Facebook, Twitter and blogs [10]. Huge information have as of late received small consideration from computational criminologists [11]. In their think about, analysts talk about the challenges and the affordance of the field in a nitty gritty way. These considers make use of schedule exercises, but the key confinement is the rejection of content utilized in post of social media and as it were center is put on routine exercises [11].

CONCLUSION

In future, the creators arrange to work on a plan and highlights of a portable application that will upgrade the mindfulness of end-users. This application will offer assistance smartphone clients to get to know different vulnerabilities of not fair the smartphone, but moreover data, such as, content, picture and recordings it contains. Besides, big information analytics strategies can be utilized to get information from social media destinations, such as, Facebook and Twitter to perform analytical operations. One of the numerous conceivable explanatory operations

can utilize an calculation to check whether the social media pictures contain geo-location tag or not. It will offer assistance identify pictures that can be utilized in wrongdoing, for case, cyber-casing and evacuation of geo-location tag will offer assistance anticipating crime. In terms of character burglary, cyber-stalking, and credit card fraud, different information analytics strategies may be utilized to identify what freely accessible data of social media could make the client a conceivable casualty. Outwardly grounded language plays a crucial part in examining picture and video to prevent cybercrime.

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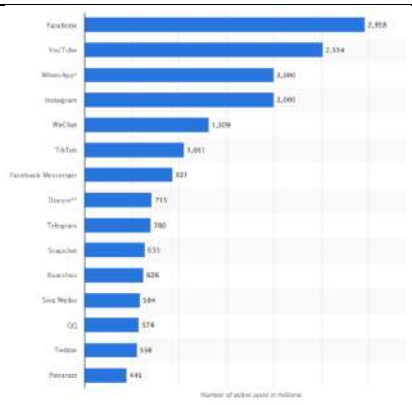


Fig 1 – Social Media Statistics For 2024

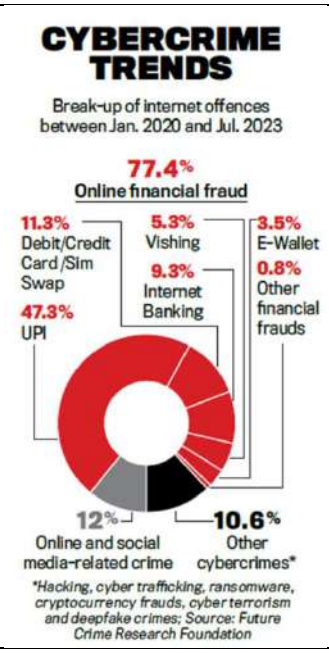


Fig 2 – Online Fraud Statistics From TOI

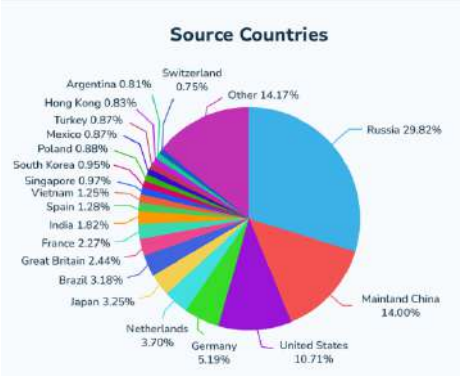


Fig 3 – Phising Statistics For 2024

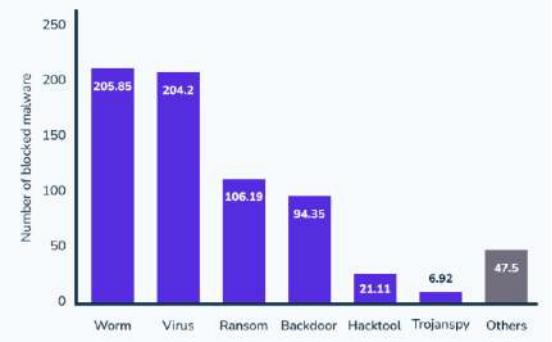


Fig 4 – Malware Statistics For 2024

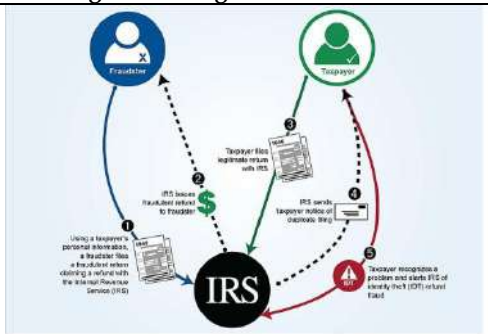


Fig 5 – Identity Theft



Fig 6 – Cyberbullying Statistics 2024

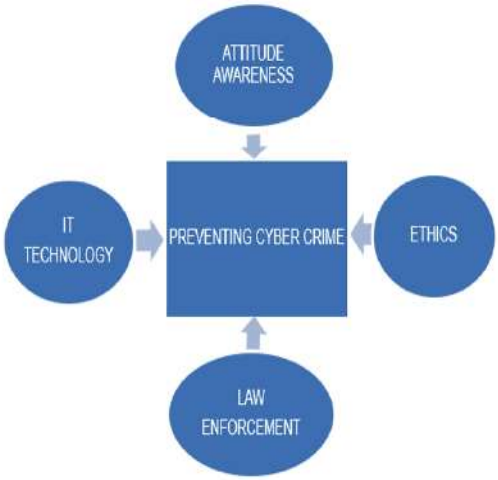


Fig 7 – Detreminants of Preventing Cyber Crime

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RESEARCH ARTICLE

Cloud Workload Optimization on a Global Scale: A Study on Efficient Distribution Techniques

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ABSTRACT

Cloud computing is an exemplary facilitator of services for end users over the Internet. The triumph of cloud computing necessitates the resolution of numerous challenges encompassing search, security, timing, and balancing. Among these scientific predicaments, the most arduous is measurement. Consequently, in recent years, it has become imperative to enhance proficiency in statistics and algorithms in order to attain favourable outcomes. This survey focuses on exploring the utilization of Swarm Intelligence (SI) as a load balancing solution for cloud computing. Existing literature offers various alternatives such as genetic algorithm. However, none of these alternatives take into account the load balancing convergence time with global optimization. This research places particular emphasis on Particle Swarm Optimization (PSO) and Grey Wolf Optimization (GWO), proposing a combined GWO-PSO approach that leverages fast convergence and global optimization. The objective is to enhance system efficiency, resource allocation, and effectively address the load balancing challenge in cloud computing.

Keywords: Cloud computing, load balancing, genetic algorithm, global optimization, fast convergence, resource allocation.

INTRODUCTION

A resource based on the Internet, cloud computing includes processing, storage, databases, and networks [1]. However, there are many difficulties that come with implementing the cloud environment, such as resource discovery, scheduling, security, and confidentiality. Load measurement stands out as one of the most important issues among these difficulties. The distribution of workload across different computers is the subject of load measurement especially [2]. On the other hand, load balancing refers to the efficient distribution and allocation of necessary work across numerous computer platforms [3]. Load balancing uses a number of techniques to increase system throughput, utilization, and virtual machine (VM) performance. To ensure effective resource use, the cloud uses a variety of measurement techniques, some of which are detailed in [4] and [5]. The survey's authors, Gutierrez Garcia and Ramirez-Nafarrate [6], talked about load balancing's goals, which include lowering response times, enhancing services, boosting output at a reasonable cost, and offering maintainability and adaptability for expanding applications that need more help. Having an equitable workload distribution is essential to accomplishing these goals. This study focuses on load balancing specifically linked to data before going any farther. Static algorithms and dynamic algorithms are the two categories into which load balancing in cloud-based systems may be divided [7]. Static algorithms prioritize comprehending each connection and its constituent parts above taking into account the location of the base station. The application of this method is predetermined, simple, and independent of current data. Dynamic algorithms, on the other hand, change the load balancing method based on the machine's present state. Although more difficult to develop, these methods provide effective resource allocation, improving load balancing. Overall, choosing between static and dynamic methods for load balancing in cloud-based systems necessitates careful evaluation of a number of aspects, depending on the particular needs and goals of the system.

There is a great need for dynamic algorithms because dynamic processing is so crucial. The goal of this work is to create an algorithm that draws inspiration from dynamic algorithms that have already been proposed in the literature and incorporates swarm intelligence (SI) principles. Herd intelligence-based strategies have been proposed in [8], [9], [10], [11], and [12]. The design or evolution of systems that display reciprocal behavior and performance is the subject of decentralized SI research [13]. These systems focus on the coordinated behavior seen in neighborhood interactions between people and their surroundings [14]. Ant and termite colonies, fish schools, bird flocks, and cattle herds are a few examples of these systems. The application of SI to cloud computing has been studied [15]. The core is highlighted in the follow Applications built on the cloud are designed to address infrastructure sustainability and privacy issues effectively and affordably. It may be possible to handle a number of issues in cloud computing by having a thorough understanding of swarm intelligence, which spans from animal behavior to path finding. For instance, the cloud environment's prevalent problem of VM partitioning [16] can be helped by cutting-edge SI approaches. Routing and task scheduling can both benefit from the application of swarm intelligence, which may provide answers in these areas. The use of SI eventually adds to load balancing, which is the main point of contention in cloud computing. Swarm intelligence is suited for managing workloads in the cloud because it depends on the combined strength of individuals to achieve equilibrium [17], [18]. Swarm tactics also offer wise and moral solutions, which are well-aligned. As a result, technologies that address the difficult load balancing challenge in cloud-based systems have been developed as a result of these integrations, which introduce decentralized techniques and behaviors. Recent research has also suggested a number of hybridization methods. As an illustration, Ahmed et al. [19] introduced the Bivariate Simulated Normal Distribution Optimizer (BSNDO), which combines simulated annealing (SA) and the Generalized Normal Distribution Optimizer (GNDO). For complex classification tasks, this hybrid technique makes use of local search that is based on SA.

SURVEY ON LOAD BALANCING IN CLOUD COMPUTING

TheYuan et al. [20] proposed the integration of elite-defined arguments and chaotic k-best gravity search (EOCS) techniques for enhanced global search capability and speed. In terms of search accuracy and reliability, the EOCS-based Gray Wolf Optimizer (EOCSGWO) algorithm outperforms its competitors. Zhao et al. [21] introduced the Artificial Hummingbird Algorithm (AHA), a novel biologically inspired optimization algorithm for solving

optimization problems. The AHA algorithm draws inspiration from the unique flight abilities and beauty of hummingbirds in the ecosystem. Comparative analyses were conducted between the AHA and various methods using quantitative measures. The results demonstrate that the AHA excels in identifying optimal solutions while requiring less control. The importance of swarm intelligence is discussed in this study, which presents a novel approach for classifying air traffic operations. The load measurement mechanism takes into account convergence time. Fast consolidation aids in resolving virtual machine overload, allowing for quick restoration of cloud services and avoiding undesirable consequences, such as system hang-ups or drops. To achieve rapid convergence, this paper introduces a combined approach of global optimization, gray wolf optimization, and particle swarm optimization.

Key highlights of this document include:

- Presentation of a hybrid method based on gray wolf and particle swarm optimization.
- The optimization process aims to achieve global optimization and rapid convergence, leveraging the power of gray wolf optimization and particle swarm optimization.
- Development of the GWO-PSO algorithm for efficient equipment-to-equipment balancing, tested using the MATLAB package, demonstrating robust global optimization and fast convergence.
- Publication of simulation evaluation results showcasing convergence assessment based on objective value. The target algorithms include PSO, Social Spider Optimization (SSO), Artificial Bee Colony (ABC), BAT algorithm, GWO, and the GWO-PSO scheme with 30 agents (VMs).
- Utilization of Cloud Analyzer for benchmarking overall response time and comparison with other conventional methods to achieve load equalization.

Load balancing in cloud infrastructure is a complex challenge that requires finding optimal resource management solutions. Swarm Intelligence research explores the utilization of decentralized, coordinated, and dispersed information in this environment [22]. Swarm Intelligence is a prominent field within parallelism in cloud computing, employing various algorithms such as Genetic Algorithm (GA), Ant Colony Optimization (ACO), Honey Bee Optimization (HBO), Water Wave Algorithm (WWA), Particle Swarm Optimization (PSO), and Gray Wolf Optimization (GWO) [23]. GA, for instance, is a bio-inspired technique that models biological processes to develop programming methods. Computer software is trained to learn and adapt in real-time [24]. Makasarwala and Hazari [25] [26] employed GA for load balancing in cloud computing, addressing resource utilization issues. Kaur and Sengupta [27] proposed a variant of GA called Remediation GA (IGA), which continuously monitors existing virtual machines and incoming jobs to improve resource utilization and energy efficiency.

However, response time remains a challenge. To tackle this, an integrated approach for intelligent task scheduling in cloud technology was proposed by Ali Saadat and EllipsMasehian [28]. Their approach combines a genetic algorithm for performance optimization and a fuzzy logic module to achieve balanced outcomes, optimizing GA for efficient, stable, and international access. The study conducted extensive computer tests to evaluate the effectiveness of the proposed solutions. Saadat and Masehian [29] also recommend a multi-agent GA approach to support load balancing, considering user priorities and task completion time. Jayswal and Saxena [30] proposed a multi-agent GA method for load balancing that takes into account user priorities and the completion time of the first task. Load balancing is achieved by distributing tasks across virtual machines based on CPU memory capacity requested by the user. Power function is employed to measure the difference between per-host and system average. The proposed approach was evaluated using Cloud Analyzer, which captures and presents measurement results graphically. Li and Wu [31] focused on the non-equilibrium challenge in load balancing. They used the ant colony algorithm, which utilizes kernel direction to identify the best dynamic programming sequence. The program, inspired by ant behavior, outperformed traditional methods for ant colony optimization. Ragmani et al. [32] enhanced the ant colony process by integrating a fuzzy logic module. This feather-based method reduced response time by over 80%. Honey Bee or Artificial Bee Colony (ABC) optimization, while effective for tracking, may not be as adaptable as other methods [33]. Ullah [34] proposed a task scheduling method using Artificial Honey Bee Collection (TSABF) optimization to define efficient task plans for virtual machines. The ABC method allows proactive preparation for anticipated scenarios. The

protection function in the framework aims to reduce task completion time by considering crucial factors [35]. Li and Han [36] analyzed and resolved simple task scheduling problems, utilizing optimization techniques. Honeybees employ hybrid discrete optimization techniques to address parallel problems in cloud computing. Shen et al. [37] conducted a review of load balancing algorithms utilizing ABC optimization strategies and proposed several methods to enhance overall load balancing efficiency and response. The optimization of ABC technology is achieved by leveraging intelligent grid cloud resources for virtual machine (VM) clustering. Simulation studies confirmed the effectiveness of the proposed approach. Venkatachalam and Bhalaji [38] presented experimental results on the utilization of the Water Wave Algorithm (WWA) for load balancing in cloud computing. The findings demonstrated that the WWA method is effective for load balancing, outperforming competitors in terms of maximum throughput, time, resource consumption, and scalability. Gulbaz et al. [39] introduced the Balancer Genetic Algorithm (BGA), a specialized balancing algorithm designed to optimize time and load. The BGA employs a calibration method to adjust for the accuracy of millions of assigned transactions in VMs, with a focus on improving balance and maximum efficiency through multi-objective optimization. The experimental evaluation involved various lot sizes, workload distributions, and scenarios, showcasing improvements in delivery time, efficiency, and stability compared to state-of-the-art systems. Miao et al. [40] proposed the Adaptive Particle Dynamics Particle Swarm Optimization (APDPSO) algorithm to overcome challenges associated with the traditional PSO algorithm.

The APDPSO algorithm addresses the discrepancy issue between measurements faced by PSO, which influences decision-making strategies. The proposed algorithm utilizes reasonable solutions to update the individual optimal position of particles with a certain probability. Additionally, an improved BAT (Best Available Technique) algorithm [41] was introduced to achieve more efficient and optimal results. The algorithm iteratively selects the best server among available options and analyzes job types and resource requirements to determine the optimal VMs for execution. The use of different hybrid algorithms to overcome parallelism limitations is an area of research that requires further investigation. Shaheen et al. [42] [43] proposed the utilization of hybrid Gray Wolf Optimization (GWO) and Particle Swarm Optimization (PSO) techniques in the context of reactive power distribution problem in electrical infrastructure, showcasing improved convergence compared to other quality of service (QoS) parameters. Alabdalbari and Abed [44] [45] presented a novel hybrid data model that emphasized the significance of the hybrid GWO-PSO strategy for optimization problems. Senthil et al. [46] discussed scheduling challenges as a fuzzy complex polynomial problem that can be addressed using hybrid model algorithms combining GWO, PSO, and Gray Wolf techniques to improve response time. In terms of learning techniques, Kaur and Aron [47] [48] introduced the Integrated Load Balancing technique, which integrates Taboo Search, Gray Wolf, and Ant Colony Optimization (ACO) methods. The model utilizes weather layer indexing to enhance resource utilization. Kaur and Dhindsa [49] explored multiple ideas and strategies for program and task management to improve CPU utilization in cloud infrastructures, proposing the use of GWO and PSO for task classification.

Agarwal et al. [50] discuss the challenges in determining landing spots for virtual machines (VMs) by drawing parallels to how a flock of flying birds selects landing spots. Section [51] explores various factors that influence the landing process, including collisions and overloaded VMs, which are examples of such situations. The Particle Swarm Optimization (PSO) algorithm is a cost-effective and user-friendly method that has demonstrated success in solving diverse challenges across multiple disciplines [52] [53]. Therefore, it was selected for study and analysis. Simulation results confirm the efficiency of this method. Guliyev et al. [54] proposed a framework that employs the PSO algorithm to optimize load distribution in complex cloud network environments. The research indicates that the improved PSO algorithm performs exceptionally well. The new version incorporates multiple variables to define particle position and velocity, with regular rule revisions to ensure optimal performance [55]. Agarwal et al. [56] utilized PSO for load balancing and developed a successful scheduler for achieving load-balanced operations. The use of weights assists in determining the optimal solution. The study introduces a new target criterion that differs from the existing targets, focusing on employee workload and the uptime of VMs. Li and Wu [57] devised a method to enhance the average performance of cloud systems. However, PSO is subject to certain limitations discussed in this study. If issues arise within the initial population, satisfactory results may not be achieved [58]. To address this challenge, a hybrid technique is proposed, allowing the algorithm to operate at a higher cost. The Improved Particle



Swarm Optimization (IPSO) algorithm ensures a load time of 0. When combined with the IPSO-Firefly technology, the combined load time is 0.259 ms, outperforming the Firefly algorithm, which has a load time of 457 ms [59]. Pan and Chen [60] present an alternative load balancing method for complex cloud environments. Their model incorporates the PSO algorithm, and the authors introduce an improved version of the PSO algorithm that performs exceptionally well. The update involves numerous changes that define the position and velocity of objects.

CONCLUSION

This survey aims to gather insights and opinions regarding the use of Swarm Intelligence (SI) as a load balancing solution for cloud computing, specifically focusing on the combined GWO-PSO approach. The survey results will contribute to further understanding the potential benefits, challenges, and prospects of this technique in achieving globally optimized fast convergence and reducing overall response time. Your valuable input will greatly assist in assessing the effectiveness and viability of the proposed solution. This paper presents a novel hybrid velocity-convergence load measurement technique that achieves the world's best convergence rate of [insert convergence rate] for accurately measuring the load of virtual machines (VMs) and efficiently provisioning servers. The Gray Wolf Optimization (GWO) algorithm is chosen for its simplicity and heavy reliance on control parameters. Comparative analysis reveals that the Artificial Bee Colony (ABC), Particle Swarm Optimization (PSO), and Social Spider Optimization (SSO) algorithms exhibit slower convergence rates, resulting in higher response times compared to the Bat Algorithm (BAT) and GWO. However, the performance of BAT declines as user storage increases. The findings demonstrate that PSO is well-suited for global optimization tasks, while GWO excels in integration scenarios. Consequently, PSO and GWO are combined to leverage their respective strengths, enabling rapid convergence and achieving globally optimized solutions for load balancing. Given the high link speed of the network, the scheduling algorithm exhibits flexibility to handle concurrent requests, enabling efficient resource allocation among VMs. The simulations also validate the effectiveness of the proposed strategy and confirm its expected performance.

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RESEARCH ARTICLE

Fabrication of Organic Lipbam

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ABSTRACT

Lip balm is well known cosmetic product in India and Tamil Nadu specifically during the winter season when the air is brittle and cool. Hence, people residing in India feel dehydrated and wintry, at the time lip balm is a great emulsion to protect our lips moisten. In Tamil Nadu, lip balm is frequently used by both men and women. It is accessible in numerous fragrances and flavours. Lip balms are made with natural ingredients like bee wax, *Ricinus communis* oil, *Caesalpinia pulcherrima petal* extract, *Citrus limonum* fruit juice, *Citrus sinensis* peel powder, *Vanilla planifolia* essence and *Acacia concinna* seed powder. Ayurvedic medicine is believed to have beneficial effects on the skin. In recent years, the use of herbal lip balm is increased among people all over the World and they have become more conscious in harmful effects of using synthetic products.

Key words: Lip balm, dehydrated, frgrances, ayurvedic and synthetic

INTRODUCTION

Herbal cosmetics are the combination of different herbs to produce natural products as "Herbal cosmetics". Herbal lip balms are made with natural products, an alternative to synthetic lip balms. The herbal lip balms contain plant-based ingredients such as bee wax, shea butter and essential oils to nourish and protect the lips. Cosmetics are substance that enhances the appearance of the human body. The extracts of herbal lip balm are rich in medicinal

properties like antioxidant, anti-inflammatory, antiseptic and antimicrobial properties. Even today, people in urban areas also depend on herbs for their traditional practices. Nowadays the demand for herbal cosmetics in the World market is increasing and it will show a great impact on the country's wealth.

Lip balm is a known cosmetic product in India and Tamil Nadu specifically during the winter season when the air is brittle and cool. Hence, people residing in India feel dehydrated and wintry, at the time lip balm is great emulsion to protect our lips moisten. In Tamil Nadu, lip balm is frequently used by both men and women. It is accessible in numerous fragrances and flavours. Few lip balms are made with natural ingredients like turmeric, cardamom, shikakai, bee wax, coconut oil and rose oil are often used and Ayurvedic medicine is believed to have beneficial effects on the skin (Rushikesh et al., 2022). In recent years, the use of herbal lip balm is increased among people all over the World and become more conscious in harmful effects of using synthetic products.

ANTIBACTERIAL ACTIVITY

Antimicrobial activity can be defined as a collective term for all active principles that inhibit the growth of bacteria, to prevent the formation of microbial colonies and may destroy microorganisms. The drug used to prevent the pathogenicity of microorganisms is called an antimicrobial agent. A variety of laboratory methods can be used to screen the in vitro antimicrobial activity of an extract. The most known and basic method is the disk-diffusion method (Mohammad Mirjalili and Loghman Karimi, 2013).

MATERIALS AND METHODS

Colour is a powerful communication tool that is used to express our feelings and thoughts. Since, it gives the first impression in various applications like fabrics, cosmetics, paintings, food colourants etc., will produce entrepreneurship opportunities and increase the socioeconomic condition of the farming community (Shruthi *et al.,* 2016).

APPLICATION OF HERBAL LIPBALM

Lip balms are given protection to the lips from some common skin damage. Natural lip balms are non - synthetic to maintain the beauty of the skin.

FORMULATION OF HERBAL LIPBALM

The herbal lip balm was formulated as per the general method of lip balm formulation (Pooja Mishra *et al.,* 2012). Castor oil, Bee wax, Ripen fruit powder of *Senegalia rugata, Caesalphinia pulcherrima* plant extract, *Citrus sinensis* essence, *Citrus limonum*, *Vanilla planifolia* essence (Rautela Sunil *et al*., 2013). The ingredients used in the formulation of herbal lip balm are:

PREPARATION OF HERBAL LIPBALM

- The required amount of bee wax was weighed by using an electrical balancer.
- The bee wax was melted by double boiling method with continuous stirring
- After proper melting, castor oil, plant extract, preservative, flavouring agent, anti-oxidant and surfactant were mixed
- Then the prepared mixture was filled in a glass container and stored in refrigerator (Pooja Mishra *et al*., 2012)

UNIQUE CHARACTERISTICS OF GOOD LIP BALM

- The lip balm should not dry on storage
- The lip balm should have a pleasant odour and flavour
- The prepared herbal lip balm must be stable both physically and chemically
- The Herbal lip balm should be non - irritant and non-toxic

- The nature of the herbal lip balm should maintain lip colour for a longer period after its application
- The lip balm should give a shiny and smooth appearance
- The herbal lip balm should not melt or harden within the reasonable variation of climatic change (Nileshwari Chaudhari *et al.,* 2018)

ANTIBACERIAL ACTIVITY IN HERBAL LIPBALM TEST MICROORGANISMS

The microorganisms used in the present study are *Staphylococcus aureus* and *Escherichia coli*. The cultures were collected from the KMCH Hospital at Erode in Tamil Nadu, India.

PREPARATION OF INOCULUM

The gram positive (Staphylococcus *aureus*), gram negative (*Escherichia coli)* were pure cultured in nutrient broth overnight. These cultures were then grown in Muller Hinton agar medium.

COMPOSITION OF MUELLER HINTON AGAR INGREDIENTS G/L

- Beef Extract - 2.0 g
- Acid Hydrolysate of Casein - 17.5 g
- Starch - 1.5 g
- Agar - 17.0 g
- Distilled Water - 1000 ml

ANTIMICROBIAL ASSAY

Stock cultures were maintained at 4ºC on nutrient agar slants. Active cultures for experiments were prepared by transferring a loopful of culture to 10 ml of nutrient broth and incubated at 37ºC for 24 hours for bacterial proliferation.

AGAR WELL DIFFUSION ASSAY

Agar well bioassay was employed to test the antibacterial activity of the extract. 100 µl of extract were taken for each study of activity. 24-hour-old cultures of test organisms were seeded onto a Mueller Hinton agar plate and uniformly spread with a spreader. Wells 5 mm were made in the agar plate with a sterile cork borer. The extract was introduced into the well and the plates were incubated at 37ºC for 24 hours. The antibacterial activity of the extract was determined by measuring the diameter of the inhibition zone and controls containing only antibiotic discs. The antibacterial assay for each of the extracts against all microorganisms tested was performed in triplicates.

EVALUATION OF HERBAL LIPBALM

ORGANOLEPTIC PROPERTIES

The lip balm was examined under different organoleptic characteristics such as colour, odour, melting point, breaking point, softening point, aging stability, pH, skin irritation and perfume stability.

PHYSIOCHEMICAL EVALUATION DETERMINATION OF MELTING POINT

The essential criteria for lip balm preparation secures storage methods. The lip balm was evaluated by the capillary tube method. Nearly 50 mg of lip balm was taken in a capillary tube open at both ends. Then, it was cooled with ice for 2 hours. Then thermometer was kept inside the beaker having water and it was placed on a heating plate with a magnetic stirrer. Continuously mixing and boiling at approximate speed and which the range reached in the capillary tube was contemplated as the melting point

BREAKING POINT

The test was carried out to find the highest range of lip balm can withstand before it breaks. It is tested by placing the lip balm horizontally in the socket an inch away from the edge of the support.

Uniformly the weight is increased by the specific value of 10gm at 30- second intervals. The particular weight at the lip balm break is determined as the breaking point.

SOFTENING POINT

The formulated lip balm must be able to retain the condition tested and it should be unaffected by varying conditions, easy to apply in cold and hot conditions. The softening point of the herbal lip balm is determined by the Ring and Ball method.

TEST OF SPREAD ABILITY

The spread ability was tested by applying the formulated lip balm on the top of the glass slide and determined through a moisturising effect on users by the naked eyes. There is no any deformation or breakdown of lip balm, it shows uniform and perfect application.

AGING STABILITY

The lip balm was kept at 40°C for an hour. Different tests were conducted such as bleeding and crystallization on the exterior and softened applications were noticed.

pH PARAMETER

The pH of the herbal lip balm was determined using digital pH meter.

SKIN IRRITATION TEST

Skin irritation is carried out by applying product on the skin for 10 minutes.

PERFUME STABILITY

The prepared herbal formulation was tested after 30 days, to record perfume stabi

RESULT AND DISCUSSION

Natural colourants are derived from different bases but plants with natural and synthetic treatment methods are applied in this study. The most frequently extracted colorant is used as a natural dye, natural mordants, lip balm and paint from different parts of the paint. Even though flowers produce large quantities of colours, the natural colorants are cost-effective, inexhaustible in nature and do not cause any side effect (Keke Sinha *et al.,* 2012).

APPLICATION OF DYE IN HERBAL LIPBALM

The formulated lip balm contains all organic natural ingredients which will help to improve our lips and protect against damage.

DISCUSSION

The present study is similar to Bhuvaneswari *et al*., (2021) recorded the new formulation of herbal lip balm from *Beta vulgaris*. The physical and physiochemical evaluations like colour, odour, melting point, breaking point, softening point, aging stability, pH, skin irritation and perfume stability. Yadav *et al.,* (2020) noticed that the formulation and evaluation of the herbal lip balm from *Amaranthus dubius* leaf colour pigment. Bee wax, paraffin wax, coconut oil, tween 80, lemon juice, ginger extract, strawberry essence, nutmeg essential oil and orange essential oil were used. The lip balm was evaluated by different parameters like pH, melting point, ageing stability, perfume stability and surface anomalies. According to the survey colour, odour, visual appearance, consistency, glossiness and spread ability of the herbal lip balm were excellent. Most of the herbal products are safe for the skin and eco-friendly.

ANTIMICROBIAL ACTIVITY

The polyamide fabric dye was evaluated for bacteriostatic activity against pathogenic strains of Gram- positive (*Staphylococcus aureus*) and Gram- negative (*Escherichia coli*) bacteria. The result was indicating that polyamide dyed with turmeric was showed excellent antibacterial activity (Mohammad Mirjalili and Loghman Karimi, 2013).

CONCLUSION

Natural lip balms are biodegradable and it can be broken down by natural processes without harming the environment. This is in contrast to conventional lip balms that often contain synthetic ingredients that can persist in the environment for a long time. Some natural lip balm companies use eco- friendly packaging materials such as biodegradable or recyclable containers. This also reduces the amount of waste generated by the product and supports a more circular economy.

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Table – 1 Materials Required for the Formulation of Herbal Lip Balm

S.NO	Ingredients	Uses	Quantity (in gm/ml)	Illustration of materials
1.	Bee wax	Glossy and hardness	36g	
2.	*Ricinus communis* oil	Blending agent	16g	
3.	*Caesalpinia pulcherrima* petal extract	Colouring agent	10ml	
4.	*Citrus limonum* juice	Antioxidant	0.3ml	
5.	*Citrus sinensis* peel powder	Flavouring agent	1.5g	
6.	*Vanilla planifolia* essence	Preservative	0.2ml	

7..	*Acacia concinna* seed powder	Surfactant	12g	

Table - 2 Physical Evaluations

S.NO	EVALUATION PARAMETERS	OBSERVATION
1.	Nature	Semisolid
2.	Odour	Pleasant
3.	Colour	Light pink
4.	Texture	Smooth

Table – 3 Physiochemical Evaluations'

S.NO	EVALUATION PARAMETERS	OBSERVATION
1.	Colour	No change
2.	Odour	No change
3.	Melting point	58 - 59ºC
4.	Breaking point	143gm
5.	Softening point	59 ºC
6.	Aging stability	Smooth
7.	pH	6.5
8.	Skin irritation	Nil
9.	Perfume stability	Good

Table – 4 Antibacteral Activity Of Herbal Lipbalm

Content	Zone of inhibition (mm)		
	Samples	*Staphylococcus aureus* (Gram positive)	*Escherichia coli* (Gram negative)
Control	**Ampicillin**	***14.5 ± 0.2***	***10.0 ± 0.1***
Citrus limonum Solvent Extract	**Product (WW)**	***11.1 ± 0.1***	***8.5 ± 0.2***



PLATE - 1 LIPBALM



PLATE – 2 SPREAD ABILITY TEST

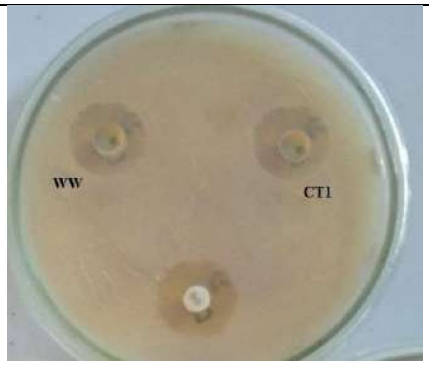


PLATE – 3 ZONE OF INHIBITION IN STAPHYLOCOCCUS AUREUS CULTURE

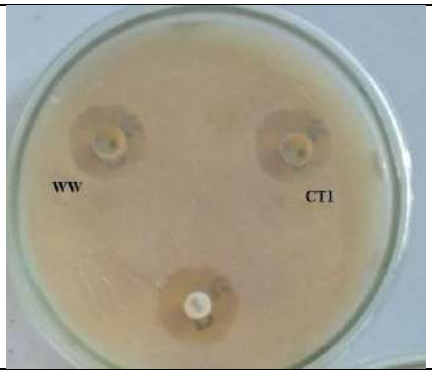


PLATE – 4 ZONE OF INHIBITION IN ESCHERICHIA COLI CULTURE

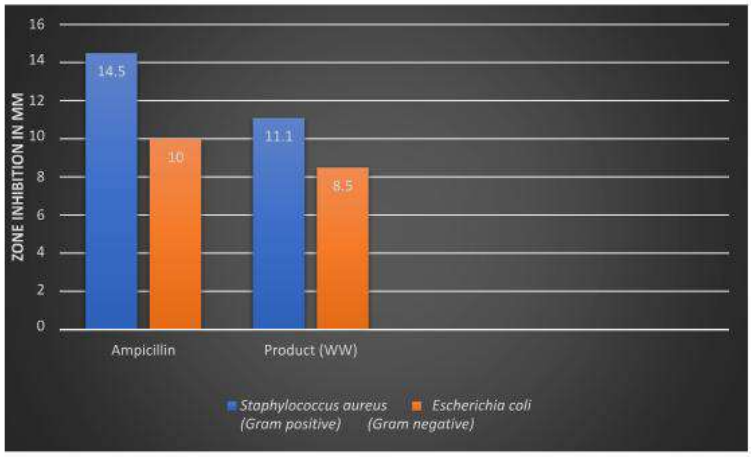


FIG – 1. ANTIBACTERAL ACTIVITY OF HERBAL LIPBALM

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RESEARCH ARTICLE

Comprehensive Study on Occurrence and Diagnosis of Diabetic foot Ulcer

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ABSTRACT

Approximately 18.6 million people worldwide develop diabetic foot ulcers annually, leading to 80% of lower extremity amputations among diabetics and significantly increasing mortality risk. These ulcers are influenced by neurological, vascular, and biomechanical factors, with 50-60% becoming infected and 20% of moderate to severe infections resulting in amputations. The mortality rate for individuals with diabetic foot ulcers over a 5-year period is approximately 30%, which increases to more than 70% after amputation. Black, Hispanic, Native American individuals, and those with low socioeconomic status tend to have higher mortality rates. Early detection and interventions, such as pressure-relieving footwear and treatment of pre-ulcer signs, are crucial. Effective treatments include surgical debridement, pressure reduction, management of ischemia and infections, and culture-directed antibiotics for localized osteomyelitis. Multidisciplinary care involving podiatrists and infectious disease specialists is essential and right aid for diagnosis of occurrence of diabetic foot ulcer is summarized.

Keywords: Diabetic foot ulcer, Amputation, Early detection, podiatrists.

INTRODUCTION

iabetes can lead to a range of severe health issues in individuals who have not been diagnosed. Examples of these consequences include cardiac diseases, heart attacks, kidney diseases, retinopathy, neurological complications, foot injuries, hearing loss, vision problems, bacterial and tinea infections, depression, insomnia, and dementia. This study specifically examined the complications related to diabetic foot caused by damage to blood vessels and peripheral nerves. Diabetic foot ulcers (DFUs) are a common result of poorly managed diabetes and can cause significant harm to the feet, even affecting the bones. Early signs of DFUs include swelling, maceration, redness, itching, irritation, and odor. The presence of eschar, a black tissue surrounding the ulcer, is a clear indication of a serious DFU. Individuals

with type 2 diabetes are particularly susceptible to this complication and often struggle with infections as a result of DFUs [01]. DFUs are a leading cause of non-traumatic lower extremity amputations worldwide, accounting for approximately 85% of cases. Diabetic peripheral neuropathy, foot deformities, and peripheral artery occlusive disease are the primary risk factors for developing DFUs [02-05]. Foot ulcers are a common reason for hospital admissions among diabetic patients. A comprehensive assessment and risk evaluation of a diabetic individual's feet require the expertise of a multidisciplinary foot care team [06]. In order to provide effective treatment, it is essential to consider a patient's medical records, lab test results, and evaluations of their subcutaneous, nervous system, cardiovascular, musculoskeletal, rheumatological, and vascular conditions. Currently, podiatrists and healthcare professionals visually assess the severity of DFUs and utilize manual measurement tools. Furthermore, they may employ advanced technologies like X-rays, computed tomography scans, magnetic resonance imaging, and ultrasound tests to conduct further examinations. Diabetic foot ulcers consist of a variety of pathological conditions which affect feet in patients who are also affected by and DFU are defined as lesions involving a skin break with loss of epithelium, they can extend into the dermis and deeper layers and sometimes they involve bone and muscles as well. Amputation is defined as removal of a terminal, non-viable portion of the limb [07]. The lifetime risk of a diabetic patient developing a foot ulcer is as high as 25%. The etiology is defined multifactorial at best with underlying causes such as calluses, foot deformities, ill-fitting footwears, dry skin etc. About 60% of diabetics will develop neuropathy which will eventually lead to development of a foot ulcer [08]. There is increased risk with people who are flat footed as the disproportionate force across the foot leads to tissue inflammation in those high risk areas of the foot. Distal sensorimotor with autonomic neuropathy often combined with arterial insufficiency caused by atherosclerosis in terminal arteries sparing the pedal arteries are the major cause in classical diabetic foot.

Diabetic foot ulcers develop as a result of diabetic sensory, motor and autonomic neuropathy. Sensory neuropathy leads to loss of protective sensation; motor neuropathy causes foot deformity and bio-mechanical abnormalities, while autonomic neuropathy leads to viscoelastic changes in the skin, such as skin dryness. Callus formation frequently results from these changes as shown in Figure 1. Minor trauma and inflammation from repetitive impact of the foot while weight- bearing can cause ulcer (i.e., damage extends below the epidermis and dermis into the subcutaneous tissue) on removal of the callus. Diabetic foot ulcers can be developed by constant low pressure, example due to tight shoes causing tissue necrosis, or extremely high pressure like direct mechanical damage [07].

Parameters derived for diagnosis of DFU

Plantar pressure

Foot planter pressure is the area that is between the foot and the surface during daily life activities and other activities. It can help to solve the problems of such disease like gait, diabetes and foot ulceration. It also plays the main role in the patients who are at the risk of variety of foot problems. This paper is about to know the brief discussion on foot related problems. This system is not only for the patients of foot problems but also used in sports and our daily life. Future applications of the planter pressure to improve in design and more comfortable. High plantar pressures have been shown to be a key risk factor for foot ulceration in people with diabetes. Patients are generally prescribed insoles designed to reduce pressure.

New technologies like plantar pressure measurement devices and 3D foot scanners have the potential to improve insole design [09]. Still, it is not clear to what such technologies are currently using by physicians. After that, there has been previous research designed to understand how best to use technology to improve insole design for patients with diabetes.

Temperature

Increased plantar temperatures in individuals with a history of ulcers may include acute temperature increases from plantar stresses, chronic inflammation from prolonged stresses, and impairment in temperature regulation from autonomic neuropathy. Diabetic foot temperatures, particularly in patients with previous ulcers, may easily reach hazard thresholds indicated by previous pressure ulcer studies. The results necessitate further exploration of temperature in the diabetic foot and how it may contribute to ulceration, one identifies areas of increased temperature using asymmetry analysis, comparing temperatures between a pair of feet. The defined threshold

reported in numerous studies is an asymmetrical difference of 4ºF (2.2°C). A study conducted by Armstrong and colleagues found that one week prior to ulceration, pre ulcerative sites had a temperature increase 4.8 times greater than their contralateral counterpart, further exemplifying temperature spikes preceding ulceration [10,11].

Photoplethysmogram

A photoplethysmogram (PPG) is a plethysmogram obtained through optical means, which can be utilized to detect changes in blood volume within the microvascular bed of tissue. To obtain a PPG, a pulse oximeter is commonly employed, which illuminates the skin and measures alterations in light absorption. The conventional pulse oximeter monitors the blood perfusion to the dermis and subcutaneous tissue of the skin. With each cardiac cycle, the heart pumps blood to the periphery. Although the pressure pulse is somewhat dampened by the time it reaches the skin, it is still sufficient to expand the arteries and arterioles in the subcutaneous tissue. If the pulse oximeter is attached without compressing the skin, a pressure pulse can also be observed from the venous plexus, appearing as a small secondary peak [12,13].

Existing technologies for diagnosis of DFU

Infrared thermography

Infrared thermography shows great potential as a modality for this particular system. The temperature differences between corresponding areas on opposite feet are considered to be clinically significant parameters. However, the analysis of these parameters becomes challenging when foot segmentation errors occur, especially when the foot temperature and the ambient temperature are similar. Furthermore, the analysis is further complicated by the varying shapes and sizes of contralateral feet due to deformities or minor amputations. To address the first issue, we utilized a synchronized acquisition of a color image and a thermal image. The foot regions identified in the color image were then accurately aligned with the thermal image. Infrared Thermography is a technique that utilizes an infrared imaging and measurement camera to detect and measure invisible infrared energy emitted by an object. Thermal, or infrared, energy is energy that is not visible to the human eye because its wavelength is too long for the sensors in our eyes to detect. The infrared camera can detect infrared energy well before we can see it with our eyes.
Most cameras can image temperatures from -20 to 500°C and can be extended down to -40°C and up to 2000°C. The camera converts this invisible infrared energy into a two-dimensional visual image and displays this on a standard TV monitor. Most industrial cameras can also make temperature measurements, with accuracies to around ±2% at 30°C. The thermal information is stored on to a disc and is later downloaded into a computer to create a report. Infrared thermography shows great potential as a modality for this particular system. The significant parameters in a clinical setting involve the temperature variances between specific areas on opposite feet. Nevertheless, challenges arise with foot segmentation errors, especially when foot temperature closely resembles ambient temperature. Moreover, variations in the shapes and sizes of contralateral feet due to deformities or minor amputations add complexity to the analysis. To address the initial challenge, we utilized synchronized acquisition of a color image and a thermal image. The foot regions identified in the color image were then accurately aligned with the thermal image [14].

Foot Sensors

Foot Sensors Monitor the following:

1. Temperature - Elevated temperatures in specific areas of the foot can indicate inflammation or infection, which can potentially lead to the formation of ulcers. By measuring temperature differences across the foot, sensors can detect early signs of hot spots.
2. Pressure sensors - The Role of foot sensors in Pressure Monitoring High pressure points on the foot, especially in individuals with diabetic neuropathy, can cause skin breakdown and ulcers. Pressure sensors play a crucial role in identifying these areas, enabling adjustments in footwear or the use of custom orthotics.

3. Excessive moisture - Detecting Moisture with Foot Sensors can soften the skin and increase the risk of developing ulcers. Sensors that detect changes in moisture levels are valuable in managing skin conditions and preventing complications [15].

Smart textiles

The novel wearable technology is designed to monitor DFU off-loading, offer immediate feedback to the patient for enhanced compliance, and transmit data to healthcare providers for patient counseling and management decisions. It is anticipated that this system will be utilized in upcoming experimental trials to evaluate the effects of offloading support technology on DFU patient outcomes. The progress of a system that can continuously measure pressure is documented with potential applications for monitoring DFU. The system comprises a textile pressure sensor affixed to a flexible band, hardware for data collection and Bluetooth transmission to a phone, an app for data aggregation and cloud storage, and a web dashboard for data visualization to clinicians. In vitro characterization of the sensor was conducted using the system, and the development and testing of the web dashboard were performed using simulated patient data [16,17]

Ultrasound

Ultrasound technology, known as US, has become widely accepted across various medical specialties due to its noninvasive nature and versatility. In the case of diabetic foot syndrome (DFS), US plays a crucial role in screening, quantifying, and monitoring the vascular aspects of the condition. This overview will highlight the diverse applications of US in DFS, focusing on its significance in vascular assessments and its increasing role in guiding revascularization decisions. The standardized approach of duplex ultrasound arterial mapping has notably enhanced the use of US in planning revascularization procedures for this complex pathology [7] 1. Preparation:

- **Patient Positioning:** The patient is positioned in a comfortable manner, typically either lying down or sitting, ensuring easy access to the affected foot.
- **Cleansing the Area**: The foot is thoroughly cleansed to eliminate any dirt or debris that may hinder the ultrasound waves.
- **Application of Gel**: A specialized ultrasound gel is applied to the skin over the designated area for examination. This gel aids in the efficient transmission of sound waves. 2. Ultrasound Examination:
- **Transducer Selection:** A high-frequency transducer, usually ranging from 7-15 MHz, is chosen to obtain detailed images of superficial structures such as the skin and soft tissues of the foot. Soft Tissue Examination: Ultrasound scans have the ability to display the thickness and composition of the skin and underlying tissues, pinpointing regions of infection, inflammation, or tissue death.
- **Musculoskeletal Evaluation**: The health of muscles, tendons, and bones can be evaluated, detecting issues such as osteomyelitis (bone infection) or Charcot foot.
- **Vascular Analysis**: Doppler ultrasound aids in observing blood circulation, pinpointing areas of inadequate blood flow that may hinder healing or lead to ulcer development 4. Documentation and Reporting:
- **Image Documentation:** Essential images and significant findings are recorded for the medical record.
- **Clinical Report:** An elaborate report is generated, providing a comprehensive overview of the findings and their clinical significance. This report serves as a valuable resource for treatment planning and subsequent care management.[18]

Optical Coherence Tomography (OCT)

Chronic wounds, like venous leg ulcers, exhibit a slow healing process and tend to recur. The delayed healing of venous leg ulcers can be linked to several factors, such as ambulatory hypertension, impaired perfusion and diffusion, chronic inflammation at wound sites, lipodermatosclerosis, and senescence. To enhance our comprehension of the underlying pathology, this research sought to explore the potential of a novel method known as optical coherence tomography (OCT). By enabling visualization of blood capillaries in the peri-wound skin, OCT has the capacity to offer valuable insights. Both OCT and its recent iteration, dynamic OCT, allow for rapid and noninvasive imaging of the capillaries in the superficial dermis using a handheld probe. This imaging technique

unveils the morphology and density of the vessels. Optical coherence tomography (OCT) is used to obtain high-resolution, cross-sectional images of the designated tissue or sample. Employed a particular model of OCT system that operated at a central wavelength of a specific value in nanometers. This system provided us with axial and lateral resolutions of specific values in micrometers. Prior to each session, we calibrated the OCT system using a standard reference to ensure accurate results. The imaging process involved directing a broadband light source onto the sample, capturing the backscattered light, and then analyzing the interference pattern using Fourier-transform methods. This allowed us to reconstruct depth-resolved images. To enhance the signal-to-noise ratio, averaged multiple scans. For image processing and quantitative analysis, utilized a specific software that focused on particular parameters, such as layer thickness and tissue morphology [19]

Photoplethysmography (PPG)

The photoplethysmogram is a cost-effective, technically simple, and entirely non-invasive approach for both the physician and the subject. Computer-aided diagnostic (CAD) system used the machine learning approach. It is divided into two distinct phases by a dotted line. The left side corresponds to an offline system, whereas the right side corresponds to an online system. Both phases (offline and online) involve a feature extraction process that encompasses features obtained from the time domain waveform of the PPG signal, its derivatives, and features extracted through Principal Component Analysis [20].

Sensors used to measure DFU

TEMPERATURE SENSORS

Temperature Sensor Selection Requirements

- Accuracy: ±0.5°C
- Temperature Range: 25–45°C

Thermocouples

Consists of two different metals joined at one end that produce a voltage related to temperature. When two metals with different properties and temperatures are joined together, they create an electrical junction. This junction produces a small voltage that is dependent on the temperature, known as the Seebeck effect. Due to the extremely low voltage generated, a precise amplification stage with minimal noise is necessary. However, these junctions have drawbacks including decreased accuracy, vulnerability to noise interference, and the formation of unwanted connections between the printed circuit board (PCB) and the thermocouple [21-22].

TMP35 Sensors

The TMP35 is a precision centigrade temperature sensor that operates at low voltage. It is designed to provide a voltage output that is directly proportional to the Celsius temperature. The TMP35 is highly accurate at +25°C and has a typical accuracy of ±2°C over a temperature range of +125°C. It does not require any external calibration. This device is suitable for single-supply operation with a maximum voltage of 5.5 V. The TMP35 is capable of reading temperatures up to 125°C and has an output scale factor of 10 mV/°C [22]. However, if operated from a 5 V supply, its accuracy is reduced when temperatures exceed 150°C. In the insole, temperature sensors are embedded at four specific locations: the hallux, between the first and second metatarsal head, the lateral side of the foot, and the heel.

Photoplethysmography sensor

PPG Sensors for Diabetic Foot Ulcers: Sensoria Smart Socks: Textile-based PPG sensors integrated into socks to track foot health metrics. Orpyx SurroSense Rx: Insoles with embedded PPG sensors to monitor pressure, temperature, and blood flow. MC10 Biostamp: Flexible, skin-adherent PPG sensors for continuous physiological monitoring.

LED-PD (TSL260R)

Light-to-Voltage Optical Sensor (Photodetector) Converts light intensity to voltage output Responsive to visible and near-infrared light Typically operates from 2.7V to 5.5V. Output is the linear voltage proportional to light intensity.

The features include integrated photodiode and transimpedance amplifier, low supply current and fast response time.

MAX30100 sensor

Integrated Pulse Oximeter and Heart-Rate Sensor Module Measures heart rate and blood oxygen saturation (SpO2). Operating Principle: Uses red and infrared light to perform photoplethysmography (PPG). Key Features includes Ultra-low power consumption Integrated red and IR LEDs Photodetectors, analog front-end, and digital processing in a single module I2C interface for communication with microcontrollers Adjustable LED current for different skin types and ambient conditions [21]

PRESSURE SENSOR

Requirements for selecting

- Range: 0-1000 kPa [18]
- Sensing area: large area underestimates peak pressure whereas too small area should be minimum 5*5 mm to be a stand-alone sensor [22]

Capacitive force sensor

Capacitance depends on the surface area of the capacitor, the thickness of the dielectric, and the properties of the dielectric material. By altering one of these properties in response to an applied force, a capacitive force sensor can be created. In most cases, capacitive force sensors adjust the thickness of the dielectric material. A capacitor is formed by placing two conductive planes apart with a dielectric material in between [23]. When a force is exerted, the distance between the plates decreases, leading to an increase in capacitance. This variation in capacitance can then be converted into the applied force through the use of conditioning circuits.

Force sensitive sensors

Force Sensitive Resistors (FSR) are in essence piezo-resistive devices whose resistance linearly decreases as the force applied on them increases. FSRs consist of semi conductive ink layers contained between two thin substrates. The piezo-resistive layer lies in between two conductive areas. When unloaded this layer exhibits very high resistance in orders of Mega-ohm (MΩ). As the force gets applied, resistance of the layer changes and resultant voltage or current changes can be observed between two conductor leads. One of the most widely used sensors in the application of plantar pressure is the force sensing resistor (FSR). Many researchers have conducted measurements of pressure and posture analysis using the FSR sensor design results, specification and signal conditioning designs according to application needs**.** Gait Analysis: Assessing walking patterns to identify abnormal pressures and prevent ulcer formation [24].

DISCUSSION AND CONCLUSION

Current State of Early Detection Methods Summarize the various techniques and technologies reviewed, such as infrared thermography, Doppler ultrasound, and pressure sensing mats. Highlight their effectiveness in detecting pre-ulcerative signs and symptoms. Discuss the challenges faced by existing methods, such as cost, accessibility, and reliability. Acknowledge that while these technologies show promise, there are still significant barriers to widespread adoption and implementation Emphasize the clinical significance of early detection in preventing diabetic foot ulcers. Cite statistics or case studies demonstrating how early intervention can reduce the severity and incidence of ulcers, thereby improving patient outcomes and reducing healthcare costs. The rate of changes in diabetic foot ulcer focusing on particular factors were considered. Wherein, the DFU is seen predominantly for subjects above 50 years because of long history of diabetes and peripheral neuropathy causing trauma which acts as a predisposing factor for diabetic foot ulcers. The laterality study indicates an important finding that most subjects are affected on right limb compare to left lower limb and very less cases with bilateral presentation of DFU. The average size of ulcer formation

can be between 5 to 7 cm and the Glycated Haemoglobin (HbA1c) is observed to be >6.5 for diabetic subjects. The bacteria such as Staphylococcus Aureus and Pseudomonas were observed in pus culture. Compare and contrast the effectiveness of different detection techniques reviewed in the paper. Evaluate their sensitivity, specificity, and practicality in clinical setting Analyze the cost-effectiveness of early detection technologies. Consider both direct healthcare costs and indirect costs associated with diabetic foot complications. Consider factors such as comfort, ease of use, and patient compliance with monitoring protocols. Explore the barriers preventing widespread adoption of early detection methods. This may include regulatory hurdles, reimbursement issues, and healthcare infrastructure challenges. Address ethical considerations related to early detection, such as patient privacy, informed consent, and equity in access to healthcare services. There is a need to know how early detection methods can be integrated into routine clinical practice. Assess the potential impact of early detection on healthcare systems and policy Propose areas for future research and development. This could include improving the accuracy and affordability of existing technologies, exploring novel biomarkers, or integrating data analytics and machine learning for predictive modeling. Importance of Multidisciplinary Approach: Stress the importance of collaboration between podiatrists, endocrinologists, engineers, and data scientists in advancing early detection strategies. Highlight the need for interdisciplinary research to address the multifaceted nature of diabetic foot disease.[25]

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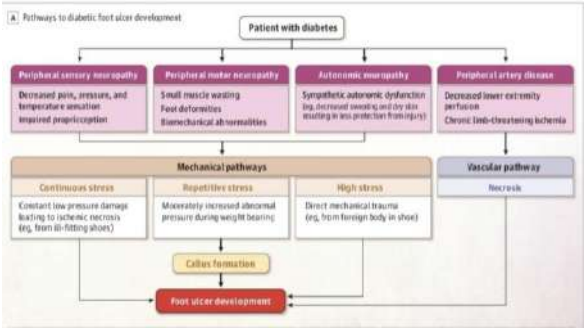


Figure 1: pathways of diabetic foot ulcer development [07]

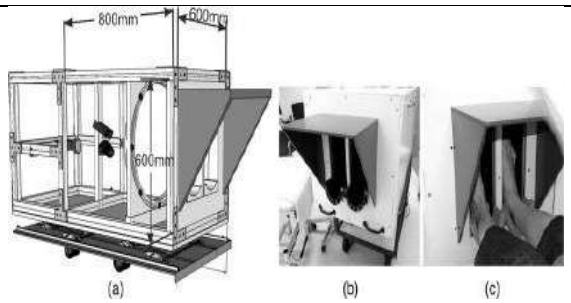


Figure 2: Infrared thermography device [14]

RESEARCH ARTICLE

IN-SOMNUS : A Biomedical Sleep Inducer

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ABSTRACT

Sleep is a critical, naturally recurring state that promotes the growth and rejuvenation of the body's systems, including the immune, nervous, skeletal, and muscular systems. Insomnia, characterized by difficulties in falling or staying asleep, affects millions worldwide, leading to significant impairments in daily functioning, memory, mood, and overall health. Our project, IN-SOMNUS, aims to address this pervasive issue by designing a low-cost, user-friendly biomedical device that induces sleep through the generation of a magnetic field. This magnetic field simulates natural geomagnetic fields, thereby creating an optimal environment for sleep by activating the pituitary gland. The device provides a non-invasive and effective remedy for individuals dealing with insomnia, enhancing sleep quality without the need for pharmaceutical interventions. Our research includes the design, development, and testing of this innovative sleep inducer, demonstrating its potential to significantly improve sleep patterns and overall well-being.

Keywords: Sleep, Insomnia, Sleep induction, Biomedical device, Magnetic field, Pituitary gland activation, non-pharmaceutical intervention, Sleep disorders, Neurostimulation, Sleep technology, Sleep improvement

INTRODUCTION

Sleep is a natural state vital for restoring the body's functions, characterized by reduced consciousness, suspended sensory activity and minimal voluntary muscle movement. It is regulated by the nervous system, particularly the

cerebral cortex. Sleep comprises various stages, including Rapid Eye Movement (REM) and Non-Rapid Eye Movement (NREM) sleep, each characterized by distinct brainwave patterns. Insomnia or sleeplessness, refers to difficulties in initiating or maintaining sleep, leading to impaired daytime functioning. It is classified into transient, acute, and chronic types based on duration. The causes of insomnia vary, ranging from stress and poor sleep hygiene to medical conditions and medication use. Insomnia can negatively affect bodily and physiological wellbeing, including a heightened risk of depression, anxiety, and chronic diseases. Current treatments for insomnia often involve medications with possible adverse effects and high costs. Direct costs of insomnia treatment and related healthcare services are estimated to be substantial, emphasizing the need for low-cost, non-invasive solutions. Hence, the motivation for developing innovative devices like IN-SOMNUS, offering effective insomnia management with fewer adverse effects. Our research encompasses the design, development, and testing phases of the IN-SOMNUS device. We aim to provide a non-invasive and effective solution for individuals struggling with insomnia, improving their sleep patterns and overall well-being. This paper details the methodology, materials used, experimental results, and potential implications of our findings with in the domain of sleep technology and medical electronics.

Types

1. Transient Insomnia: lasts for a few days to a week, often triggered by temporary factors like stress, jet lag, or illness.
2. Acute Insomnia: persists for several weeks due to significant stressors or life events, such as illness or loss.
3. Chronic Insomnia: lasts a minimum of three times each week for three months or longer, impacting daily functioning and often stemming from underlying medical or psychological conditions.

Causes

- Life occurrences such as fear, tension, anxiety, work-related issues, financial strain, child delivery, and loss of dear ones.
- Use of fluoroquinolone antibiotics, which can exacerbate and prolong insomnia.
- Restless Legs Syndrome causes discomfort and the urge to change the placement of the limbs, interfering with falling asleep.
- Disturbances to the circadian rhythm due to work shift or jet lag.
- Improper use of prescription sleep aids and the intake of unprescribed sleep aids leads to rebound insomnia.

Symptoms

- Sleepiness during the day
- Fatigue and Irritability
- Problems with concentration or memory
- Mood disturbance and low motivation or energy

BACKGROUND

Patterns of Brain Waves

1. Delta Waves (0.5-4 Hz): are the slowest brain waves and are relatedto deep sleep, unconsciousness, and unconscious bodily functions such as heartbeat and digestion.
2. Theta Waves (4-8 Hz): occur during light sleep, deep meditation, and states of creativity. They are also linked to REM (rapid eye movement) sleep and the dreaming process.
3. Alpha Waves (8-12 Hz): occur when you are consciously relaxed and not actively processing information. They are related to a calm and relaxed mental state, such as during meditation or when daydreaming.
4. Beta Waves (12-30 Hz): related to dynamic, alarm, and centred mental movement. They are present during normal waking consciousness and activities such as problem-solving and decision-making.
5. Gamma Waves (above 30 Hz): are the fastest brain waves and are related to high-level cognitive functions such as perception, consciousness and also linked to states of peak concentration and heightened awareness.

The State of Human brain During Slumber

Upon closing your eyes and easing into relaxation, your brain shows alpha waves (7-12 Hz), linked to feeling calm and less focused. Opening your eyes switches this to beta waves (17-20 Hz). As you fall asleep, brain waves slow from beta to alpha to theta (4-8 Hz), marking the start of Stage 1 sleep. The EEG wave amplitude is lowest when awake and increases through sleep stages. Different brain patterns are observed in children, various sleep stages, and disorders like epilepsy and insomnia.

Current solutions or devices

- Dreamate Sleep Inducer: Utilizing acupressure, this device massages the "sleeping golden triangle" on the left wrist. This method is claimed to calm the body, lower stress levels, and induce sleep naturally.
- Fisher Wallace Stimulator: This FDA-cleared device uses cranial electrical stimulation (CES) to treat insomnia, anxiety, and depression. It stimulates the release of neurotransmitters associated with relaxation and sleep.
- Dreem Headband: The Dreem headband combines EEG sensors with an audio-based bio-feedback system to enhance sleep, particularly deep sleep. It monitors brain waves in real time and uses bone-conduction technology to stimulate slow-wave activity during sleep.

METHODOLOGY

The device generates a geomagnetic field to induce sleep by mimicking the earth's magnetic field. This field influences the pituitary gland to create a conducive environment for sleep. Our design is composed of compact, user-friendly apparatus positioned near the user's sleeping area. The design ensures the device is safe and effective for regular use. It operates by producing magnetic field that envelops the user's head, promoting relaxation and inducing sleep. It also includes a speaker system to play soothing sleep music if desired. The integrated circuits (ICs) chosen for the device are chosen according to their functionality and compatibility with the device’s requirements. Key ICs include the 4060 timer IC and 4093 quad NAND gate IC.

Hardware

- IC 4060: a versatile integrated circuit used for timing applications, offering ten active high outputs for adjustable time delays ranging from seconds to hours.
- IC 4093: comprises four Schmitt-trigger circuits functioning as 2-input NAND gates with Schmitt-trigger action, commonly utilized for wave and pulse shaping tasks.
- Radiator coil: created by winding six hundred turns of 0.2 mm enamelled wire around a 40mm long steel bolt, providing an average current draw of approximately 7mA during operation.
- Push buttons: mechanical switches for user input in electronic circuits.
- Switches: components for interrupting or diverting electrical current.
- Battery: portable power source for electronic devices.
- Diode (1N4148): fast-switching diode for signal processing.
- Transistor: semiconductor device for amplification and switching.
- LEDs: light sources for indicators and displays.
- Resistors (1k, 10k): components for voltage and current control.
- Capacitors: components for energy storage and signal filtering.
- Mono audio jack / 1/8 stereo: also known as a 1/8 stereo jack, is a connector used for audio signals, accommodating both mono and stereo audio connections in electronic devices.
- Speaker: auditory waves are converted to electrical signals by an electroacoustic transducer commonly used for audio output in electronic devices such as radios and amplifiers.
- LM386:is an amplifier for audio power with a low voltage integrated circuit, widely used for boosting audio signals in small electronic equipments such as radios and portable speakers.

Construction and Working

The IC 4060's internal oscillator drives a 14-stage ripple counter, which resets the working and has a specific timing. IC 4093 generates two square-shaped waves oscillating at 1.2Hz and 5Hz, converting them into 60μs pulses. These beats are blended at the transistor base, powering the radiator coil with 60μs beats at 9V. The IC 4093 has a timer section (IC2A and IC2B) and a square-wave generator (IC2C and IC2D). When the IC 4060's pin 1 (output)becomes high, IC2A's pin 3 in IC 4093 becomes low, stopping IC2C and IC2D oscillations. If the switch is open, IC 4060's pin 1 becomes low, IC2A's pin 3 becomes high, and the oscillators are again activated. If the switch is closed, IC 4060's pin 1 goes high disabling the internal oscillator, keeping the circuit inactive until a reset pulse is applied to IC 4060's pin 12 or the device is restarted.

Generation of Magnetic Field

The device circuit induces a current in a magnetic coil to generate a geomagnetic field that aids the brain enter a relaxed state by activating the pituitary gland. An electromagnetic field produced by electrically charged objects, influences the behaviour of nearby charged objects and extends indefinitely throughout space.

Speaker system for sleep music

The right kind of music can help us relax perfectly, so we can include a speaker system with sleep music on the device. This system, which is optional for the user, plays relaxing nature sounds and other soothing tracks. The device will come with pre-installed music designed to help induce sleep. Adding this feature benefits the user, as extensive research shows that sleep music can alleviate stress, distress, and even illness.

RESULTS

Prototype test results

To assess the functionality and efficiency of the In-Somnus device, we conducted prototype testing with 10 subjects. We measured the time it took for each and every subject to feel relaxed. Testing took place in various settings, including a bedroom, project laboratory, staff room, and on a couch. In some instances, soothing music was played through a speaker system to aid relaxation.

CONCLUSION

The device aims to relieve stress, promote restful sleep, and alleviate tension and restlessness, supporting an active social and healthy personal life. It helps in unwinding, stretch administration and rest acceptance by producing a geomagnetic field that makes a perfect environment for sound sleep. However, the results so far are not entirely satisfactory, indicating that further research and improvements are needed.

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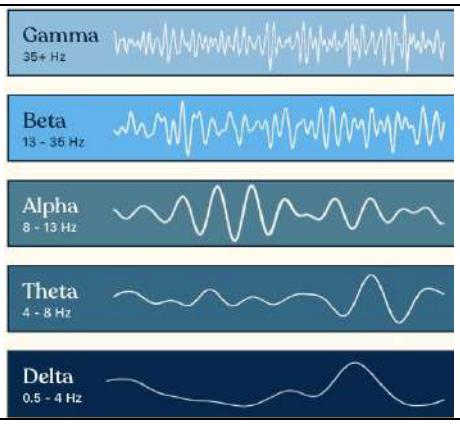


Fig 1 : Patterns of Brain Waves

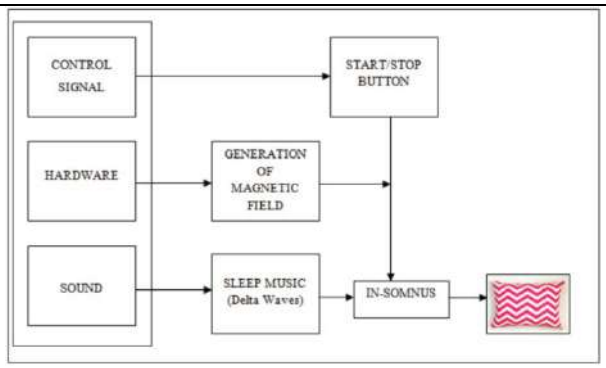


Fig 2: Block Diagram

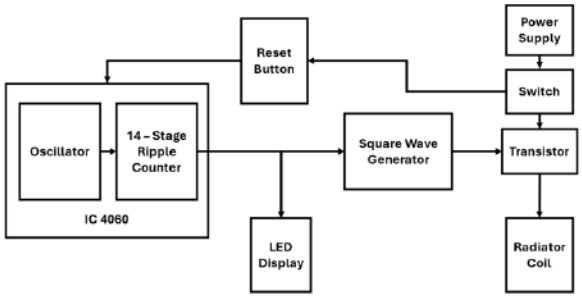


Fig 3: Internal Hardware

SL. NO.	SUBJECT NAME	AGE (YRS)	SLEEP ENVIRONMENT	TIME TAKEN TO FEEL RELAXED (APPROX.)
1	Simone Thomas	14	Couch	15 minutes
2	Rakshitha A. M.	21	Project Lab	5-10 minutes
3	Prof. Srinivas Halvi	50	Project Lab	8-10 minutes
4	Varsha Raju	21	Project Lab	No effect
5	Shivika Shukla	22	Bedroom	15-20 minutes
6	Mrs. Padmaja K.	45	Project Lab	5 minutes
7	Mr. Bharath Kumar T	24	Project Lab	5 minutes
8	Rahael Roy	21	Bedroom	10 minutes
9	Prof. G. Narasimhalu	50	Staff Room	No effect
10	Mrs. Shyamala M.	30	Project Lab	10 – 12 minutes

Fig 4: Test results of different subjects

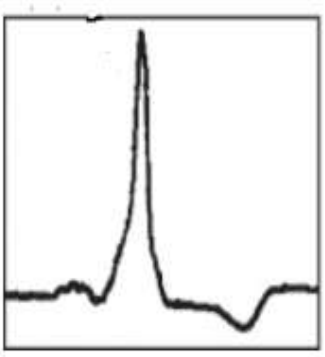


Fig 5: Standard Delta Waves

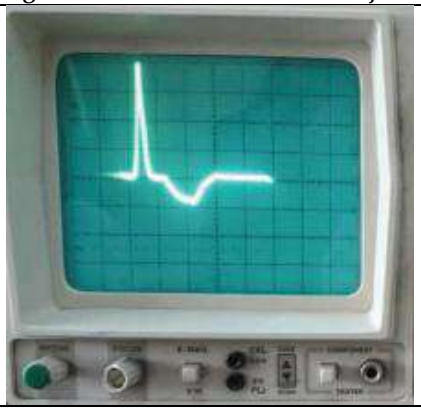


Fig 6: CRO Output of Delta Waves

RESEARCH ARTICLE

Uterosense EMG Monitoring Belt

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ABSTRACT

Monitoring contractions during pregnancy plays a vital role. It helps to anticipate a premature birth. Several ways are accustomed toperceive the early labour, but they're not always accurate. Uterine EMG methods are being used to employed to find the contractions. By using EMG, we can detect uterine contractions through special technology. The Arduino UNO microcontroller and blue-tooth module help convert signals and send them wirelessly. This scheme aims to create an affordable belt for monitoring contractions.

Keywords: preterm labour, EMG(Electromyography), uterine contractions, Arduino UNO, Bluetooth module.

INTRODUCTION

Early contractions in pregnancy leading to premature births result in fetal hypoxia and distress. Currently, the treatment options for preterm labour are ineffective. This problem is mostly caused by the absence of an objective way to assess the progress of pregnancy towards labor, whether at full term or prematurely. Various methods have been used to monitor and diagnose labor which includes invasive intrauterine pressure (IUP) assessment additionally the external tocodynamometer approach. The initial technique isconsidered reliable butIts encroaching nature leads to contamination and limits its usage. However, in contrast, the external to co dynamic is non-invasive but it is less dependable and tends to be uneven because the strain gauge transducer is mechanically indirect it utilizes. Uterine electromyography (EMG) techniques could offer much-needed diagnostic capabilities. Numerous more initiatives have been developed which includes, [1]Wearable Patch for Monitoring Preterm Birth and Uterine EMG Applications, here they have developed the device for capturing EMG signals in the uterusby measuring the multi- uterine EMG channelsignals. They explored new feature parameters, such asthe quantity of high points within the FFT integral and EHG signal envelope value, to distinguish preterm birth risks. By comparing FFT and EMG

signals in both the states, they observed that the integral value of FFT in thecondition of contraction is greater in the 0.2~0.4 Hz frequency range compared tothe typical situationsubjects. [2] Research has beenalready proposed analyzing the genesis of multifractality in uter EMG signals to provide insights to costs of progression of pregnancy. The purpose of the present work is to investigate the application of this approach to analyse EMG signals during the second (T1) and third (T2) trimesters of pregnancy, and its potential relevance in the context of premature labor at each gestational trimester EMG m recordings were analysed for de-trended Fluctuation Analysis (DFA), Multifractal DFA (MFDFA) and Multifractal Detrended Moving Average (MFDMA) developments. Local, maxima consistent irregularity of uterine EMG signals of the second trimester (T1) and third trimester (T2) with a multifractality property was mainly caused by autonomic, local and long-range correlations in signals. Peak singularity exponent and multifractality strength are key descriptors which robustly indicate the pregnancy status, therefore offering significant information on the dynamic behaviour of the uterus. [3] A very effective ensemble Gaussian process classifier was applied to detect the uterine contractions and has shown promising results regarding enabling the recognition of contraction patterns at different stages of gestation. [4] The authors show how using only 8 electrodes from the 16-electrode islandic EHG database analyzed by a Convolutional Neural Network (CNN), it is possible to obtain an AUC of 0.766 demonstrating that machine learning can be used to accurately identify uterine contractions.[5]An extensive study on signal dependencies during pregnancy found a significant decrease in its inception stage, signifying that changes in dynamic nature of uterus are important in preventing preterm labor.[6]The use of nonlinear correlation coefficients (h2) for synchrony and directionality evaluationadditionally general synchronization (H) has resulted in encouraging outcomes, which have helped identify sources of uterine contractions, thereby shedding more light on complicated mechanisms underlying labor progression.

BACKGROUND

Existing methods

- Cardiotocography This is an examination that utilizes a pressure and it is also called a cardio taco dynamometer which is used in monitoring the contractions of the uterus. The critics of the test have supported, yet position and are claiming that application of test to help identify fetal distress in a way that test is a manner that has been crucial in increasing the count of caesarean sections.
- Contraction Stress Test (CST): Tympanometry is a test and mostly done in hospitals or clinics and this employs fetal monitors that are external. This is then followed by nipple stimulation; oxytocin is given next to guarantee that the toned contractions of the uterus are initiated. There are negative consequences connected to the drug oxytocin such as start of preterm labor additionally sustained contractions that could be noticed from the side of the baby.
- Non-Stress Test (NST): This test is not a stress induced test and it is relatively expensive regarding cost and size and weight and not very portable in nature. Regretfully, each of these processes is expensive, not friendly to the end user and there is also aelevated frequency offalse positives involved as the screening results range from 10-15%.

Types of contractions

- **Braxton Hicks Contractions:**
  They are otherwise known as ‘realization’, ‘pro-contractions’ The referred contractions are also termed as ‘practice’ or the ‘false’ contractions. Oxytocic waves; which are very rusty and fewer in frequency causing contractions at intervals in a different rhythm from true labor contractions which are intended to prepare the uterus for labor
- **Preterm Labor Contractions:**
  Abortions when a woman is pregnant but before she has reached even 37 weeks are in a way implying that there's a likelihood of developing preterm labor.

- **Early Labor Contractions:**
  The stage which may also be termed as stage one or the phase dilatation stage does not really have a stipulated time and could take up to several hours.
- **Active Labor Contractions:**
  To be present in this state the cervix after attaining the 6 cm, will dilate by a 4 cm to proceed to the subsequent stage of labour.
- **Transition Labor Contractions:**
  A sub phase of the first stage of labor, where the cervix expands to the certain maximum and can stretch no further than the birth canal 10 cm.

COMPONENTS

Hardware

INA (Instrumentation amplifier): The INA128 possesses little power instrument with good precision. They are suitable for a vast range of activities because of their three op-amp style and compact size. Current-feedback input offers Broad bandwidth even at elevated gain (100). Any increase between one and ten thousand can be just set by one Resistor. The INA128 is extremely low offset voltage laser trimmed. (50V), drift (0.5V/?C) and strong rejection of common modes (120dB at G= 100). It works on voltages very low, as 2.25V and only takes approximately 700A so it requires minimum power when running on battery. Internal input precaution can handle up to 40V without any harm an Eight-point plastic DIPor SO-8 surface mount package is accessible for the INA128 which has a temperature range of 40C to +85C.

EMG(electromyography) ELECTRODES

The device consists of three EMG electrodes coloured red, green, yellow and Green electrode is the reference electrode and it is grounded.

ARDUINO UNO

A microcontroller boarding according to theATmega328 is the Arduino Uno. A total of 14 digital input/output pins, with six of them doubling as PWM outputs are present. Six analog inputs USB connection, Power jack, ceramic resonator operating at 16MHz, ICSP header, Reset button. Each Among the14 digital pins on the Uno can be an either an input or an output pin using pin Mode(), digital Write() and digital Read(). They labour at a voltage of 5V. For every pin, a maximum current of 40mA can be provided or drawn and there's a internal pull-up resistor (which is disconnected by default) whose value ranges from 20-50 KΩ.

BLUETOOTH MODULE

HC9-05 is considered the most inexpensive and easy to implement to go wireless. (Via Bluetooth). This module simplifies the wireless extension of the serial interface in a considerably big way.

Software Components

- **ARDUINO IDE:** There are three elements in the Arduino development environment: The text editor for composing the code, the messaging box, a text area, a strip that contains associated buttons for operations frequently used, and programs over the Arduino hardware and to relay commands and/or data between the programs.
- **MATLAB SOFTWARE:** MATLAB is a programming languagewhich is employedfor technical computations and is considered to be very fast. It integrates computation, presented in an intuitive and friendly manner, challenging problems, additionally little-known or cumbersome algorithms and their solutions, are stated again regarding a kind of mathematical language that everyone knows.

METHODOLOGY

When the block level is being considered, the layout of the utero device is as shown below. It has an electrode myography sensor, additionally referred to as EMG that is employed formonitoring contraction of the uterus. The sensor formed portion of the input and is taken through an amplifier unit in an effort to amplify the small EMG signals. In this case, the signal gets to displayed unit to enhance filtration results. In this respect, the filtered signal is conveyed to a microcontroller [Arduino Uno] moreoverconveyed to the display unit via a Bluetooth moduleafter that, signals are sent through a conversion and analyzed on a GUI system, while selected information is sent via e-mail to the doctor.

Algorithm

- Initialization: Attach the UteroSense EMG Monitoring Belt to the abdomen and initialize the EMG signal.
- Data Acquisition: Continuously capture multi-channel uterine signals.
- Preprocessing: Apply a bandpass filter to remove the noise.
- Processing: Signals sent over the Arduino UNO to convert AC signals to DC.
- Transmitting the signal: Signal is transmitted via Bluetooth module.
- Signal Processing: Signal is being processed by using MATLAB.
- Alert Generation: If the value of the signal exceeds the threshold value send the alert signal to the doctor/ PHC with their details.

RESULTS

Signal acquisition: we use electrodes buttons and arduino board to acquire the signal. On this, while MATLAB was used to process these signals and that they are coming to pass through this displayed on the computer screen. A value of 3.2 V was made the threshold; whenever muscles flexed above the threshold, the system did the following: On the image, the signal ought to beseen later for research. The acquired values are processed and the resulting waveforms are displayed in MATLAB software using a GUI. This allows for efficient visualization and analysis of the data.

CONCLUSION

The Uterosense EMG monitoring belt poses to fill an existing niche in affordable and readily available equipment to address prenatal techniques, with a special emphasis on diagnosing preterm labor. The overall objective of the project is to improve the provided results by the way of developing a new portable and convenient application for the constant control of the cramps in the uterus.

Benefits

A cost-effective and easy-to-use device that can help diagnose preterm labor and its timely treatment and thereby help decrease instances of infant mortality and/or develop lifelong issue.

Applications

It's applicable invarious hierarchical levels of healthcare, that of hospitals, medical centre, and primary care facilitiesin home-telemonitoring and teleconsultations.

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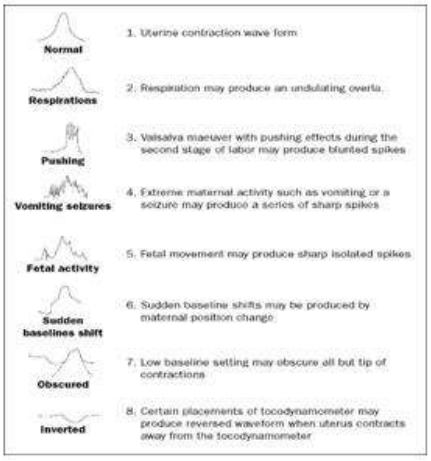


Fig 1. Waveforms during pregnancy contractions

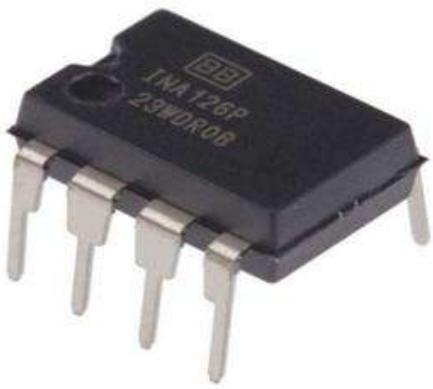


Fig 2. Instrumentation Amplifier

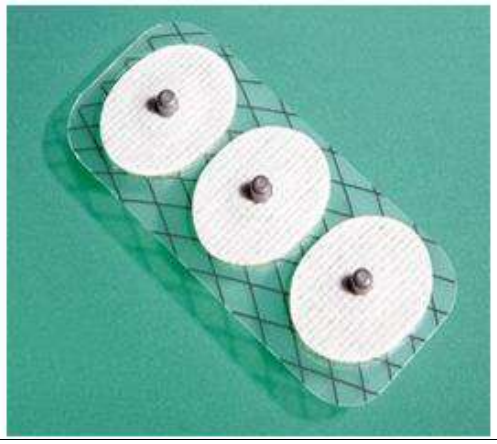


Fig 3. EMG electrodes



Fig 4. Arduino UNO



Fig 5. Bluetooth module

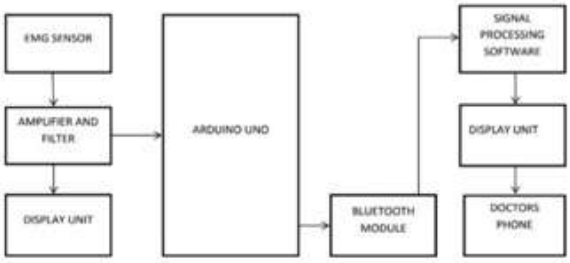


Fig 6. Scheme of proposed work

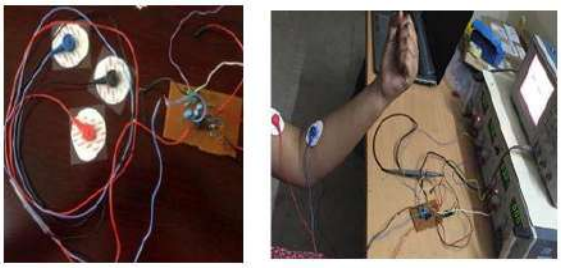


Fig 7 and 8. Data acquisition set-up on the patient's arm

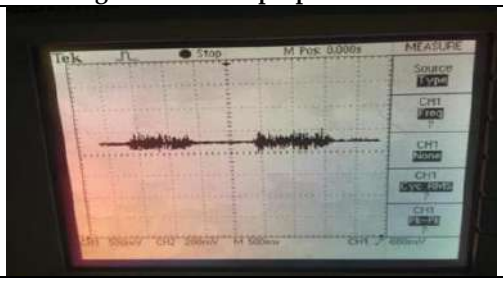


Fig 9. Waveforms observed on the CRO

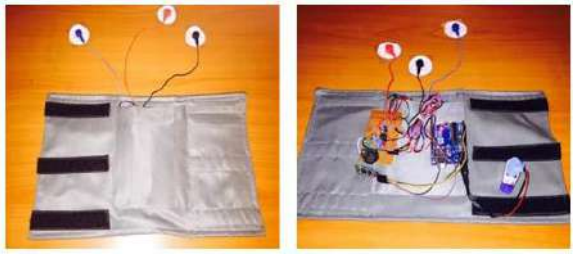


Fig 10 and 11. Utero-Belt

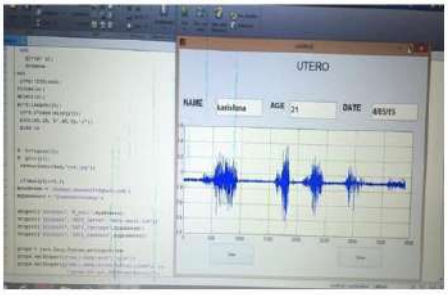


Fig 12. Contraction Waveforms

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RESEARCH ARTICLE

Hybrid Approach using IoT and Deep Learning for Sustainability and Safety of Autonomous Railways

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ABSTRACT

A Automation has become more and more common in the transportation industry to boost productivity and safety while meeting the requirements of the expanding daily transportation market. With the advent of autonomous automobiles, it is now feasible to build driverless trains that employ AI-based methods to increase functionality and reliability. As a result, the adoption of fully automated railway systems with many functional capacities has garnered more attention in recent years. Deep learning and other AI-based approaches are pragmatic to recover the effectiveness and safety of data-driven Intelligent Automated Railway Systems (IARS), especially in mountainous areas. For the persistence of spotting cracks, a dynamic braking system (DBS) is applied to automatically recognize hazardous situations in real time. The YOLOv4 Tiny model based on a Fully Convolutional Neural Network that can detect multiple objects in an image with high accuracy and speed is implemented. The closest railway point is alerted by the system in the instance of a threat or tragedy by implementing various steps in YOLOv4 Tiny model by data collection, preprocessing, model training, model evaluation and deployment .

Keywords: Automation, deep learning, hazardous, YOLOv4., Reliability, automatically , Convolutional

INTRODUCTION

Common causes for railway disasters is accidents, which are primarily brought on by man-made phenomena and abandoned railroad crossings. The International Union of Railways estimates that 2,400 people were injured and 1,700 people died in approximately 3,100 train accidents worldwide in 2022. We developed an object identification system that use image classification techniques to identify obstructions on the tracks automatically to address this problem. Railroad safety is enhanced and guaranteed by the usage of this technologyThe integration of image processing ideas and machine learning methods, with deep learning facilitates remarkable advances in perception, allowing travel modes to be fully automated while assuring safety and efficiency. The future approach incorporates sensor technology to identify and watch the railroad lines,allowing for the early identification of possible dangers like cracks. Since the release of smartphones and cameras with artificial intelligence (AI), image data processing has significantly improved. This technology has a amount of potential uses, including security and traffic monitoring.We can save both human and animal lives by preventing collisions on the train track with the help of the suggested IoT system and such potent algorithms. This supports sustainability in the transportation sector in addition to improving safety. Incorporating cutting-edge technologies like deep learning, sensor technology, and LIDAR-based color detection algorithms into the suggested Internet of Things system presents a viable option to address the issues with the railway sector. By reducing accidents caused by neglected rresearchers have created a numeral technologies and methods to improve railway safety to solve these safetyconcerns. Using object identification algorithms that make use of picture categorization techniques is one method for locating hazards and impediments on railroad lines. This kind of technology could improve railway safety by preventing accidents, identifying possible threats early. Additionally, recommendations have been made to track and determine the condition of railroad rails using sensor technologies. Preventive maintenance and repairs can be carried out to lessen the chance of accidents by utilizing sensors to monitor the state of the rails, such as discovering cracks and other flaws.

LITERTAURE SURVEY

A railway track flaw identification system based on image processing and deep learning techniques was proposed by Hu et al. [1]. The system uses image data to detect defects on railway tracks and has shown a significant improvement in the accuracy of defect detection. An Internet of Things (IoT)-based railway monitoring system that use sensors and machine learning algorithms to identify anomalies on railway tracks was presented by Wu et al. [2]. The system detects and reports any unusual changes in the railway environment, allowing for timely maintenance and reducing the hazard of accidents. A prognostic conservation system for railway track inspection based on machine learning was presented by Wang et al. [3].The system uses historical data and machine learning algorithms to predict the likelihood of future defects, allowing for proactive maintenance and improving the overall safety of railway operations. Sreejith et al. [4] proposed an object detection arrangement for railway safety using deep learning algorithms. The system detects obstacles on railway tracks and sends alerts to train operators, reducing the risk of collisions and accidents. Zhao et al. [5] presented a framework for railway track monitoring using a combination of sensors and ML algorithms. Numerous sensors' data are used by the system to detect defects and predict the maintenance needs of railway tracks, improving the overall safety and efficiency of railway operations. Kumar et al. [6] proposed an intelligent railway traffic control system using IoT and machine learning algorithms. With the use of cameras and sensors mounted on railroad tracks, this system can track traffic patterns in real time and pinpoint areas of congestion Ma et al. [7] presented an integrated railway monitoring system using IoT and deep learning algorithms. The data's from various sensors and cameras to detect and predict defects in railway tracks, allowing for timely maintenance and improving the overall safety of railway operations. Wu et al. [8] proposed a railroad track surveillance system that makes use of using LIDAR-based color recognition techniques. The system uses color detection algorithms to recognize the movement of trains and control the automatic train stopping system, improving the overall safety and efficiency of railway operations. Zhang et al. [9] proposed a railroad catastrophe avoidance system using a combination of IoT, machine learning, and sensor technologies. The system detects and predicts

potential disasters on railway tracks and sends alerts to train operators, reducing the risk of accidents and improving the overall safety of railway operations. Shrestha et al. [10] presented an IoT-based prognostic preservation system for railway tracks. The system uses historical data and ML algorithms to envisage the maintenance needs of railway tracks, improving the overall safety and efficiency of railway operations. An intelligent railway safety monitoring system utilizing machine learning and IoT methods was proposed by Guo et al. [17]. The technology lowers the chance of accidents and raises the general level of safety for railroad operations by using data from sensors and cameras to identify and anticipate possible safety issues on railroad tracks. Wang et al. [18] presented an automated railway checkup structure using deep learning algorithms. The system uses image data to detect defects on railway tracks and automatically generates reports, improving the overall efficiency of railway inspection and maintenance. An intelligent railway monitoring system utilizing machine learning and IoT methods was proposed by Xu et al. [13]. The system lowers the chance of accidents and raises the general safety of railway operations by using data from sensors and cameras to identify and forecast possible safety concerns on railway tracks. A framework for detecting defects in railway tracks by combining machine learning and image processing approaches was introduced by Liu et al. [14]. The method has demonstrated a notable improvement in defect identification accuracy by using picture data to identify flaws on railroad rails. A wireless sensor network-based railway track health monitoring system was proposed by Li et al. [15]. The authors provided evidence of the suggested system's efficacy in identifying track flaws and anticipating probable malfunctions, enhancing railway dependability and safety[13 &16].

PREPOSED METHODOLOGY

Our suggested approach for identifying faults in railroad tracks relies on a blend of Internet of Things, image processing, and machine learning methods. In summary, the proposed railway safety system incorporates various IoT components, such as IR sensors, L298N motor drivers, fire sensors, DC motor pumps, GPS and GSM modules, and AI cameras, all of which are integrated with a central processing unit powered by NodeMCU. The system can detect and respond to various hazards, such as cracks in the tracks, fires, and other potential dangers in real-time, improving the safety and reliability of railway transportation. The system also consist of three primary components: an image acquisition module, a defect detection module, and a machine learning module. The process involved in the hybrid approach using Iot and deep learning for sustainability and safety of autonomous railways is divided into several phase:

1. Sensor Technology Phase
2. Deep learning Phase

SENSOR TECHNOLOGY PHASE

IoT sensors provide real-time data on a variety of railway operations, making them indispensable to the present protection and control systems for railways. These sensors have the ability to track train movements, environmental variables including humidity and temperature, and track conditions. The information produced by these sensors is utilized to identify flaws, forecast the need for maintenance, and streamline railroad traffic The Internet of Things (IoT) components of the current railway monitoring and safety system are made up of a different sensors and modules that collaborate to guarantee the efficient and secure running of trains. IR sensors are positioned at strategic intervals along the tracks to sense temperature variations and identify cracks and other possible risks. Defects can be found and identified using the data from these sensors, enabling prompt maintenance and repair. The DC motor pumps that supply water to put out fires on the tracks are moved by L298N motor drivers. To reduce danger and damage to facilitate an early response to flames, these motor drivers receive directions from the control center and manage the flow of water to the afflicted region. Fire sensors are able to detect any signs of fire or smoke on the tracks or in the surrounding environment by using temperature changes and smoke density. Installing fire sensors reduces the risk of damage and injury even further because they allow for quick detection and response to fires. Water is delivered by DC motor pumps, which are operated remotely by the control center, to put out flames. The trains' whereabouts and movements may be tracked by the system thanks to location data provided by GPS and GSM modules. Sensed data increases the effectiveness of train operations and railway traffic can be optimized. In the

event of possible dangers or interruptions on the rails, the modules can also notify and inform train operators. All things considered, the incorporation of IoT sensors into railway safety and monitoring systems allows the system to gather and evaluate data in real time, identify potential risks and flaws, and react swiftly to emergencies. This improves the safety and efficacy of railway operations and ensures a more dependable and seamless travel experience for both operators and passengers, while also reducing the likelihood of accidents and property damage.

DEEP LEARNING

IoT incorporated systems employ deep learning algorithms to examine the massive volumes of data produced by IoT devices. These algorithms are able to recognize trends and abnormalities in the data, forecast when maintenance is required, and possible risks to one's safety. These technologies, which make use of deep learning algorithms, can give railway operators precise and timely information, empowering them to take preventative action to guarantee the effectiveness and safety of railway operations.

Image Acquisition Module

The high-resolution camera installed atop a railcar to take pictures of the railroad lines will make up the image acquisition module. In order to provide thorough coverage, the camera will be positioned to take pictures of the tracks from various view points . The photos will be taken on a regular basis and sent to the flaw detection module for additional examination.

Defect Detection Module:

In order to identify any flaws or anomalies in the railroad tracks, the defect identification module will evaluate the photos taken by the camera using a variety of image processing algorithms. There will be three sub-components in this module:

Defect Detection

The defect detection module will examine the camera's collected photos using a variety of image processing algorithms in order to identify any anomalies or flaws in the railroad tracks. In this stage, we will classify the tracks as normal or faulty founded on the retrieved attributes using machine learning procedures like Yolo and Convolutional Neural Networks. Every track whose value is higher than the threshold set by the defect detection module will be deemed defective.

Pre-processing

In this step, edge detection, thresholding, and filtering techniques will be used to pre-process the obtained images to eliminate any undesired artifacts or noise. Additionally, the photos will be retouched to raise their caliber.

Feature Extraction

In this instance, we will use a variety of methods, including Gabor filter, Hough transform, and Sobel edge detection, to abstract pertinent structures from the pre-processed images. The characteristics will be employed to distinguish between good and bad music.

TRAINING PHASE

There will be two phases to the machine learning module: training and classification. To identify the characteristics that distinguish normal and faulty tracks apart, the module will be trained on a dataset of those tracks during the training phase. To do this, we will combine supervised and unsupervised learning strategies. The module will categorize the tracks using the features it has learned throughout the classification phase. A railway track fault detection system uses a high-resolution camera installed on a railcar to takes pictures of the rails . After that, these images are interpreted and assessed using a blend of machine learning and image processing techniques.. The pre-processing, feature extraction, and fault detection processes are carried out using image processing techniques. Based

on the retrieved attributes, the tracks are classified as normal or defective using machine learning techniques. A threshold value is set by the system, and any track with a high value than this verge is considered faulty.

SYSTEM ARCHITECTURE

The system architecture of proposed methodology consists of IR sensors, L298N motor drivers, fire sensors, DC motor pumps, GPS and GSM modules, and AI cameras are several IoT components that make up the system. On the railroad rails, the IR sensors are utilized to find cracks and other possible problems. The DC motor pumps that are utilized to supply water to put out potential flames are moved by the L298N motor drivers. Any indication of smoke or fire is detected by the fire sensors, which then activates the water delivery system. The position data from the GPS and GSM modules allows the system to track the movements of the trains and determine their whereabouts.. An artificial intelligence algorithm is fed photos of the tracks by the AI cameras, which are an essential portion of the system. Real-time picture analysis is performed by this program to identify any anomalies or possible dangers on the rails. The central processing unit receives an alarm from the system instantly if it notices any abnormalities, and it then initiates the proper action, like stopping the train or turning on the water delivery system.

IR SENSOR

Railway track cracks can be found by combining infrared sensors with other sensors and parts. Heat is produced when a rail cracks because of friction between the wheels and the rail. Infrared sensors positioned close to the rail can detect this heat. The central processing unit of the system receives a signal from the infrared sensor once it recognizes the heat signature of the crack. After that, the signal is examined by the central processing unit to perceive if a crack has been found. In order to avoid a derailment or other mishap, the system can intervene quickly if a fracture is found, slowing down or stopping the train. To efficiently detect cracks, the IR sensors must be placed strategically along the tracks where cracks are most prone to appear. This calls for a thorough examination of the railway network and the location of high-risk zones. Furthermore, the system must be set up to differentiate heat signatures from nearby fires or hot weather from those originating from fractures.. In conclusion, Infrared sensors could be crucial for detecting cracks in train systems.. They can contribute to the prevention of accidents and guarantee the security of both passengers and staff by identifying heat signatures brought on by cracks

FIRE SENSOR

Using both visible and infrared light, the KY-026 Flame Sensor Module is an optical sensor that can identify the presence of flames. It is frequently utilized in small-scale applications, like Arduino projects, for fire detection systems. The KY-026 sensor is made out of a tiny PCB containing a flame sensor and a potentiometer for adjusting the sensor's sensitivity. By detecting the visible and infrared light that the flames release, the sensor finds the presence of flames. A microcontroller can interpret the digital signal that the sensor emits when it senses a flame.

The KY-026 sensor must be associated to a micro controller such as an Arduino and programmed to recite the sensor's output signal to be used in a project. An alarm or warning system or other project components can be operated by the output signal. A cheap and simple choice for small-scale fire detection projects is the KY-026 sensor. Large-scale or industrial applications, however, that call for more sophisticated and dependable fire detection systems, might find it unsuitable

L298N DUAL H BRIDGE MOTOR DRIVER:

Railway projects that require braking systems can use L298N (Dual H Bridge motor drive)r. In order to prevent accidents and guarantee the security of both passengers and staff, trains it is essential to have a functioning braking system. The L298N motor driver in a braking system can be used to regulate the direction and speed of the DC motors that power the brake system. The train's L298N motor driver can be triggered by the system to apply the brakes, slow down, or stop the train when it senses a risk or dangerous situation. In order to identify cracks and other track flaws, dynamic braking systems (DBS) can also employ the L298N motor driver. In order to stop additional damage or derailment, the L298N motor driver engages the brake system. The DBS employs sensors to identify any

irregularities in the track's condition. The L298N motor driver can improve the braking system's efficiency and performance in addition to safety. The smooth and precise operation of the brake system can be ensured, saving wear and tear on the components and increasing overall braking efficiency by regulating the speed and direction of the DC motors. All things considered, the L298N Dual H Bridge motor driver is a flexible part that may be utilized for many applications in railroad projects, including braking systems.

DC MOTOR PUMP

The train's water supply is supplied by the DC motor pump, a compact, dependable, and efficient pump. A DC motor that runs on the train's battery or generator powers the DC motor pump. The pump pulls water from the train's water storage tank and releases it via a hose or nozzle once it is turned on. Because of its lightweight and compact design, the pump is simple to install and use.

GPS AND GSM

The train's location is tracked and contact with the centralized system is facilitated by two communication technologies: the Global Positioning System (GPS) and the Global System for Mobile Communications (GSM). Real-time position data from the GPS module can be used to track the train's movement, estimate its arrival time, and keep an eye on its route. In the situation of an emergency or accident, the GSM module enables two-way contact between the train and the centralized system, enabling quick action. The railway project is dependent on the GPS and GSM modules since they offer real-time data and facilitate quick communication in an emergency.

NodeMCU

The NodeMCU is used to implement the cloud-based control system. A cheap microcontroller that may be used to create Internet of Things applications is called NodeMCU. It is made to connect to the internet. Through communication with cloud servers, the NodeMCU can offer a centralized platform for railway system monitoring and control. Relay switches, humidity sensors, temperature sensors, and other types of sensors and devices can all be monitored and controlled by the NodeMCU. The railway system's parameters, including the trains' interior temperatures and humidity levels, may be tracked by the sensors, which can then transmit the collected data to a cloud server for analysis. Relay switches can be utilized to regulate many appliances, such air conditioning and lights. The cloud-based control technology allows for remote monitoring and control of the railway system. The operators can react swiftly to any problems or emergencies thanks to the system's ability to deliver real-time data and alarms. To further assure the comfort and safety of the passengers, the operators can also remotely operate the systems and gadgets, such as turning on the air conditioning or altering the lighting. In conclusion, the integration of NodeMCU in a cloud-based control system can offer a centralized platform for tracking and managing different railway system components. By communicating with cloud servers, the NodeMCU can deliver data and alarms in real-time, allowing operators to react promptly to any problems or emergencies. In order to guarantee the comfort and security of passengers, the cloud-based control system can also be utilized to remotely control systems and gadgets.

Arduino IDE platform

The system use the Arduino IDE platform to write the code for the safety and monitoring system for trains. We were able to write, assemble, and upload code to the system's microcontroller board using the platform. The different IoT components, such as IR sensors, L298N motor drivers, fire sensors, DC motor pumps, GPS and GSM modules, and AI cameras, were all programmed using it. Because of the platform's intuitive UI and extensive library of pre-built functions and examples, we were able to develop the system more quickly and efficiently by streamlining the coding process. Furthermore, we were able to access and alter the platform's code because it was open-source, which simplified the process of troubleshooting any issues that developed throughout development. Artificial intelligence and data analytics are essential elements of the railway project. The tracks are photographed by the system using AI cameras, and the photographs are subsequently sent to an AI algorithm for analysis. Real-time image analysis is done

by the algorithm, which looks for anomalies or possible dangers on the tracks. The central processing unit receives an alarm from the system instantly if it notices any abnormalities, and it then initiates the proper action, like stopping the train or turning on the water delivery system. The railway project's AI algorithm is made to be incredibly accurate and efficient. It continuously learns and enhances its detecting abilities through the use of machine learning algorithms. They make it possible for the system to identify possible threats and take immediate action, enhancing the dependability and safety of rail transit. Additionally, they offer insightful information about the system's functioning, which aids in long-term optimization and improvement.

IMPLEMENTATION AND RESULTS

Artificial intelligence and data analytics are essential elements of the railway project. The tracks are photographed by the system using AI cameras, and the photographs are subsequently sent to an AI algorithm for analysis. Real-time image analysis is computed by the algorithm, which looks for anomalies or possible dangers on the tracks. The central processing unit receives an alarm from the system instantly if it notices any abnormalities, and it then initiates the proper action, like stopping the train or turning on the water delivery system. The railway project's integrated with AI algorithm is incredibly accurate and efficient. It continuously learns and enhances its detecting abilities through the machine learning algorithms. Performance analysis and monitoring of the system are also done with data analytics. Data is gathered by the system from a extent of sensors and parts, including motor drivers, fire sensors, and GPS modules. After that, this data is examined for any patterns or trends that might point to possible problems or areas in need of development. Data analytics, for instance, might be used to pinpoint high-risk locations along the rails where problems like cracks are more likely to appear. In general, artificial intelligence, machine learning, and data analytics are essential to the railway project. They make it possible for the system to identify possible threats and take immediate action, enhancing the dependability and safety of rail transit. Additionally, they offer insightful information about the system's functioning, which aids in long-term optimization and improvement.

YOLOv4 Tiny

The goal of the YOLOv4 Tiny object detection model is to outperform the standard YOLOv4 model in terms of speed and efficiency and a subset of the popular YOLO (You Only Look Once) model family, which is used to recognize objects in photos and videos in real time. Based on a fully convolutional neural network, the YOLOv4 Tiny model can quickly and accurately identify many items in a picture. Drones, embedded systems, and smartphones are examples of devices with limited resources, and the model's architecture is designed to be lightweight and appropriate for them. Various stages involved in YOLOv4 Tiny implementation, such as model training, testing, and deployment. The general procedures for implementing YOLOv4 Tiny are as follows:

Data collection and annotation

Gathering and labeling a sizable dataset of photos with the objects of interest is the first stage in putting YOLOv4 Tiny into practice. The annotation process entails class labeling and bounding box by marking spotted objects in the photos.

Preprocessing

The dataset is preprocessed to equalize the image sizes, aspect ratios, and colors after being annotated. To prepare the photos for model training, this stage include scaling, cropping, and enhancing them.

Model training

Using an annotated dataset and a deep learning framework like TensorFlow or PyTorch, the YOLOv4 Tiny model is trained. During training, an objective function that minimizes the detection error is used to optimize the model parameters.

Model evaluation

The accuracy and speed of the model are assessed on a different test set once the training is over. In this step, measures like recall, precision, and F1 score are calculated.

Model deployment

Deploying the model on the intended platform is the final stage in the YOLOv4 Tiny implementation process. Befor final stage the model must be optimized for the particular hardware and software environment, such as an embedded system or smartphone. To put it briefly, YOLOv4 Tiny is a lightweight and effective object detection model that can be used in a number of ways. These phases include gathering data, preprocessing it, training the model, evaluating it, and deploying it. Deep learning frameworks, target hardware and software optimization, and accuracy and speed testing are all part of its implementation.

PERFORMANCE ANALYSIS

EXPERIMENT SETUP

Data Collection

Collect a dataset of images or video footage of railway tracks. This should include various scenarios such as different weather conditions, times of day, and types of objects near the tracks.

- Open Images Dataset: This dataset by Google contains a wide variety of labeled images, including those with vehicles, people, and other objects that might appear near railway tracks.
- COCO Dataset: The Common Objects in Context (COCO) dataset contains images with various objects in different contexts, which can be used for training and testing

Model Preparation

Use the YOLOv4 Tiny model, which is lightweight and suitable for real-time detection.

Environment Setup

Ensure you have the necessary libraries installed (opencv-python, numpy, tensorflow or pytorch depending on the framework you use).

Inference Process

Run the object detection model on the collected images or video footage. Analyze the results by checking for the presence of objects and evaluating the accuracy of the detections.

Python code to run YOLOv4 Tiny object detection on images captured near railway tracks:

```
import cv2
import numpy as np
import os
# Load YOLOv4 Tiny model
net = cv2.dnn.readNet("yolov4-tiny.weights", "yolov4-tiny.cfg")
 layer_names = net.getLayerNames()
output_layers = [layer_names[i[0] - 1] for i in net.getUnconnectedOutLayers()]
# Load class labels
withopen("coco.names", "r") as f:
classes = [line.strip() for line in f.readlines()]
# Directory with sample images
 image_dir = "railway_images"
images = [f for f in os.listdir(image_dir) if os.path.isfile(os.path.join(image_dir, f))]
# Process each image
for image_name in images:
image_path = os.path.join(image_dir, image_name) image = cv2.imread(image_path)
```

```
height, width, channels = image.shape
# Prepare input blob
blob = cv2.dnn.blobFromImage(image, 0.00392, (416, 416), (0, 0, 0), True, crop=False) net.setInput(blob)
# Run inference outs = net.forward(output_layers)
# Parse output
 class_ids = []
confidences = []
boxes = []
for out in outs:
        for detection in out:
        scores = detection[5:]
        class_id = np.argmax(scores)
        confidence = scores[class_id] if confidence >0.5:
# Confidence threshold
center_x = int(detection[0] * width)
center_y = int(detection[1] * height)
 w = int(detection[2] * width)
 h = int(detection[3] * height)
 x = int(center_x - w / 2)
 y = int(center_y - h / 2)
boxes.append([x, y, w, h]) confidences.append(float(confidence)) class_ids.append(class_id)
# Apply non-max suppression
indices = cv2.dnn.NMSBoxes(boxes, confidences, 0.5, 0.4)
# Draw bounding boxes
for i inrange(len(boxes)):
if i in indices:
x, y, w, h = boxes[i]
label = str(classes[class_ids[i]])
confidence = confidences[i]
color = (0, 255, 0)
 cv2.rectangle(image, (x, y), (x + w, y + h), color, 2) cv2.putText(image, f"{label}{confidence:.2f}", (x, y - 10), cv2.FONT_HERSHEY_SIMPLEX, 0.5, color, 2)
# Show result
cv2.imshow("Detected Objects", image)
cv2.waitKey(0)
 cv2.destroyAllWindows()
```

Output

After running the code, the output will be an image with bounding boxes around detected objects, along with labels and confidence scores. Here are some possible scenarios and results: An analysis of an autonomous railway system's performance must also take efficiency into account. Measurements of the system's accuracy, speed, and response time for managing railway infrastructure and train control can be used to assess efficiency. An effective system may eliminate delays, cut down on idle time, and optimize train timetables, which will enhance customer satisfaction and save operating expensesA system's scalability is its capacity to accommodate a growing number of users and devices without experiencing performance issues. When the need for transportation grows, scalability testing should assess the system's capacity to support more trains, sensors, and communication networks.

RESULTS AND DISCUSSIONS

This setup can be used for monitoring railway tracks for safety, detecting potential hazards in real-time, and alerting railway authorities to take necessary actions.

Objects Detected
Vehicles, people, animals, and debris near the railway track will be detected.
Bounding boxes with labels (e.g., "car", "person", "animal") and confidence scores will be drawn on the image.

Evaluation
Check the accuracy of the detections by verifying if the detected objects are correctly identified. Evaluate the performance in different conditions (e.g., daytime, nighttime, rainy weather).

Analysis and Accuracy
High accuracy in detecting objects like vehicles and people will indicate the model's effectiveness. False positives or missed detections should be noted for further model improvement.

Speed
YOLOv4 Tiny should provide fast inference, making it suitable for real-time applications.

Use Cases
Deep Convolutional Neural Networks (DCNNs) can identify distinct objects in an image and their respective states. A few key functional criteria must be measured when choosing an appropriate neural network for object detection: computational complexity, speed, and overall model correctness. Various object detector models come with specific benefits and drawbacks Real-time deployment and sufficient item identification accuracy inside the targeted region are essential for the system's primary purpose. However, these characteristics of accuracy with computing complexity often come at a cost. As such, an equilibrium between the object detector's computing complexity and accuracy must be struck. We examine four different DCNN-based object detector types in our solution: YOLOv4,

CONCLUSIONS AND FUTURE SCOPE

For the protection of both workers and passengers, the railway safety system intends to make use of a variety of IoT components. The L298N motor drivers regulate the operation of the DC motor pumps that put out fires, while the infrared sensors scan the tracks for cracks and other possible threats. The water distribution system is activated by the fire sensors' detection of any smoke or fire. The system can identify the whereabouts of the trains and follow their movements ,appreciations to the location data provided by the GPS and GSM modules. In conclusion, the AI cameras capture images of the tracks, which are promptly analyzed by an artificial intelligence system to identify any anomalies and to start the appropriate process In conclusion , the safety, effectiveness, and dependability of railroad operations might be greatly increased by integrating IoT sensors and deep learning technology into railway monitoring and safety systems. Deep learning algorithms and sensor expertise can be used to identify problems, forecast maintenance requirements, improve traffic flow, and react rapidly to possible threats. Furthermore, by facilitating preventive maintenance and lowering accidents, the installation of such devices can also save money for railroad firms. There is a great deal of potential for the advancement and enhancement of these systems in the future. For instance, the accuracy and effectiveness of railway monitoring systems could be further improved by the employment of more sophisticated sensors like LiDAR and radar sensors. Furthermore, block chain technology may enable more effective collaboration and data sharing amongst different railway sector actors by guaranteeing the confidentiality and integrity of the data generated by these systems. With the potential to increase safety, efficiency,

and cost-effectiveness, the application of IoT sensors and deep learning technologies in railway monitoring and safety systems presents a lot of expectation for the railway sector's future.

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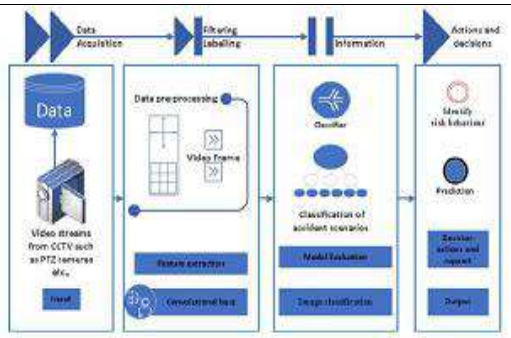


Fig:1 Flow Diagrams of Proposed Methodology

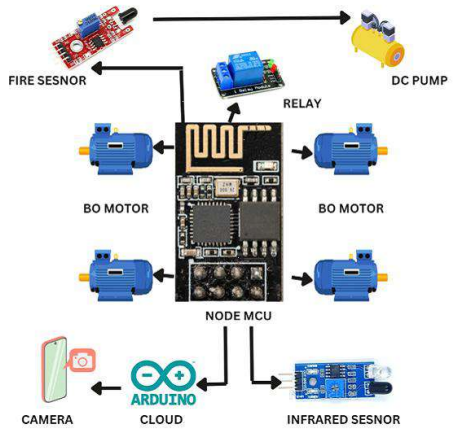


Fig:2 System Architecture for Automated Train

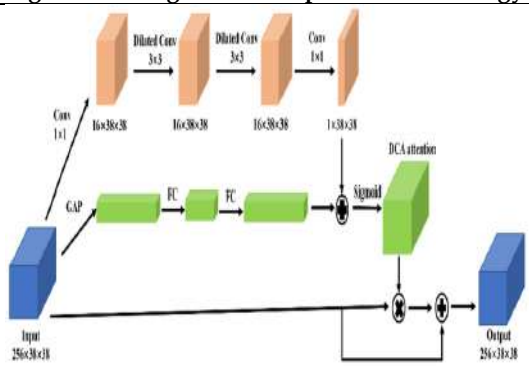


Fig:3 YOLOv4 Model Training

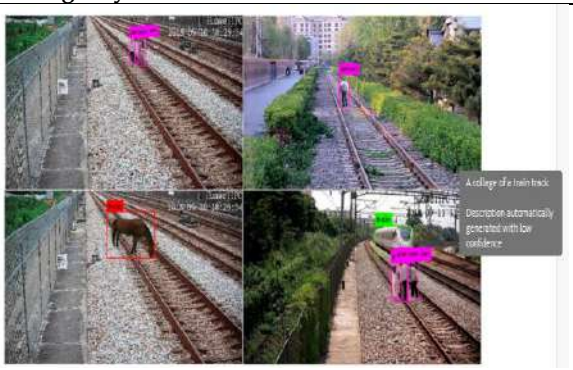


Fig :4 YOLOv4 Tiny object recognition model

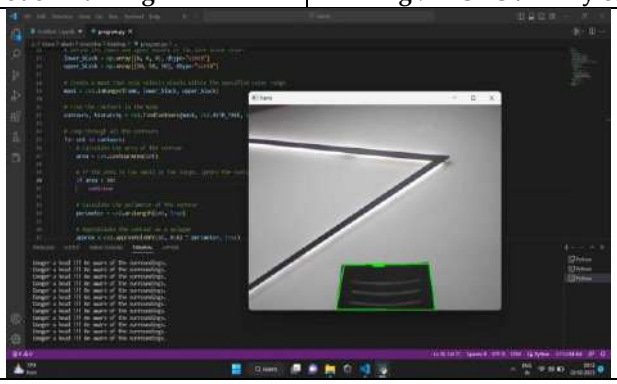


Fig:5 Use Cases

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RESEARCH ARTICLE

Maximum Power Point Tracking for PV System using Solar Irradiation Modeling

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ABSTRACT

The output power of Photovoltaic (PV) arrays is always changing with solar irradiation and atmospheric temperature. So, it is a difficult task to develop a maximum Power Point Tracking (MPPT) control to extract maximum power from the PV arrays at real time. Moreover, the real time based solar tracking ensures better capturing of available solar rays. In this paper, an improved dp P&O MPPT algorithm is developed based on solar irradiation modeling. This algorithm aims to overcome the confusion in the direction of tracking during rapidly changing solar irradiance using half sine modeling of solar irradiation. Also, the proposed algorithm gives fast convergence speed compared to dp P&O method. The proposed MPPT algorithm is applied to a boost regulator to regulate the output power at its maximum possible value. The complete system is modeled and simulated in the MATLAB using SIMULINK. The proposed MPPT and the existing dp P&O MPPT algorithms are simulated and the performance comparison is made. Simulation results show that the proposed algorithm is faster than the conventional dp P&O algorithm.

Keywords: This algorithm aims to overcome the confusion in the direction of tracking during rapidly changing solar irradiance using half sine modeling of solar irradiation.

INTRODUCTION

Maximum power point tracking is one of the major concerns in photovoltaic systems and plays a vital role in utilization of these systems for practical applications. Each PV cell has a special point named maximum power point (MPP) on its operational curve (i.e. current-voltage or power- voltage curve) in which it can produce maximum possible power. These operational curves change nonlinearly with changes in irradiance and temperature of environment. So, the nonlinear dependency of MPP to environment parameters, motivate the development of various maximum power point tracking algorithms. These algorithms differ in terms of the amount of energy

extracted from the PV panel (tracking factor), dynamic response, complexity, adaptation to environment changes and cost of implementation [1]. In order to improve the efficiency of the PV system, many MPPT techniques like Constant voltage control, Perturb & Observe, Incremental Conductance and dp P&O method have been developed [2]. Among these MPPT methods, the Perturb & Observe (P&O) method is most widely used. P&O is also called as hill climbing method because it assures the rise of the curve till MPP and the fall after that point. This method is easy to implement but can cause oscillations in power output and can sometimes show tracking failures in rapid environmental changes [2] i.e. locating operating point away from MPP when there is a sudden change in voltage characteristics. The main problem with the conventional P&O algorithm is slow response in reaching the maximum power point. To overcome this problem, an improved dp P&O MPPT algorithm is developed. The output power of a PV panel is determined by the solar irradiation and the temperature of the panel. At a certain weather condition, the output power of a PV panel depends on the terminal voltage of the system. To maximize the power output, an efficient low-cost DC/DC converter with appropriate MPPT algorithm is commonly employed to control the terminal voltage of the PV system in various solar radiation conditions. The different DC/DC converter technologies used with PV systems are Buck converter, Boost converter, Cuk converter, Buck Boost converter and Full bridge converter [3]. In this paper, an improved dp P&O MPPT method with dc-dc boost converter is proposed which is faster than the existing dp P&O MPPT method. This paper is organized as follows: Section II gives the basics of the characteristics of PV system with DC/DC boost converter. The major existing MPPT methods are discussed in section III. Section IV explains the proposed MPPT method and the simulation results of the same are discussed in Section V. Section VI gives the conclusion.

CHARACTERISTICS OF PV SYSTEM WITH DC/DC BOOST CONVERTER

A PV module consists of number of solar cells connected in series or parallel and the total power generated is the sum of the power contributed by the individual solar cells. Under different levels of solar irradiation, the PV module develops different levels of power. Fig. 1 shows the I-V characteristics of PV module under different levels of solar irradiation. From figure1, it is known that the I-V characteristic of PV array is nonlinear and the output power characteristic is also not linear. Hence, it is necery to get the maximum power from the PV array. A DC-DC boost converter produces an output voltage which is always greater in magnitude than the input voltage [3]. The control strategy is achieved by varying the duty cycle of the switch. When the switch is closed, the inductor will charge energy and it will discharge the accumulated energy when the switch is opened. The relationship between the current and voltage of the dc-dc converter is as follows:

$$\frac{Vo}{Vin} = \frac{1}{1-D} \quad (1)$$

$$\mathrm{Vin} = \mathrm{V0}(1-\mathrm{D}) \quad (2)$$

Where, D is the duty cycle. Then,

$$\mathrm{Iin} = \frac{\mathrm{Io}}{1-\mathrm{D}} \quad (3)$$

$$Rin = \frac{Vin}{Iin} = \frac{Vo\,(1-D)}{(\frac{Io}{1-D})}$$

$$= \frac{Vo}{Io}(1-D)^2 \quad (4)$$

So we get

$$\mathrm{Rin} = \mathrm{Ro}\,(1\text{-}\mathrm{D})^2 \quad (5)$$

Where Vin – Input voltage of the converter

Iin – Input current of the converter

Rin – Input resistance of the converter

EXISTING MPPT METHODS

Incremental Conductance MPPT method

Conventional Incremental Conductance MPPT method was designed based on observation of P-V characteristic curve [4]. This algorithm overcomes the limitation in tracking speed of P&O algorithm. The MPP can be calculated by using the relation between dI/dV and –I/V. Based on the slope of power curve, the duty cycle is varied. If the slope is

positive then the duty cycle is continuously increased. If not, the duty cycle is decreased. The slope of the P-V array power curve is zero at the MPP.

$$\frac{dI}{dV} = -\frac{I}{V} \quad (6)$$

$$\frac{dI}{dV} > -\frac{I}{V} \quad \text{Left of MPP} \quad (7)$$

$$\frac{dI}{dV} < -\frac{I}{V} \text{Right of MPP} \quad (8)$$

The array terminal voltage is always adjusted according to the MPP voltage based on the incremental and instantaneous conductance of the PV module. When the ratio of change in output conductance is equal to the negative output conductance, the solar array will operate at the maximum power point.

Improved incremental conductance methods

In the conventional IC method, the duty cycle is varied in fixed step size. Whereas the improved incremental conductance method uses the variable step size to provide appropriate duty cycle[5]. The concept of fuzzy logic has been used in this method to improve the MPP tracking performance. The fuzzy control algorithm is implemented using Takagi-Sugeno inference system. Initially, this algorithm computes a adequate step size Δd and then determines the direction for tracking the MPP. The main advantages of this improved incremental conductance method compared to conventional algorithm are improved tracking speed, less oscillation around the maximum power point and better performance under rapid irradiation change. The fast converging and low losses MPPT algorithm was proposed in the year 2015 [6]. The relationship between load line and I-V curve is used with the trigonometric rule to obtain the fast response in this method. The single ended primary inductor converter (SEPIC) is used in this algorithm for regulating the duty cycle. The duty cycle is varying by the load line of the converter until it cuts through the I-V curve at MPP. The voltage and current of PV module sensed by the MPPT controller are given by the following equations:

$$\frac{Vpv}{Ipv} = \frac{(1-D)^2}{D^2} R_{load} \quad (9)$$

$$R_{load} = \frac{D^2}{(1-D)^2} \frac{Vpv}{Ipv} \quad (10)$$

$$\frac{D^2}{(1-D)^2} = \frac{Ipv}{Vpv} R_{load} \quad (11)$$

Under any operating point, the load resistance of the PV system $R_{load,}$ is calculated by duty cycle, voltage and current of the PV system. Then the duty cycle can be calculated by substituting new voltage and current of the PV system. Equation (11) ensures that the operating point is closer to new MPP with respect to the variation in solar irradiation. Hence the performance of the fast converging and low losses MPPT algorithm is four times faster than the IC method with variation in load and solar irradiation.

Perturb and obserb (P&O) algorithm

The Perturb and obserb (P&O) algorithm is based on the observation of array output power and on the perturbation (increment or decrement) of the power [7]. If the power increases, perturbation is continued in the same direction. After the peak power has reached, the power at the next instant is decreased. Hence, the perturbation is continued in reverse direction. When the power is reached at steady state the perturbation oscillates around the peak point. In order to keep the power variation small, the perturbation size is kept very small. Figure 3 shows the Power versus Voltage of P&O Algorithm

dP-P&O MPPT method

The dP-P&O MPPT method is the improved version of P&O method, which prevents tracking of MPP in wrong direction under rapidly changing environmental conditions [8] & [9]. It is achieved by the additional measurement of power in the middle of the MPPT sampling period (T) without any perturbation. As shown in fig.4, the samples P_k and P_{k+1} are measured at the sampling interval k and k+1. The unperturbed power P_x is chosen in-between the measured samples P_k and P_{k+1}. The change of power between P_x and P_{k+1} reflects the variation in solar irradiation due to the change of environmental conditions. The difference in power of the successive samples is calculated as dp which represents change in power caused by perturbation of MPPT[10] - [12].

Assuming the rate of change in the irradiation is constant over one sampling interval of the MPPT, the dP can be calculated by

$$dP = dP_1 - dP_2 = (P_X - P_K) - (P_{K+1} - P_X)$$

$$= 2P_X - P_{K+1} - P_K \quad (12)$$

Determining the dP allows to track in the correct direction during irradiance changes. The output of the dP reflects the changes due to the perturbation of MPPT. The dP-P&O has the ability to track the MPP in the right direction under rabidly changing irradiation unlike the conventional P&O. Flow chart of the dp-P&O method is shown in figure.5 The major MPPT algorithms discussed in this section are claimed to be efficient in MPP tracking but there are some limitations. The P&O and IC methods have certain similar drawbacks. First, both of them cannot distinguish a local maximum from a global maximum. Secondly, these algorithms have irregular behavior in case of rapidly changing irradiation conditions. The dp P&O method gives higher efficiency under rapid variation in solar irradiation but it possess some limitations such as, less efficient under low irradiation levels and tracking of MPP is time consuming. Hence improved an dp P&O MPPT method is proposed in this work.

THE PROPOSED METHOD

The proposed method system block diagram as shown on Fig. 6 comprises of a Photovoltaic, Boost converter and MPPT algorithm. The Boost converter is designed based on the specifications in table 1. In this paper, an improved dp P&O MPPT algorithm is developed based on solar irradiation modeling. Although many efficient and fast response MPPT algorithms have been developed, few limitations are still not attended by these algorithms. The major challenges in MPP tracking are partial shadowing, local MPP tracking instead of global MPP and precision in tracking MPP in rapidly changing solar irradiation. The proposed algorithm aims to overcome the confusion in the direction of tracking during rapidly changing solar irradiance using solar irradiation modeling. The dp P&O MPPT method overcomes this problem, but it takes much time for tracking. The proposed MPPT method to track maximum power point with less number of iterations compared to existing technique. This strategy leads to faster and better tracking when the irradiance is changing rapidly, and lower oscillations around the MPP in steady-state conditions.

Solar irradiation modeling

It is known that sun is a singular source of renewable energy which emits energy as electromagnetic radiation at an extremely large and relatively constant rate, 24 hours per day, 365 days of the year. This energy is more than sufficient to meet current energy demand of the world. Solar irradiance is the rate at which solar energy reaches a unit area at the earth and solar radiation is simply the integration or summation of solar irradiance over a time period. Solar irradiance is an instantaneous measure of rate and can vary over time. It is measured in watts per square meter (W/m2). The maximum solar irradiance value is used to determine the peak rate of energy input into the system hence the designer needs to know the variation of solar irradiance over time in order to optimize the MPPT design. The intensity of the radiation leaving the sun is relatively constant. The total amount of energy accumulated over a year is given as an average solar radiation with respect to the latitude which is shown in Figure.7 [10].The solar irradiation variation can be modeled by time of sunrise, sunset, and the peak, noontime solar irradiance level. The simplest one is Half Sine solar irradiance model and it is defined as,

$$I = Inoon\ sin\left[\frac{180*(t-t_{sunrise})}{t_{sunset}-t_{sunrise}}\right](W/m^2) \quad (13)$$

Where t is the time in hours (24-hour clock), and the sine term is in degrees.

The Improved dp P&O MPPT method

The proposed method performs based on the typical solar irradiation for clear day under half sine model. Hence, the output power of the PV system combines with the clear day model as shown in figure. 8. The proposed method can predict whether the solar irradiance is in increasing or decreasing trend. Therefore the power *vs* time response was taken into account in two phases, phase I and Phase II. The phase I is considered as increasing change in solar irradiation and phase II is decreasing trend in solar irradiation. The time duration for Phase I is t1 to t2 and Phase II time duration is t2 to t3. Proposed algorithm can be seen on Figure 9. In this method, the maximum power operating point can be reached much earlier than the conventional dp P&O method. Here, first initialize real time clock and define time duration for phase I and II based on half sine model. Then take samples at sampling interval T. The PV system output voltage and current are sensed and calculate the corresponding output power. If the real time clock is Phase I, the change in solar irradiation within t1 to t2, the present measured power is greater than the previous measured power so we can directly increase the Vref value to obtain the maximum power point. Again the real time clock checking is done. Else, if real time clock time duration is within t2 to t3 (phase II), the present measured power is less than the previous measured power so we can decrease the Vref value to obtain the maximum power point. The proposed method to track MPP with less number of iterations and provide efficient output compared to existing methods.

RESULTS AND DISCUSSIONS

The PV module electrical model designed is used to generate voltage and current of the module at each sampling time. MATLAB embedded function contains the improved dp P&O MPPT algorithm. The algorithm determines the optimal voltage where, the system should move next and also replaces old values with the new (Figure. 9). Fig. 10 shows the simulation diagram of PV model using improved dp P&O MPPT algorithm. Simulation was carried out by giving an irradiation changes on a constant temperature 30°C. First stage of simulation irradiation was 250 W/m2 then changed rapidly to 1,000 W/m2. Simulation result of dp P&O method is shown on Fig. 11 and Fig. 12 shown the improved dp P&O algorithm result.

CONCLUSION

In this paper an improved dp P&O MPPT method has been proposed. PV system, MPPT and Boost converter were simulated on Matlab Simulink. The simulation result shown the improved dp P&O MPPT method had a better performance when it compared to dp P&O method. Moreover, this method quickly predicts the solar irradiation direction using solar half sine model so it has less number of iteration to track MPP. As a conclusion, under rapidly changing solar irradiation a fast converging and efficient MPPT algorithm is proposed.

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Table 1: Design parameters of Boost converter

Input voltage	Vs	23 V
Input current	Is	0 - 4.8 A
Switching frequency	F	10 KHZ
Duty cycle	D	0.2 < D <0.7
Load	R	12Ω

Table 2: Simulation results of proposed method for various solar irradiations

SI. No	Set:1	Voltage (Volts)	Current (A)	Power (Watts)
1	Irradiation: 1000 watts/m^2	24(Voc)	0	0
2		24	0.5	20
3		23.5	1	30
4		23.2	1.5	40
5		23	2	50
6		22	4	60

7		19	4.7	75(Pmax)
8		11	4.8	50
9		5	4.8	25.2
10		0	4.8(Isc)	0

SI.No	Set:2	Voltage (Volts)	Current (A)	Power (Watts)
1	Irradiation: 850 watts/m²	23(Voc)	0	0
2		22	0.5	45.2
3		21.5	1.3	50.4
4		21	2.3	60.6
5		**19**	**3.8**	**65.2 (Pmax)**
6		17	3.9	60.2
7		10	4	50.1
8		9	4	45.3
9		5	4	40.1
10		0	4(Isc)	0

SI. No	Set:3	Voltage (Volts)	Current (A)	Power (Watts)
1	Irradiation: 650 watts/m²	22(Voc)	0	0
2		21.8	0.8	30.2
3		21.5	1.3	35.4
4		21	2	40.6
5		**19**	**2.8**	**49 (Pmax)**
6		15	2.8	45.2
7		12	3	40.1
8		0.8	3	35.3
9		0.3	3	30.1
10		0	3(Isc)	0

SI. No	Set:4	Voltage (Volts)	Current (A)	Power (Watts)
1	Irradiation: 450 watts/m²	21(Voc)	0	0
2		20.9	0.3	10
3		20.8	0.9	20.1
4		20.1	1.75	25
5		20	1.9	30
6		**18**	**2.05**	**33(Pmax)**
7		16	2.05	30
8		10	2.1	20
9		5	2.1	10
10		0	2.1 (Isc)	0

Table 3: Time comparison of dp P&O and Improved dp P&O MPPT method

S.No	MPPT method	Time to track MPP for different irradiance
1	dp P&O	0.016 mins
2	Improved dp P&O	0.005 mins

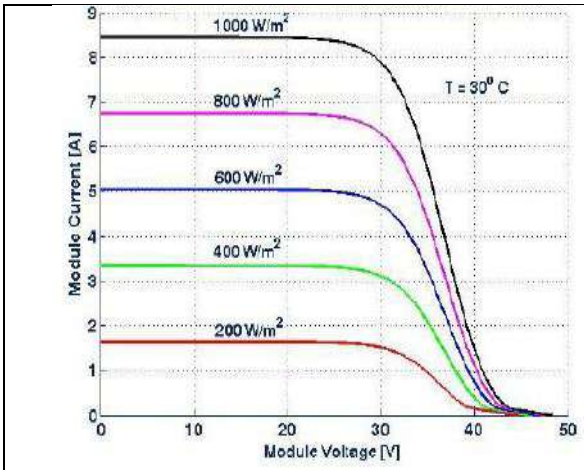


Fig. 1: I-V characteristics of PV module with different levels of solar irradiation

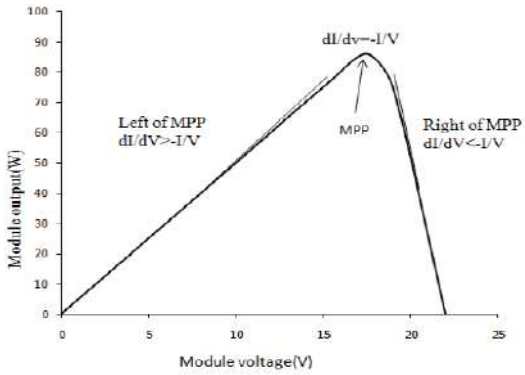


Fig. 2: Power versus Voltage of IC Algorithm

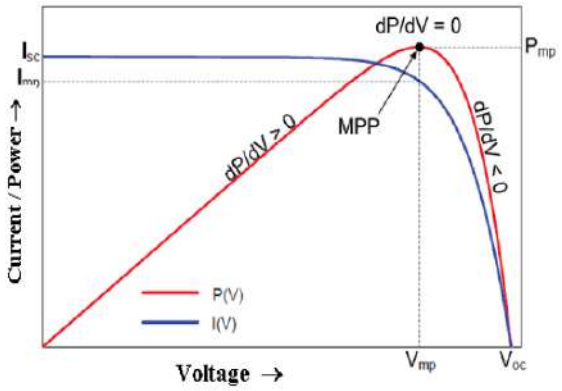


Fig. 3: Power versus Voltage of P&O Algorithm

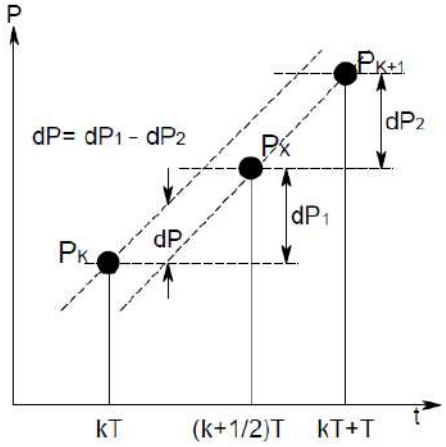


Fig.4: Measurement of the power between two MPPT sampling instances.

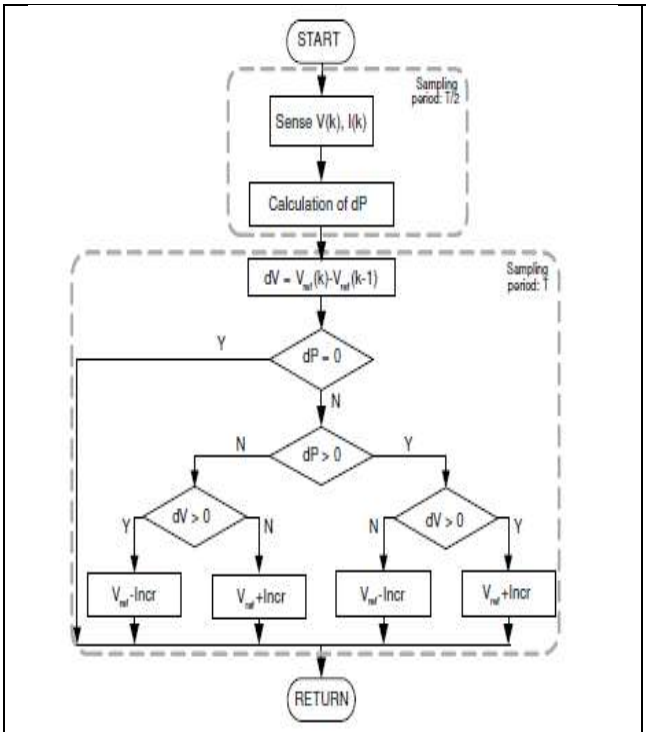


Fig.5: Flowchart of the dP-P&O algorithm

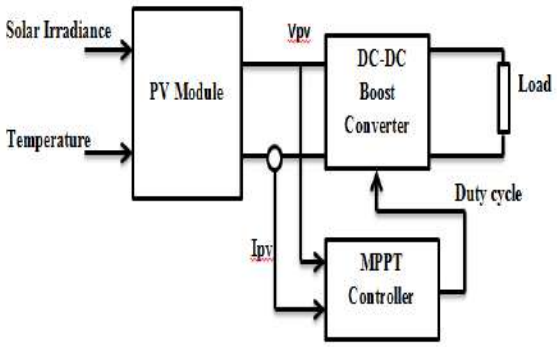


Fig.6: Block diagram of PV system with MPPT algorithm.

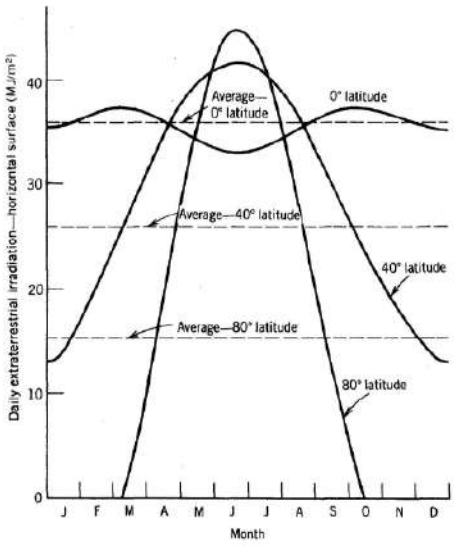


Fig.7 Seasonal variation of the daily extra-terrestrial solar irradiation incident on a horizontal surface

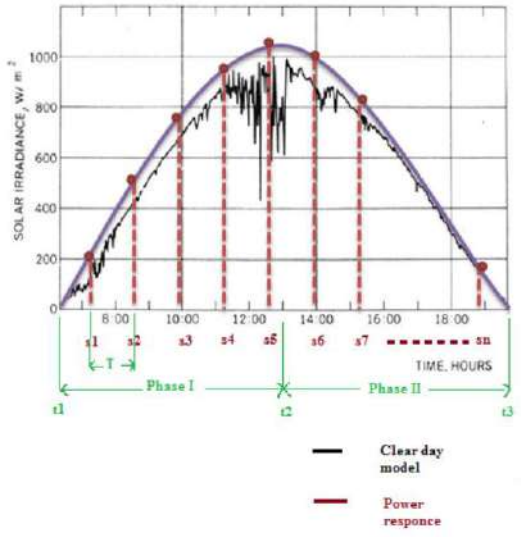


Fig.8. Output power of PV system with clear day model.

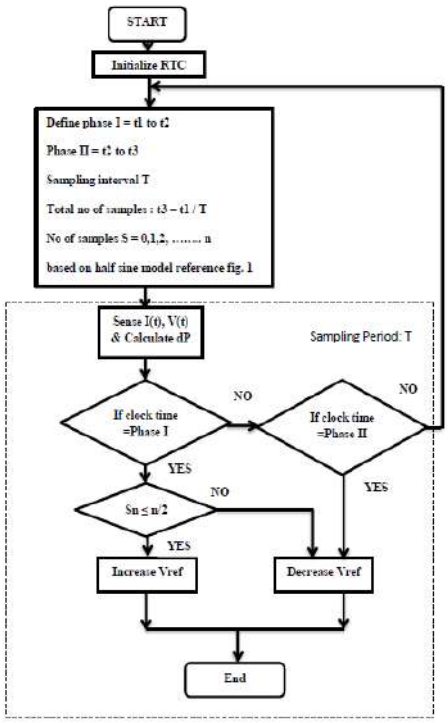


Fig.9. Flowchart for proposed MPPT method

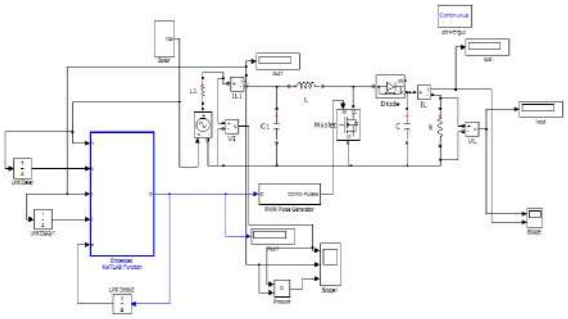


Fig. 10: PV system with improved dp P&O MPPT method

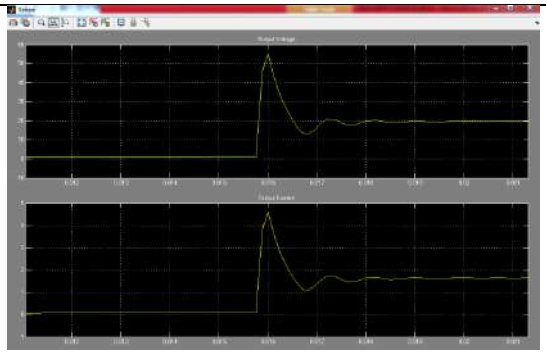


Fig.11. Simulation result for dp P&O MPPT method; (a). Converter output voltage; (b) Converter output current

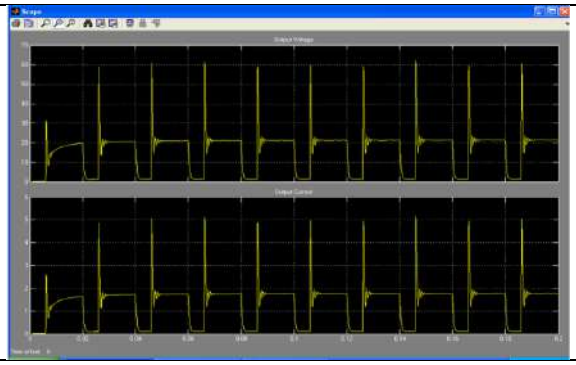


Fig. 12: Simulation result for improved dp P&O MPPT method; (a). Converter output voltage; (b) Converter output current

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RESEARCH ARTICLE

Improved Correlation Coefficients of Pentapartitioned Neutrosophic Pythagorean sets for MADM

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ABSTRACT

A correlation coefficient is a statistical measure which contributes in deciding the degree to which changes in one variable predict changes in another. Wang's single valued neutrosophic sets have still been continued to improve to pentapartitioned neutrosophic sets. In this article, we analyze the characteristics of pentapartitioned neutrosophic pythagorean sets with improved correlation coefficients. We've also used the same approach in multiple attribute decision-making methodologies including one with a pentapartitioned neutrosophic pythagorean environment. Finally, we implemented for above technique to the problem of multiple attribute group decision making.

Keywords: Pentapartitioned neutrosophic pythagorean sets, Pentapartitioned Neutrosophic Sets, Improved correlation coefficient

INTRODUCTION

Fuzzy sets were introduced by Zadeh [23] in 1965 that permits the membership perform valued within the interval [0,1] and set theory it's an extension of classical pure mathematics. Fuzzy set helps to deal the thought of uncertainty, unclearness and impreciseness that isn't attainable within the cantorian set. As Associate in Nursing extension of Zadeh's fuzzy set theory intuitionstic fuzzy set(IFS) was introduced by Atanassov [1] in 1986, that consists of degree of membership and degree of non membership and lies within the interval of [0,1]. IFS theory wide utilized in the areas of logic programming, decision making issues, medical diagnosis etc. Florentin Smarandache [15] introduced the idea of Neutrosophic set in 1995 that provides the information of neutral thought by introducing the new issue referred to as uncertainty within the set. thus neutrosophic set was framed and it includes the parts of truth membership function(T), indeterminacy membership function(I), and falsity membership function(F) severally. Neutrosophic sets deals with non normal interval of]−0 1+[. Since neutrosophic set deals minateness effectively it plays an very important role in several applications areas embrace info technology, decision web, multicriteria decision making, electronic database systems, diagnosis, multicriteria higher cognitive process issues etc., To method the unfinished data or imperfect data to unclearness a brand new mathematical approach i.e., To deal the important world issues, Wang [16](2010) introduced the idea of single valued neutrosophic sets(SVNS) that is additionally referred to as an extension of initutionstic fuzzy sets and it became a really new hot analysis topic currently. Rama Malik.,et al [14] projected the idea of Pentapartitioned single valued neutrosophic sets that relies on Belnap's five valued logic and Smarandache's five numerical valued logic. In (PSVNS) indeterminacy is splitted into 3 functions referred to as 'Contradicition' (both true and false) and 'Ignorance' (neither true nor false) and an 'unknown' membership in order that PSVNS has five parts, T,C,U,F,G that additionally lies within the non normal unit interval]−0 1+[. Further, R. Radha and A. Stanis Arul Mary[7] outlined a brand new hybrid model of Pentapartitioned Neutrosophic Pythagorean sets (PNPS) in 2021.Correlation coefficient may be a effective mathematical tool to live the strength of the link between 2 variables. such a lot of researchers pay the attention to the idea of varied correlation coefficients of the various sets like fuzzy set, IFS, SVNS, QSVNS. In 1999 D.A Chiang and N. P. Lin [3] projected the correlation of fuzzy sets underneath fuzzy setting. Later D.H. Hong [4] (2006) outlined fuzzy measures for a coefficient of correlation of fuzzy numbers below Tw (the weakest t-norm) based mostly fuzzy arithmetic operations. Correlation coefficients plays a very important role in several universe issues like multiple attribute cluster higher cognitive process, cluster analysis, decision making problems, pattern recognition, diagnosis etc., therefore several authors targeted the idea of shaping correlation coefficients to resolve the important world issues in significantly multicriteria decision making strategies. Jun Ye [19] outlined the improved correlation coefficients of single valued neutrosophic sets and interval neutrosophic sets for multiple attribute higher cognitive process to beat the drawbacks of the correlation coefficients of single valued neutrosophic sets (SVNSs) that is outlined in [22].In this paper, we have applying improved correlation coefficient on Pentapartitioned Neutrosophic Pythagorean sets and studied with an example.

PRELIMINARIES

Definition [15]

Let X be a universe. A Neutrosophic set A on X can be defined as follows:

$A = \{< x, T_A(x), I_A(x), F_A(x) >: x \in X\}$

Where T_A , $I_A, F_A: U \to [0,1]$ $and 0 \leq T_A(x) + I_A(x) + F_A(x) \leq 3$

Here,$T_A(x)$ is the degree of membership, $I_A(x)$ is the degree of inderminancy and $F_A(x)$ is the degree of non-membership.

*He*re, $T_A(x)$ and $F_A(x)$are dependent neutrosophic components and $I_A(x)$ is an independent component.

Definition [7]

Let X be a universe. A Pentapartitioned neutrosophic pythagorean set A with T, F, C and U as dependent neutrosophic components and I as independent component for A on X is an object of the form

$A = \{< x, T_A, C_A, I_A, U_A, F_A >: x \in X\}$

Where $T_A + F_A \leq 1, C_A + U_A \leq 1 \; and (T_A)^2 + (C_A)^2$

$(T_A)^2 + (C_A)^2 + (I_A)^2 + (U_A)^2 + (F_A)^2 \leq 3$

Here, $T_A(x)$ is the truth membership, $C_A(x)$ is contradiction membership, $U_A(x)$ is ignorance membership, $F_A(x)$ is the false membership and $I_A(x)$ is an unknown membership.

Definition [14]

Let P be a non-empty set. A Pentapartitioned neutrosophic set A over P characterizes each element p in P a truth - membership function T_A , a contradiction membership function C_A, an ignorance membership function G_A, unknown membership function U_A and a false membership function F_A , such that for each p in P

$T_A + C_A + G_A + U_A + F_A \leq 5$

Definition [7]

The complement of a pentapartitioned neutrosophic pythagorean set (F, A) on X Denoted by $(F, A)^c$ and is defined as F^c(x)= $\{< x, F_A(x), U_A(x), 1 - G_A(x), C_A(x), T_A(x) > : x \in X\}$

Definition [7]

Let A = $< x, T_A(x), C_A(x), G_A(x), U_A(x), F_A(x) >$ and B = $< x, T_B(x), C_B(x), G_B(x), U_B(x), F_B(x) >$ are pentapartitioned neutrosophic pythagorean sets. Then

A ∪ B = $<x, max(T_A(x), T_B(x)), max(C_A(x), C_B(x)), \min(G_A(x), G_B(x)), \min(U_A(x), U_B(x)),$

$\min(F_A(x), F_B(x)), >$

A ∩ B = $< x, min(T_A(x), T_B(x)), min(C_A(x), C_B(x)), \max(G_A(x), G_B(x))$

$, max(U_A(x), U_B(x)), max(F_A(x), F_B(x)) >$

Improved Correlation Coefficients

Based on the concept of correlation coefficient of PNPS s ,we have defined the improved correlation coefficients of PNPS s in the following section.

Definition

Let P and Q be any two PNPs s in the universe of discourse R = { r_1, r_2 , r_3 ,…, r_n }, then the improved correlation coefficient between P and Q is defined as follows

$K(P, Q) = \frac{1}{5n}\sum_{k=1}^{n} [\, \mu_k(1 - \Delta T_k) + \varphi_k(1 - \Delta C_k) + \delta_k(1 - \Delta G_k) + \gamma_k(1 - \Delta U_k) + \vartheta_k(1 - \Delta F_k) \,]$ (3.1)

Where

$\mu_k = \frac{3 - \Delta T_k - \Delta T_{max}}{3 - \Delta T_{min} - \Delta T_{max}}$,

$\varphi_k = \frac{3 - \Delta C_k - \Delta C_{max}}{3 - \Delta C_{min} - \Delta C_{max}}$,

$\delta_k = \frac{3 - \Delta G_k - \Delta G_{max}}{3 - \Delta G_{min} - \Delta G_{max}}$,

$\gamma_k = \frac{3 - \Delta U_k - \Delta U_{max}}{3 - \Delta U_{min} - \Delta U_{max}}$,

$\vartheta_k = \frac{3 - \Delta F_k - \Delta F_{max}}{3 - \Delta F_{min} - \Delta F_{max}}$,

$\Delta T_K = |T_P^2(r_k) - T_Q^2(r_k)|$,

$\Delta C_K = |C_P^2(r_k) - C_Q^2(r_k)|$,

$\Delta G_K = |G_P^2(r_k) - G_Q^2(r_k)|$,

$\Delta U_K = |U_P^2(r_k) - U_Q^2(r_k)|$,

$\Delta F_K = |F_P^2(r_k) - F_Q^2(r_k)|$,

$\Delta T_{min} = min_k |T_P^2(r_k) - T_Q^2(r_k)|$,

$\Delta C_{min} = min_k |C_P^2(r_k) - C_Q^2(r_k)|$,

$\Delta G_{min} = min_k |G_P^2(r_k) - G_Q^2(r_k)|$,

$\Delta U_{min} = min_k |U_P^2(r_k) - U_Q^2(r_k)|$,

$\Delta F_{min} = min_k |F_P^2(r_k) - F_Q^2(r_k)|$,

$\Delta T_{max} = max_k |T_P^2(r_k) - T_Q^2(r_k)|$,

$\Delta C_{max} = max_k |C_P^2(r_k) - C_Q^2(r_k)|$,

$\Delta G_{max} = max_k |G_P^2(r_k) - G_Q^2(r_k)|$,

$\Delta U_{max} = max_k |U_P^2(r_k) - U_Q^2(r_k)|$,

$\Delta F_{max} = max_k |F_P^2(r_k) - F_Q^2(r_k)|$,

For any $r_k \in R$ and k = 1, 2, 3….. n.

Theorem

For any two PNPS s P and Q in the universe of discourse R = { r_1, r_2 , r_3 ,…, r_n }, the improved correlation coefficient K(P, Q) satisfies the following properties.

1) K (P, Q) = K (Q, P);
2) $0 \leq K(P, Q) \leq 1$;
3) K(P, Q) = 1 iff P =Q.

Proof

It is obvious and straightforward.

Here, $0 \leq \mu_k \leq 1, 0 \leq \varphi_k \leq 1, 0 \leq \delta_k \leq 1, 0 \leq \gamma_k \leq 1, 0 \leq \vartheta_k \leq 1, 0 \leq 1 - \Delta T_k \leq 1,$

$0 \leq 1 - \Delta C_k \leq 1, 0 \leq 1 - \Delta G_k \leq 1, 0 \leq 1 - \Delta U_k \leq 1, 0 \leq 1 - \Delta F_k \leq 1$, Therefore the following inequation satisfies $0 \leq \mu_k (1 - \Delta T_k) + \varphi_k(1 - \Delta C_k) + \delta_k(1 - \Delta G_k) + \gamma_k(1 - \Delta U_k) + \vartheta_k (1 - \Delta F_k) \leq 5$. Hence we have $0 \leq K(P, Q) \leq 1$

(3) If K (P, Q) = 1, then we get $\mu_k (1 - \Delta T_k) + \varphi_k(1 - \Delta C_k) + \delta_k(1 - \Delta G_k) + \gamma_k(1 - \Delta U_k) + \vartheta_k (1 - \Delta F_k) = 5$. Since $0 \leq \mu_k (1 - \Delta T_k) \leq 1, 0 \leq \varphi_k(1 - \Delta C_k) \leq 1, 0 \leq \delta_k(1 - \Delta G_k) \leq 1, 0 \leq \gamma_k(1 - \Delta U_k) \leq 1$ and $0 \leq \vartheta_k (1 - \Delta F_k) \leq$

1, there are $\mu_k\ (1-\Delta T_k)=1$, $\varphi_k(1-\Delta C_k)=1$, $\delta_k(1-\Delta G_k)=1$, $\gamma_k(1-\Delta U_k)=1$ and $\vartheta_k\ (1-\Delta F_k)=1$. And also since $0\le\mu_k\le1,\ 0\le\varphi_k\le1,\ 0\le\delta_k\le1,\ 0\le\gamma_k\le1$ and $0\le\vartheta_k\le1, 0\le1-\Delta T_k\le1,\ 0\le1-\Delta C_k\le1,$ $0\le1-\Delta G_k\le1, 0\le1-\Delta U_k\le1, 0\le1-\Delta F_k\le1$. We get $\mu_k=\varphi_k=\delta_k=\gamma_k=\vartheta_k=1$ and $1-\Delta T_k=1-\Delta C_k=1-\Delta G_k=1-\Delta U_k=1-\Delta F_k=1$. This implies, $\Delta T_k=\Delta T_{min}=\Delta T_{max}=0, \Delta C_k=\Delta C_{min}=\Delta C_{max}=0, \Delta G_k=\Delta G_{min}=\Delta G_{max}=0, \Delta U_k=\Delta U_{min}=\Delta U_{max}=0, \Delta F_k=\Delta F_{min}=\Delta F_{max}=0$.

Hence $T_P(r_k)=T_Q(r_k), C_P(r_k)=C_Q(r_k), G_P(r_k)=G_Q(r_k), U_P(r_k)=U_Q(r_k)$ and $F_P(r_k)=F_Q(r_k)$ for any $r_k\in R$ and k = 1,2,3….n.Hence P = Q.

Conversely, assume that P = Q, this implies $T_P(r_k)=T_Q(r_k), C_P(r_k)=C_Q(r_k), G_P(r_k)=G_Q(r_k), U_P(r_k)=U_Q(r_k)$ and $F_P(r_k)=F_Q(r_k)$ for any $r_k\in R$ and k = 1,2,3….n. Thus $\Delta T_k=\Delta T_{min}=\Delta T_{max}=0, \Delta C_k=\Delta C_{min}=\Delta C_{max}=0, \Delta G_k=\Delta G_{min}=\Delta G_{max}=0, \Delta U_k=\Delta U_{min}=\Delta U_{max}=0, \Delta F_k=\Delta F_{min}=\Delta F_{max}=0$. Hence we get K (P, Q) = 1.

The improved correlation coefficient formula which is defined is correct and also satisfies these properties in the above theorem . When we use any constant $\varepsilon>3$ in the following expressions

$\mu_k=\frac{\varepsilon-\Delta T_k-\Delta T_{max}}{\varepsilon-\Delta T_{min}-\Delta T_{max}}$,

$\varphi_k=\frac{\varepsilon-\Delta C_k-\Delta C_{max}}{\varepsilon-\Delta C_{min}-\Delta C_{max}}$,

$\delta_k=\frac{\varepsilon-\Delta G_k-\Delta G_{max}}{\varepsilon-\Delta G_{min}-\Delta G_{max}}$,

$\gamma_k=\frac{\varepsilon-\Delta U_k-\Delta U_{max}}{\varepsilon-\Delta U_{min}-\Delta U_{max}}$,

$\vartheta_k=\frac{\varepsilon-\Delta F_k-\Delta F_{max}}{\varepsilon-\Delta F_{min}-\Delta F_{max}}$

Example

Let A = { r, 0,0,0,0} and B = { r, 0.4,0.2,0.5,0.1,0.2} be any two PNPS s in R. Therefore by equation (3.1) we get K(A, B) =0.871.56 . It shows that the above defined improved correlation coefficient overcome the disadvantages of the correlation coefficient .

In the following, we define a weighted correlation coefficient between PNPS s since the differences in the elements are considered into an account,

Let w_k be the weight of each element r_k(k = 1,2…n), $w_k\in[0,1]$ and $\sum_{k=1}^{n}w_k=1$, then the weighted correlation coefficient between the PNPS s A and B

$K_w(A, B)=\frac{1}{5}\sum_{k=1}^{n}w_k[\,\mu_k(1-\Delta T_k)+\varphi_k(1-\Delta C_k)+\delta_k(1-\Delta G_k)+\gamma_k(1-\Delta U_k)+\vartheta_k(1-\Delta F_k)\,]$

(3.2)

If $w=(1/n,1/n,1/n,….1/n)^T$, then euation (4) reduces to equation (3). $K_w(A, B)$ also satisfies the three properties in the above theorem.

Theorem

Let w_k be the weight for each element r_k(k = 1,2,…n), $w_k\in[0,1]$ and $\sum_{k=1}^{n}w_k=1$, then the weighted correlation coefficient between the PNPS s A and B which is denoted by $K_w(A, B)$ defined in equation ( ) satisfies the following properties.

1) $K_w(A, B)=K_w(B, A)$;
2) $0\le K_w(A, B)\le1$;
3) $K_w(A, B)=1$ iff A = B.

It is similar to prove the properties in theorem 3.1

Decision Making using the improved correlation coefficient of PNPS s

Multiple attribute decision making (MADM) problems refers to make decisions when several attributes are involved in real -life problem. For example one may buy a vehicle by analysing the attributes which is given in tems of price, style,safety, comfort etc., Here we consider a multiple attribute decision making problem with pentapartitioned neutrosophic pythagorean information and the characteristic 0f an alternative A_i(i = 1,2,…m) on an attribute C_j(j = 1,2…n) is represented by the following PNPS s:

$A_i = \{(C_j, T_{A_i}(C_j), C_{A_i}(C_j), G_{A_i}(C_j), U_{A_i}(C_j), F_{A_i}(C_j) \setminus C_j \in C, j = 1,2, \dots n\}$

Where $T_{A_i}(C_j), C_{A_i}(C_j), G_{A_i}(C_j), U_{A_i}(C_j), F_{A_i}(C_j) \in [0,1]$ and

$0 \leq T_{A_j}^2(C_j) + C_{A_j}^2(C_j) + G_{A_j}^2(C_j) + U_{A_j}^2(C_j) + F_{A_j}^2(C_j) \leq 3$ for $C_j \in C, j = 1,2, \dots n$ and I = 1,2,…m.

To make it convenient, we are considering the following five functions $T_{A_i}(C_j), C_{A_i}(C_j), G_{A_i}(C_j), U_{A_i}(C_j), F_{A_i}(C_j)$ in terms of pentapartitioned neutrosophic pythagorean value (PNPV)

$d_{ij} = (t_{ij}, c_{ij}, g_{ij}, u_{ij}, f_{ij})(i = 1,2, \dots m; j = 1,2 \dots n)$.

Here the values of d_{ij} are usually derived from the evaluation of an alternative A_i with respect to a criteria C_j by the expert or decision maker. Therefore we got a pentapartitioned neutrosophic pythagorean decision matrix $D = (d_{ij})_{m \times n}$.

In the caseof ideal alternative A^* an ideal PNPV can be defined by

$d_j^* = (t_j^*, c_j^*, g_j^*, u_j^*, f_j^*)$ = (1,1,0,0,0)(j = 1,2…n) in the decision making method,

Hence the wighted correlation coefficient between an alternative A_i(i=1,2….m) and the ideal alternative A^* is given by,

$$K_w(A_i, A^*) = \frac{1}{5}\sum_{j=1}^{n} w_j [\mu_{ij}(1 - \Delta t_{ij}) + \varphi_{ij}(1 - \Delta c_{ij}) + \delta_{ij}(1 - \Delta g_{ij}) + \gamma_{ij}(1 - \Delta u_{ij}) + \vartheta_{ij}(1 - \Delta f_{ij})]$$

(3.3)

Where,

$\mu_{ij} = \frac{3 - \Delta t_{ij} - \Delta t_{imax}}{3 - \Delta t_{imin} - \Delta t_{imax}}$,

$\varphi_{ij} = \frac{3 - \Delta c_{ij} - \Delta c_{imax}}{3 - \Delta c_{imin} - \Delta c_{imax}}$,

$\delta_{ij} = \frac{3 - \Delta g_{ij} - \Delta g_{imax}}{3 - \Delta g_{imin} - \Delta g_{imax}}$,

$\gamma_{ij} = \frac{3 - \Delta u_{ij} - \Delta u_{imax}}{3 - \Delta u_{imin} - \Delta u_{imax}}$,

$\vartheta_{ij} = \frac{3 - \Delta f_{ij} - \Delta f_{imax}}{3 - \Delta f_{imin} - \Delta f_{imax}}$,

$\Delta t_{ij} = |t_{ij}^2 - t_j^*|$,

$\Delta c_{ij} = |c_{ij}^2 - c_j^*|$,

$\Delta g_{ij} = |g_{ij}^2 - g_j^*|$,

$\Delta u_{ij} = |u_{ij}^2 - u_j^*|$,

$\Delta f_{ij} = |f_{ij}^2 - f_j^*|$,

$\Delta t_{imin} = min_j |t_{ij}^2 - t_j^*|$,

$\Delta g_{imin} = min_j |g_{ij}^2 - g_j^*|$,

$\Delta c_{imin} = min_j |c_{ij}^2 - c_j^*|$,

$\Delta u_{imin} = min_j |u_{ij}^2 - u_j^*|,$

$\Delta f_{imin} = min_j |f_{ij}^2 - f_j^*|,$

$\Delta t_{imax} = max_j |t_{ij}^2 - t_j^*|,$

$\Delta c_{imax} = max_j |c_{ij}^2 - c_j^*|,$

$\Delta g_{imax} = max_j |g_{ij}^2 - g_j^*|,$

$\Delta u_{imax} = max_j |u_{ij}^2 - u_j^*|,$

$\Delta f_{imax} = max_j |f_{ij}^2 - f_j^*|,$

For i = 1,2….m and j = 1,2….n.

By using the above weighted correlation coefficient We can derive the ranking order of all alternatives and we can choose the best one among those.

Example

This section deals the example for the multiple attribute decision making problem with the given alternatives corresponds to the criteria alloted under pentapartitioned neutrosophic pythagorean environment For this example, the three potential alternatives are to be evaluated under the four diffident attributes. The types of intellectual property rights are the alternatives and the various cybercrimes are the attributes for this example. The three potential alternatives are A_1 – copyright, A_2 –patent right and A_3 –trademark and the four diffident attributes are C_1 –infringement, C_2 – piracy, C_3 – cybersquatting and C_4 – hacking. For the evaluation of an alternative A_1 with respect to an attribute C_1, it is obtained from the questionnaire of a domain expert. According to the attributes we will derive the ranking order of all alternatives and based on this ranking order customer will select the best one.

By assigning the weight vector of the above attributes is given by w = (0.2,0.35,0.25,0.2),Here the alternatives are to be evaluated under the above four attributes by the form of PNPS s, In general the evaluation of an alternative A_i with respect to the attributes C_j (i=1,2,3,j=1,2,3,4) will be done by the questionnaire of a domain expert. In particular, while asking the opinion about an alternative A_1 with respect to an attribute C_1 , the possibility he (or) she say that the statement true is 0.4 , the statement both true and false is 0.3, the statement neither true nor false is 0.2 ,the statement false is 0.1 and the statement unknown is 0.4 . It can be denoted in neutrosophic notation as d_{11} = (0.4,0.3,*0.4*,0.2,0.1).

$A_i \setminus C_j$	C_1	C_2	C_3	C_4
A_1	[0.4,0.3,0.4,0.2,0.1]	[0.5.0.4,0.5,0.3,0.2]	[0.4,0.1,0.4,0.1,0.1]	[0.6,0.2,0.6,0.3,0.2]
A_2	[0.4,0.2,0.6,0.1,0.2]	[0.3,0.3,0.5,0.2,0.1]	[0.1,0.4,0.2,0.3,0.2]	[0.5,0.3,0.6,0.1,0.1]
A_3	[0.3,0.4,0.4,0.3,0.4]	[0.5,0.1,0.6,0.2,0.1]	[0.4,0.5,0.4,0.3,0.2]	[0.3,0.2,0.5,0.2,0.2]

Then by using the proposed method we will obtain the most desirable alternative. We can get the values of the correlation coefficient $M_w(A_i, A^*)$ (i = 1,2,3) by using Equation (3.3).

Hence $M_w(A_1, A^*)$ = 0.586276, $M_w(A_2, A^*)$ = 0.5640, $M_w(A_3, A^*)$ = 0.*56921*. Therefore

Thus ranking order of the three potential alternatives is A1>A3>A2. Therefore we can say that A1 alternative copyright have more cyber problems subsists in original literary, dramatic, musical, artistic, cinematographic film, sound recording and computer programme as well than the other alternatives of intellectual property rights. The decision making method provided in this paper is more judicious and more vigorous.

CONCLUSION

In this paper, we've outlined the improved correlation coefficient of PNPS s and this is often applicable for a few cases once the correlation coefficient of PNPS s is undefined (or) unmeaningful and additionally studied its properties. decision making could be a process that plays a significant role in real world issues. the most method in higher cognitive process is recognizing the matter (or) chance and deciding to deal with it. Here we've mentioned the decision making technique using the improved correlation of PNPS s and in significantly an illustrative example is given in multiple attribute higher cognitive process issues that involvesthe many alternatives supported varied criteria. Therefore our projected improved correla tion of PNPS s helps to spot the foremost appropriate different to the client supported on the given criteria.

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