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RESEARCH ARTICLE

NANO *gα-NORMAL SPACES AND ALMOST NANO *gα-NORMAL SPACES

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ABSTRACT

The aim of this paper is to introduce a new class of different normal spaces, namely nano*gα-normal spaces, strongly nano*gα-closed, almost *gα-irresolute functions in nano topological spaces and their properties also studied.

Keywords: nano*gα-normal spaces, strongly nano*gα-closed functions, almost *gα-irresolute functions.

1. INTRODUCTION

In the year 1971, Vigiline [1] who defined semi normal spaces and it is an important topological property. The class of almost normal spaces is proved that a space is normal if and only if its both a semi normal spaces and an almost normal space by Singal and Arya [2]. In 2013, Lellis Thivagar [3] who introduced nano topology and defined in forms of lower approximations, upper approximations and boundary region of a subset of a universe using and equivalence relation on it. The author also defined the basis, nano interior operator and nano closure operator in nano topological spaces. The concepts of nano continuous and nano pre-continuous and their properties were also studied by Lellis Thivagar [3]. The Characterizations of mildly nano gb-normal spaces were introduced by Dhanis Arul Mary and Arockiarani [4].

2. Nano*gα-normal spaces

Definition 2.1 Let $(U,\tau_R(X))$ be a Nano topological spaces. A subset A of$(U,\tau_R(X))$ is called Nano*gα-closed set if $Ncl(A)\subseteq V$ Where $A\subseteq V$ and V is Nano gα-open.

Definition 2.2 A nano topological space $(U, \tau_R(X))$ is said to nano*gα-normal if for any pair of disjoint nano-closed sets A and B, there exist nano *gα-open sets M and N such that $A \subset M$ and $B \subset N$.

Example 2.3 Let U = {x, y, z} with U/R = {{x}, {y, z}}. Then the nano topology $\tau_R(X)$ = {U, φ, {x}, {y, z}}. Hence the only pair of disjoint closed subsets of $(U, \tau_R(Y))$ is {y, z}, {x}. Also {x}, {y, z} are *gα-open sets such that $\{x\} \subset \{x\}, \{y,z\} \subset \{y,z\}$.

Theorem 2.4 For a nano topological space f: $(U, \tau_R(X)) \rightarrow (V, \tau_R'(Y))$
the followings statements are equivalent:
(i) U is *gα-normal.
(ii) for every pair of nano open sets M and N whose union is U, there exist nano *gα-closed sets A and B such that $A \subset M$ and $B \subset N$ and $A \cup B = U$.
(iii) for every nano closed sets H and every nano open set K containing H, there exists nano *gα-open set M such that $H \subset M \subset N^{*}g\alpha cl(M) \subset K$.

Proof. (i) ⇒ (ii) let M and N be a pair of nano open sets in a nano *gα-normal space U such that U = M ∪ N . Then U − M , U − N are disjoint nano closed sets since U is nano *gα-normal there exist nano *gα-open sets M_1 and such N_1 such that $U - M \subset M_1$ and $U - N \subset N_1$ Let $A = U - M_1$, $B = U - N_1$ Then A and B are nano *gα-closed sets such that $A \subset M$ and $B \subset N$ and $A \cup B = U$.
(ii)⇒ (iii) Let H be a nano closed set and K be a nano open set containing H. Then U − H and K are nano open sets whose union is U. Then by (ii), there exist nano *gα-closed sets P_1 and P_2 such that $P_1 \subset U - H$ and $P_2 \subset K$ and $P_1 \cup P_2 = U$. Then $H \subset U - P_1$ and $U - K \subset U - P_2$ and $(U - P_1) \cap (U - P_2) = \varphi$. Let $M = U - P_1$ and $N = U - P_2$. Then M and N are disjoint nano *gα-open sets such that $H \subset M \subset U - N \subset K$. As U − N is nano*gα-closed set, we have
$N^{*}g\alpha\text{-cl}(M) \subset U - N$ and $H \subset M \subset N^{*}g\alpha\text{-cl}(M) \subset K$.
(iii)⇒ (i) Let H_1 and H_2 are two disjoint nano closed sets of U. Put $K = U - H_2$. Then

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$H_2 \cap K = \varphi$. $H \subset K$ where K is a nano open set. Then by (iii), there exists a nano $^*g\alpha$-open sets M of U such that $H_1 \subset M \subset N\ ^*g\alpha\text{-cl}(M) \subset K$. It follows that $H_2 \subset U - N\ ^*g\alpha\text{-cl}(M) = N$. Say, then N is nano $^*g\alpha$-open and $M \cap N = \varphi$. Hence H_1 and H_2 are separated by nano $^*g\alpha$-open sets M and N. Therefore U is nano $^*g\alpha$-normal.

Definition 2.5 A function f: $(U, \tau_R(X)) \to (V, \tau_R'(Y))$ is called strongly nano $^*g\alpha$-open if $f(M) \in N\ ^*g\alpha O(V)$ for each $M \in N^*g\alpha O(U)$.

Definition 2.6 A function f: $(U, \tau_R(X)) \to (V, \tau_R'(Y))$ is called strongly nano$^*g\alpha$-closed if $f(M) \in N\ ^*g\alpha C(V)$ for each $M \in N^*g\alpha C(U)$.

Theorem 2.7 A function $f : (U, \tau_R(X)) \to (V, \tau_R'(Y))$ is called strongly nano $^*g\alpha$-closed if and only if for each subset B in V and for each nano $^*g\alpha$-open set M in U containing $f^{-1}(B)$, there exist a nano $^*g\alpha$-open set N containing B such that $f^{-1}(N) \subset M$.

Proof. Suppose that f is strongly nano $^*g\alpha$-closed. Let B be a subset of V and $M \in N\ ^*g\alpha O(U)$ containing $f^{-1}(B)$. Put $N = V - f(U - M)$, then N is a nano$^*g\alpha$-open set of V such that $B \subset N$ and $f^{-1}(N) \subset M$. Conversely let K be any nano $^*g\alpha$-closed set of U. Then $f^{-1}(V - f(K)) \subset U - K$ and $U - K \in N\ ^*g\alpha O(U)$. There exists a nano $^*g\alpha$-open set N of V such that $V - f(K) \subset N$ and $f^{-1}(N) \subset U - K$. Therefore we have $f(K) \supset V - N$ and $K \subset f^{-1}(V - N)$. Hence we obtain $f(K) = V - N$ and f (K) is nano $^*g\alpha$-closed in V. This shows that f is strongly nano $^*g\alpha$-closed.

Theorem 2.8 If $f : (U, \tau_R(X)) \to (V, \tau_R'(Y))$ is a strongly nano $^*g\alpha$-closed continuous function from a nano $^*g\alpha$-normal space U on to a space V, then V is nano $^*g\alpha$-normal.

Proof. Let K_1 and K_2 are disjoint nano closed sets in V. Then $f^{-1}(K_1)$ and $f^{-1}(K_2)$ are nano closed sets in V. Since U is nano $^*g\alpha$-normal then there exist disjoint nano $^*g\alpha$-open sets M and N such that $f^{-1}(K_1) \subset M$ and $f^{-1}(K_2) \subset N$. Then there exist nano $^*g\alpha$-open sets A and B such that $K_1 \subset A$, $K_2 \subset B$, $f^{-1}(A) \subset M$ and $f^{-1}(B) \subset N$. Also A and B are disjoint. Thus V is nano $^*g\alpha$-normal.

Definition 2.9 A function f: $(U, \tau_R(X)) \to (V, \tau_R'(Y))$ is called almost nano$^*g\alpha$-irresolute if for each u in U and each nano $^*g\alpha$-neighbourhood N of f (u), $N\ ^*g\alpha - cl(f^{-1}(N))$ is a nano $^*g\alpha$-neighbourhood of u.

Lemma 2.10 For a function f: $(U, \tau_R(X)) \to (V, \tau_R'(Y))$ the following statements are equivalent.

(i)f is almost nano $^*g\alpha$-irresolute.

(ii) $f^{-1}(N) \subset N\ ^*g\alpha\text{-int}(N\ ^*g\alpha\text{-cl}(f^{-1}(N)))$ for every $N \in N\ ^*g\alpha O(V)$.

Theorem 2.11 A function $f : (U, \tau_R(X)) \to (V, \tau_R'(Y))$ almost nano$^*g\alpha$-irresolute if and only if $f(N\ ^*g\alpha - cl(M)) \subset N\ ^*g\alpha - cl(f(M))$ for every $M \in N\ ^*g\alpha O(U)$.

Proof. Let $M \in N\ ^*g\alpha O(U)$. Suppose $V \notin N\ ^*g\alpha - cl(f(M))$. Then there exists $N \in N\ ^*g\alpha O(V, v))$ such that $N \cap f(M) = \varphi$. Hence, $f^{-1}(N) \cap M = \varphi$ .Since $M \in N\ ^*g\alpha O(U)$. We have $N\ ^*g\alpha - int(N\ ^*g\alpha - cl(f^{-1}(N))) \cap N\ ^*g\alpha - cl(M) = \varphi$. Then by lemma [2.10], $f^{-1}(N) \cap N\ ^*g\alpha - cl(M) = \varphi$ and hence $N \cap f(N\ ^*g\alpha - cl(M)) = \varphi$. This implies that $V \notin f(N\ ^*g\alpha - cl(M))$.

Conversely if $N \in N\ ^*g\alpha O(V)$ then $P = U/N\ ^*g\alpha - cl(f^{-1}(N)) \in N\ ^*g\alpha O(U)$. By hypothesis, $f(N\ ^*g\alpha - cl(P)) \subset N\ ^*g\alpha - cl(f(P))$ and hence, $U/N\ ^*g\alpha - int(N\ ^*g\alpha - cl(f^{-1}(N))) = N\ ^*g\alpha - cl(P) \subset f^{-1}(N\ ^*g\alpha - cl(f(P))) \subset f^{-1}N\ ^*g\alpha - cl(f(U)/f^{-1}(N)) \subset f^{-1}N\ ^*g\alpha cl(V/N) \subset f^{-1}(V/N) = U/f^{-1}(N)$.

Therefore $f^{-1}(N) \subset N\ ^*g\alpha - int(N\ ^*g\alpha - cl(f^{-1}(N))$. By Lemma [3.10], f is almost nano $^*g\alpha$-irresolute.

Theorem 2.11 If f: $(U, \tau_R(X)) \to (V, \tau_R'(Y))$ is a strongly nano$^*g\alpha$-open continuous almost nano$^*g\alpha$-irresolute function from a nano$^*g\alpha$-normal space U onto a space V. Then V is nano$^*g\alpha$-normal space.

Proof. Let A be a nano closed set of K and B be a nano open set containing A.

Then by continuity of f , $f^{-1}(A)$ is nano closed and $f^{-1}(B)$ is nano open set of U such that $f^{-1}(A) \subset f^{-1}(B)$. As U is nano$^*g\alpha$-normal, there exists a nano $^*g\alpha$-open set M in U such that $f^{-1}(A) \subset M \subset N\ ^*g\alpha - cl(M) \subset f^{-1}(B)$ by Theorem 2.4. Then $f(f^{-1}(A)) \subset f(M) \subset f(N\ ^*g\alpha cl(M)) \subset f(f^{-1}(B))$. Since f is strongly nano $^*g\alpha$-open almost nano $^*g\alpha$-irresolute surjection, we obtain $A \subset f(M) \subset N\ ^*g\alpha - cl(f(M) \subset B$. Then again Theorem 3.4 the space V is a nano $^*g\alpha$-normal.

3. Almost nano $^*g\alpha$-normal spaces

Definition 3.1 A nano topological spaces $(U, \tau_R(X))$ is said to be almost nano $^*g\alpha$-normal if for each nano $^*g\alpha$-closed set A and nano regular closed set B such that $A \cap B = \varphi$, there exist disjoint nano $^*g\alpha$-open sets M and N such that $A \subset M$ and $B \subset N$.

Definition 3.2 A nano topological spaces $(U, \tau_R(X))$ is said to be quasi nano$^*g\alpha$-closed if f (A) is nano $^*g\alpha$-closed in V for each $A \in N\ ^*g\alpha C(U)$.

Theorem 3.3 For a nano topological spaces $(U, \tau_R(X))$ the following statements are equivalent:

(i) U is almost nano $^*g\alpha$-normal.

(ii) For every pair of nano sets A and B, one of which is nano $^*g\alpha$-open and the other is nano regular open whose union is U, there exist nano nano $^*g\alpha$-closed sets H and K such that $H \subset A$ and $K \subset B$ and $H \cup K = U$.

(iii) For every nano $^*g\alpha$-closed set H and nano regular open set K containing H, there exists a nano $^*g\alpha$-open set N such that $H \subset B \subset N\ ^*g\alpha cl(B) \subset K$.

Proof. (i) $\Rightarrow$ (ii) Let A and B be a pair of nano open sets in a nano $^*g\alpha$-normal space U such that $U = A \cup B$. Then $U - A$ and $U - B$ are two disjoint nano $^*g\alpha$-closed sets. Since U is nano $^*g\alpha$-normal there exist nano$^*g\alpha$-open sets A_1 and such B_1, such that $U - A \subset A_1$ and $U - B \subset B_1$. Let $H = U - A_1$, $K = U - B_1$. Then H and K are nano $^*g\alpha$-closed sets such that $H \subset A$ and $K \subset B$ and $H \cup K = U$.

(ii)$\Rightarrow$ (iii) Let A be a nano $^*g\alpha$-closed set and B be a nano $^*g\alpha$-open set containing A. The $U - A$ and B are nano $^*g\alpha$-open sets whose union is U. Then by (ii), there existnano $^*g\alpha$-closed sets W_1 and W_2 such that $W_1 \subset U - A$ and $W_2 \subset B$ and $W_1 \cup W_2 = U$. Then $A \subset U - W_1$ and $U - B \subset W_2$ and $(U - W_1) \cap (U - W_2) = \varphi$. Let $X = U - W_1$ and $Y = U - W_2$. Then A and B are disjoint nano $^*g\alpha$-open sets such that $A \subset U - Y \subset B$. As $U - Y$ is nano
$^*g\alpha$-closed set, we have N $^*g\alpha cl(X) \subset U - Y$ and $A \subset X \subset N\ ^*g\alpha cl(X) \subset B$.

(iii)$\Rightarrow$ (i): Let A_1 and A_2 be any two disjoint nano $^*g\alpha$-closed sets of U.Put $B = U - A_2$, then $A_2 \cap B = \varphi$. $A_1 \subset B$ where B is a nano$^*g\alpha$-open sets. Then by (iii), there exists a nano $^*g\alpha$-open set X of U such that $A_1 \subset U - N\ ^*g\alpha cl(X) = Y$, then Y is nano $^*g\alpha$-open and $X \cap Y = \varphi$. Hence A_1 and A_2 are seperated by nano $^*g\alpha$-open sets X and Y. Therefore U is nano $^*g\alpha$-normal.

Theorem 3.4 If $f : (U, \tau_R(X)) \rightarrow (V, \tau_R'(Y))$ is a nano $^*g\alpha$-continuous, quasi nano $^*g\alpha$-closed surjection and U is nano $^*g\alpha$-normal, then V is normal.

Proof Let W_1 and W_2 be any disjoint nano $^*g\alpha$-closed sets of V. Since f is nano $^*g\alpha$-continuous, $f^{-1}(W_1)$ and $f^{-1}(W_2)$ are disjoint nano $^*g\alpha$-closed sets of U. Since U is nano $^*g\alpha$-normal, there exist disjoint N_1 and $N_2 \in N\ ^*g\alpha O(V)$, such that $f^{-1}(W_1) \subset N_i$ for i = 1, 2. Put $Q_i = V - f(U - N_i$ then Q_i is nano$^*g\alpha$-open in V, $W_2 \subset Q_i$ and $f^{-1}(Q_i) \subset N_i$ for i = 1, 2. Since $N_1 \cap N_2 = \varphi$ and f is surjective. We have $Q_1 \cap Q_2 = \varphi$. This shows that V is nano $^*g\alpha$-normal.

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RESEARCH ARTICLE

CHECKLIST OF BIRD SPECIES IN DHARMADAM ESTUARY IN KANNUR DISTRICT OF KERALA

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ABSTRACT

A total of 20 bird species belongs to 7 orders and 11 families were recorded in Dharmadam estuary in Kannur district. The record of migratory bird Eurasian Curlew and two species near threatened birds within a short period of study and this record indicate that Dharmadam estuary may be attracting more number of migratory bird species. A long-term study is needed to understand the seasonal variation of the bird species in Dharmadam estuary in Kannur district.

Keywords: Birds, Dharmadam estuary, Kannur, Migratory

1. INTRODUCTION

The Kerala state's hydrologic potential associated with the coastal system constitutes 41 west flowing rivers (all seasonal, 4 of them moderately large, and others only minor ones), and the associated vast lacustrine system along the coast. The river systems mostly drain into the backwaters and estuaries in the coastal plains before emptying into the sea. The closer proximity of the Western Ghats to the west coast and the consequent descending gradients of land cause the river run offs in spate during the rainy monsoon period [1]. As a result, the inflows from the uplands reaching the backwaters and estuaries discharge sizeable sediment load into the sea, with little deltaic accretion associated with the estuaries. Estuaries are complex ecosystem with many interacting organisms. Estuaries are important throughout the world for wildlife protections, recreations, pollution, and sediment control food prevention and food production [2]. According to Odum (1983) estuaries are semi-enclosed coastal water body that has a free connection with the open sea. The uniqueness of the different types of habitats in and near estuaries attracts both resident and migratory bird species. The present study was undertaken to prepare a detailed checklist of avifauna in Dharmadam estuary in Kerela.

2. STUDY AREA

Dharmadam estuary is situated between 11o 45’ 50” N-75o 28’41.3” E in Kannur district. The estuary has an area of 10.68 km^2 Dharmadam Island surrounded by the Anjarakkandy River on three sides, and the Arabian Sea on the fourth side. The habitat of the study sites are mainly mangrove, aquaculture lands and estuaries. The important habitat is scrubland, woodland, wetland the patches of scrubs with dense foliage, the wide exposure of mud flats, during low tide and the seashore and its sand dunes provide rich sources of food for resident as well as wintering species of birds. The mudflats in Dharmdam estuaries and the wide coastal belt with sand dunes rich in animal life can support a vast assemblage of marshy birds.

3. MATERIALS AND METHODS

The study was mainly based on direct observational methods. The whole area was surveyed by using various transit. Photographs of the birds were taken by using Nikon D3400 to support the further identification and birds were identified with the help of Birds of the Indian Subcontinent field guide [3]. The field surveys was conducted from January and February, 2019 performed in the morning (7a.m to 9a.m) and in the evening (4 p.m to 6 p.m) because birds are very active during this time due to peak activity of prey abundance. SOPMA (Self Optimized Prediction Method with Alignment) was used for the secondary structure prediction.

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Table 1. Checklist of bird species in Dharmadam estuary in Kannur district

Order	Family	Common Name	Scientific Name	Status
Coraciiformes	Alcedinidae	Blue-eared Kingfisher	*Alcedo meninting*	R
Gruiformes	Rallidae	White-breasted Waterhen	*Amaurornis phoenicurus*	R
Charadriiformes	Scolopacidae	Eurasian Curlew	*Numenius arquata**	M
		Ruddy Turnstone	*Arenaria interpres*	M
		Wood Sandpiper	*Tringa glareola*	M
		Temminck's Stint	*Calidris temminckii*	M
		Kentish Plover	*Charadrius alexandrinus*	M
Falconiformes	Accipitridae	Brahminy Kite	*Haliastur indus*	R
Suliformes	Phalacrocoracidae	Little Cormorant	*Microcarbo niger*	R
Pelecaniformes	Threskiornithidae	Oriental White Ibis	*Threskiornis melanocephalus**	R
	Ardeidae	Striated Heron	*Butorides striata*	R
		Western Reef Egret	*Egretta gularis*	M
		Intermediate Egret	*Ardea intermedia*	M
		Little Egret	*Egretta garzetta**	M
		Indian Pond Heron	*Ardeola grayii*	M
		Grey Heron	*Ardea cinerea*	M
		Black-crowned Night Heron	*Nycticorax nycticorax*	M
Passeriformes	Corvidae	House Crow	*Corvus splendens*	R
	Muscicapidae	Oriental Magpie Robin	*Copsychus saularis*	R
	Pycnonotidae	Red -whiskered Bulbul	*Pycnonotus jocosus*	R

Abrevations: R: Resident, M: Migratory
***Near Threatened**

3. RESULTS AND DISCUSSION

A total of 20 bird species were recorded and all birds species represents 7 orders and 11families. The maximum birds occurred the order Ciconiiformes followed by Charadriiformes Passeriformes and single species recorded in the rest of the orders. There are nine migratory birds species was recorded during the survey (Table.1). Among the bird species Eurasian curlew (*Numenius arquat*), Little egret (*Egretta garzetta*), and Oriental White Ibis (*Threskiornis melanocephalus*) are listed as Near Threatened category (IUCN). The Darter (Snake bird), *Anhinga rufa*were occasionally sighted from the area [1] not seen during our study. Bird species richness and community structure differed from region to region. Pearson [4], Karr [5] and Crowell [6] stated

that a species is found with greatest frequency and abundance in the habitats to which it is best adapted. Within a geographical area, species are not evenly distributed across all available habitats and tend to use some habitats more than the others [7]. Amongst all vertebrate faunal taxa, avian fauna shows maximum diversity. Kerala encompasses 516 species of birds [8]. Record of the more migratory bird species during the shortest period of our study indicates that presence of various habitats in Dharmadam estuary might attracting more number of both resident and migratory bird species. We recommend that long term ecological study might help to understand the species richness in varied habitats and to address the conservation measures in the Dhramadam estuary.

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RESEARCH ARTICLE

INTERVAL SEQUENCING PROBLEM

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ABSTRACT

This paper deals with sequencing problems for 'n' jobs on single machine, 'n' jobs on two machines, 'n' jobs on three machines and 'n' jobs on 'm' machines. Here, we consider the sequencing problem where the processing time, due dates, weights are taken as intervals. An algorithm is provided for obtaining an optimal sequence and also for determining the minimum duration taken to complete all the jobs. To illustrate this, numerical examples are provided.

Keywords: Sequencing problem, Intervals, Optimal sequence, Total time elapsed, Idle time.

1. INTRODUCTION

Operations Research is relatively a new discipline which originated during World War II, and later became very popular throughout the world. It is used successfully in almost all the fields. Operations Research helps us to make better decisions in complex scenarios. It also includes the application of scientific tools for finding the optimum solution to a problem involving the operations of a system.

Sequencing problem is considered to be one of the important applications of Operations research. A series, in which a few jobs or tasks are to be performed following an order, is called sequencing. An algorithm was proposed by Johnson [1] for scheduling jobs in two machines. Its primary objective is to find an optimal sequence of jobs and to reduce the total amount of time it takes to complete all the jobs. It also reduces the amount of idle time between the two machines. Furthermore, Johnson's method has been extended to 'm' machines problem with an objective to complete all the jobs in a minimum duration.

Generally, in sequencing problems, the processing times are valued precisely. But in reality, it is perceived that the processing times during the performance of the job are imprecise and uncertain. In order to handle this uncertainties, we use fuzzy interval and fuzzy numbers. Here, we consider intervals. Interval computation was first suggested by Dwyer [2]. The concept of fuzzy sets was proposed by Zadeh [3]. Radhakrishnan et. al. [4] have solved problems on Game thoery using interval paramers. Radhakrishnan et. al. [5] have discussed and solved problems related to Critical Path Method and Programme Evaluation Review Technique with intervals and also with the conversion of fuzzy parameters (triangular and trapezoidal) into intervals using α-cuts.

The rest of this paper is organized as follows:

In section 2, basic preliminaries of interval and its arithmetic, types of intervals, ordering of intervals are given. In section 3, basic terminologies of sequencing and an algorithm for solving sequencing problem is provided. In section 4, numerical examples illustrating the algorithm are given. Finally, the conclusion.

2. PRELIMINARIES

2.1. Interval Number

An interval number A is defined as $A = [\beta_1, \beta_2] = \{x: \beta_1 \leq x \leq \beta_2, x \in \mathbb{R}\}$. Here, $\beta_1, \beta_2 \in \mathbb{R}$ are the lower and upper bounds of the interval.

2.1.1. Arithmetic operations of interval

Let A = [β_1,β_2] and B= [γ_1,γ_2] be two intervals. Then

Addition: A+B =$[\beta_1 + \gamma_1, \beta_2 + \gamma_2]$

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Subtraction: A-B = $[\beta_1 - \gamma_2, \beta_2 - \gamma_1]$

Multiplication: A*B = $[\min(\beta_1\gamma_1, \beta_1\gamma_2, \beta_2\gamma_1, \beta_2\gamma_2), \max(\beta_1\gamma_1, \beta_1\gamma_2, \beta_2\gamma_1, \beta_2\gamma_2)]$

Division: $\frac{A}{B} = \frac{[\beta_1,\beta_2]}{[\gamma_1,\gamma_2]} = [\beta_1,\beta_2].\frac{1}{[\gamma_1,\gamma_2]}$

where $\frac{1}{[\gamma_1,\gamma_2]} = \left[\frac{1}{\gamma_2}, \frac{1}{\gamma_1}\right], 0 \notin [\gamma_1,\gamma_2]$

$\frac{1}{[\gamma_1,0]} = \left[-\infty, \frac{1}{\gamma_1}\right]$

$\frac{1}{[0,\gamma_2]} = \left[\frac{1}{\gamma_2}, \infty\right]$ and

$\frac{1}{[\gamma_1,\gamma_2]} = \left[-\infty, \frac{1}{\gamma_1}\right] \cup \left[\frac{1}{\gamma_2}, \infty\right]$ = [-∞, ∞], $0 \in [\gamma_1, \gamma_2]$

Scalar Multiplication:

Let A= $[\beta_1, \beta_2]$ then uA= $[u\beta_1, u\beta_2]$, u≥ 0 and uA= $[u\beta_2, u\beta_1]$, $u \leq 0$.

2.2. Types of intervals

Let A = $[\beta_1, \beta_2]$ and B= $[\gamma_1, \gamma_2]$ be two intervals. Therefore these can be classified into three types as follows:

Type I- Non overlapping intervals:

If two intervals are disjoint then they are known as non-overlapping intervals.

Type II- Partially overlapping intervals:

If one interval contains the other interval partially then they are known as partially overlapping intervals.

Type III- Completely overlapping intervals:

If one interval completely contained in the other interval then they are known as completely overlapping intervals.

These three types of intervals are shown in Figure 1

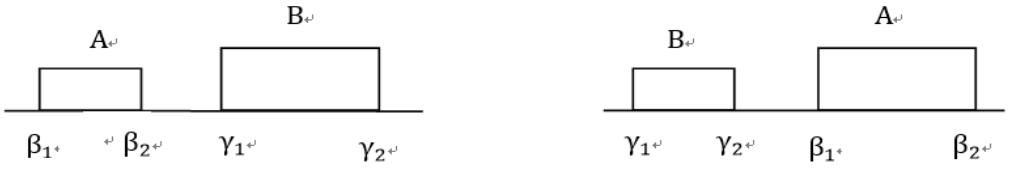

Figure 1(a): Type – I intervals

Figure 1(b): Type – II intervals

Figure 1(c): Type – III intervals

Figure 1: Different types of intervals

2.3. Ordering of intervals:

Let A= $[\beta_1, \beta_2]$ be the interval number. It can also be expressed by its centre and radius and it is denoted by 〈a_C, a_w〉 , where $a_C = \frac{\beta_1+\beta_2}{2}$ and $a_w = \frac{\beta_2-\beta_1}{2}$ and they are known as centre and radius of the interval respectively.

Let A= $[\beta_1, \beta_2]$ = 〈a_C, a_W〉 and B =$[\gamma_1, \gamma_2]$ = 〈b_C, b_W〉 . Then the relation on interval number is defined as

i. A < B iff $a_C < b_C$ whenever $a_C \neq b_C$.
ii. A > B iff $a_C > b_C$ whenever $a_C \neq b_C$.
iii. A < B iff $a_w < b_w$ whenever $a_C = b_C$.
iv. A > B iff $a_w > b_w$ whenever $a_C = b_C$.

3. Sequencing Problem

3.1. Principal assumptions:

While solving a sequencing problem, the following assumptions are made:

i. The processing times on different machines are not dependent of the order of the job in which they are to be performed.
ii. No machine can process more than one job concurrently.
iii. The time required in transferring a job from one machine to another machine is negligible and it is taken as zero.
iv. Each operation as well as job once started must be completed.
v. Processing times are known and fixed.
vi. An operation must be completed before its succeeding operation starts.

3.2. Basic Terminologies

a) Number of Machines:

Number of service facilities through which the job is to be passed.

b) Processing Time:

The time which is required for a job to process on a particular machine.

c) Processing Order:

It is a sequence in which various machines are needed for completion of the job.

d) Total elapsed time:

Total elapsed time is the total time required to complete the jobs from first to the last in a sequence.

e) Idle Time:

Idle time on a machine is the time for which the machine remains idle during the total elapsed time.

f) No passing rule:

If each of the n jobs is to be processed through two machines M_1 and M_2 in the order M_1 M_2 then it must go on machine M_1 first and then to Machine M_2.

3.3. Algorithm for Solving Interval sequencing Problem

3.3.1. Processing n jobs on single machine

Consider 'n' jobs processing on single machine where the processing time is given with the following objective:

1. Any new job which comes should not affect the processing time of these 'n' jobs.
2. If a new job comes, it has to wait for being considered in the next batch of jobs until the processing of the current 'n' jobs is completed.

This type of problem can be completely described as

i. Only single machine is involved.
ii. The processing time, due dates and weights are denoted as intervals.

Notations:

Let n_i - number of different jobs,
t_i - processing time of job i,
c_i - completion time of job i,
T_{c_i} - Total completion time of jobs,
d_i - due date of job i,
w_i - weight of job i,
L_i - Lateness of job i = c_i - d_i
S_i - Slack time of job i = d_i - t_i

Use the ordering of intervals to obtain an optimal sequence. The optimal sequence for an interval sequencing problem of a single machine can be determined by the following rules:

A. SPT Rule (Shortest Processing Time):

Jobs are arranged in ascending order of processing time.

B. WSPT Rule (Weighted Shortest Processing Time):

Jobs are arranged with minimum processing time per unit of importance in increasing order.

C. EDD Rule (Earliest Due Date):

Jobs are arranged in the increasing order of due dates of jobs.

D. Hodgson's Algorithm:

This Algorithm is applicable only if the number of late jobs is more than one. Number of late jobs can be identified using

EDD rule. Select the first late job and examine the longest processing time and remove it. Repeat the process until all the late jobs get vanished.

E. STR (Slack Time Remaining) Rule:

Jobs are arranged in the increasing order of Slack time.

After obtaining an optimal sequence for a single machine, we calculate the following:

i. Mean flow time = $\frac{\sum T_{c_j}}{\text{Number of jobs}}$

ii. Average in process inventory = $\frac{\sum(\text{Jobs waiting as in process inventory} * \text{range})}{\sum \text{Range}}$

where range = Time out of job n_i – Time in of job n_i

iii. Weighted Mean Flow time = $\frac{\sum_{i=1}^{n} w_i T_{c_j}}{\sum_{i=1}^{n} w_i}$

iv. Mean lateness = $\frac{\sum L_i}{\text{Number of jobs}}$

v. Number of late jobs = No. of positive lateness.

3.3.2. Processing 'n' jobs on two machines

Let A_1', A_2'... A_n' be the processing times of 'n' jobs on Machine 1 and B_1', B_2'...B_n' be the processing times of 'n' jobs on Machine 2. The problem is to find the order in which the 'n' jobs are to be processed through two machines with the minimum total elapsed time.

Procedure:

Step 1: Use ordering of intervals to identify the minimum processing time from the given list of processing times A_1', A_2' ...A_n' and B_1', B_2'... B_n'.

Step 2: If the minimum processing time is A_p' (i.e., job number p on machine 1) then do the p^{th} job first in the sequence. If the minimum processing time is B_q' (i.e., job number q on machine 2) then do the q^{th} job last in the sequence.

Step 3:

a) If there is a tie in minimum processing of both machines (i.e., $A_p' = B_q'$), process the p^{th} job first and q^{th} job last in the sequence.

b) If the tie for the minimum occurs among the processing time on Machine 1, select the job corresponding to the minimum of processing time on Machine 2 and process it first.

c) If the tie for the minimum occurs among the processing time on Machine 2, select the job corresponding to the minimum of processing time on Machine 1 and process it last.

Step 4: Cancel the jobs already assigned and repeat steps 2 to 4 until all the jobs have been assigned.

The resulting order will minimise the total elapsed time and it is known as optimal sequence.

Step 5: After obtaining an optimal sequence as stated above, the total elapsed time and also the idle time on machines 1 and 2 are calculated as follows:

Total elapsed time = Time out of the last job on machine 2.

Idle time for machine 1 = Total elapsed time - time when the last job is out of machine 1

Idle time for machine 2 = Time at which the first job on machine 1 finishes in a sequence $+\sum_{i=2}^{n} \left\{ \begin{matrix} (\text{time when the } i^{th} \text{ job starts on machine 2}) \\ -(\text{time when the } (i-1)^{th} \text{ finishes on machine 2}) \end{matrix} \right\}$

3.3.3. Processing 'n' jobs on three machines

Let A_1', A_2'... A_n' be the processing times of 'n' jobs on Machine 1, B_1', B_2'... B_n' be the processing times of 'n' jobs on Machine 2 and C_1', C_2'... C_n' be the processing times of 'n' jobs on Machine 3. There is no standard procedure to obtain an optimal sequence for processing 'n' jobs on 3 Machines. So, we have to convert the three machine problem into a two machine problem by satisfying any one or both of the following conditions.

1. Min (A_i') $\geq$ Max (B_i'), for i= 1, 2 .... n
2. Min (C_i') $\geq$ Max (B_i'), for i= 1, 2 .... n

To determine the minimum or maximum of processing time on machines, we use ordering of intervals.

If one of the above conditions is satisfied, we introduce two fictitious machines G and H such that the processing times on G and H are given by

$G = A_i' + B_i'$, for i= 1, 2... n

$H = B_i' + C_i'$, for i= 1, 2... n

Now we can proceed to determine the optimal sequence using 3.3.2.

After obtaining an optimal sequence, the total elapsed time and also the idle time on machines 1, 2 and 3 are calculated as follows:

Total elapsed time = Time out of the last job on machine 3.

Idle time for machine 1 = Total elapsed time - time when the last job is out of machine 1

Idle time for machine 2 = (Total elapsed time - time when the last job is out of machine 2)
+ Time at which the first job in a sequence finishes on machine 1
$$+\sum_{i=2}^{n}\left\{\begin{array}{l}\left(\text{time when the } i^{th} \text{ job starts on machine 2}\right)\\ -\left(\text{time when the } (i-1)^{th} \text{ finishes on machine 2}\right)\end{array}\right\}$$

Idle time for machine 3 = Time at which the first job in a sequence finishes on machine 2
$$+\sum_{i=2}^{n}\left\{\begin{array}{l}\left(\text{time when the } i^{th} \text{ job starts on machine 3}\right)\\ -\left(\text{time when the } (i-1)^{th} \text{ finishes on machine 3}\right)\end{array}\right\}$$

3.3.4. Processing 'n' jobs on 'm' machines

Let there be 'n' jobs which are to be processed through 'm' machines M_1, M_2 ...M_m in the order M_1, M_2 ...M_m and T_{ik} be the time taken by the i^{th} job on k^{th} machine.

Procedure

Step 1: Use ordering of intervals to identify Min T_{i1} (Minimum time for the first machine), Min T_{im} (Minimum time on the last machine) and Max (T_{ik}) for k=2, 3... m-1 and i=1, 2 ...n (Maximum time on intermediate machines).

Step 2: Check the following conditions:

(i) Minimum Time T_{i1} for the first machine (M_1) $\geq$ Maximum time (T_{ik}) on intermediate machines (M_2 to M_{m-1})

(ii) Minimum time T_{im} for the last machine (M_m) $\geq$ Maximum Time (T_{ik}) on intermediate machines (M_2 to M_{m-1}). (i.e., the minimum processing time on the machines M_1 and M_m (First and last machines) should be greater than or equal to maximum time on any of the 2 to m-1 machines).

Step 3: If the conditions in step 3 are not satisfied, the problem cannot be solved by this method, hence go to next step.

Step 4: Convert the 'n' job 'm' machine problem into 'n' job two machine problem by considering two machines G and H such that
$G_{ij} = T_{i1}+T_{i2}+ \ldots + T_{i(m-1)}$
$H_{ij} = T_{i2}+T_{i3}+ \ldots +T_{im}$

Step 5: Now we can proceed to determine the optimal sequence using 3.3.2. After obtaining an optimal sequence, the total elapsed time and also the idle time on machines are determined.

4. NUMERICAL EXAMPLE

1. Eight jobs A, B, C, D, E, F, G and H are to be processed on a single machine. The processing time, due dates, importance weights of the jobs are represented below. Assuming that no new jobs arrived thereafter, determine using SPT Rule, WSPT Rule, EDD Rule, STR Rule and Hodgson's Algorithm.

i. Optimal Sequence
ii. Completion time of the jobs
iii. Mean flow time as well as weighted mean flow time
iv. Average in process inventory
v. Lateness, mean lateness and maximum lateness
vi. Number of jobs actually late.

Jobs	A	B	C	D	E	F	G	H
Processing Time (t_i)	[3,7]	[6,10]	[5,7]	[1,5]	[8,12]	[13,15]	[4,10]	[1,5]
Due date (d_i)	[14,16]	[8,12]	[13,17]	[24,26]	[18,22]	[38,42]	[44,46]	[49,51]
Importance weight (w_i)	[0.5,1.5]	[1,3]	[1,5]	[0.5,1.5]	[1,3]	[1,5]	[1,3]	[0.5,1.5]

I. SPT Rule:

i. Use the ordering of intervals to obtain an optimal sequence. The optimal sequence is obtained by arranging the processing time in increasing order.
Optimal Sequence: D-H-A-C-G-B-E-F

ii. Completion time of jobs

Jobs	**D**	**H**	**A**	**C**	**G**	**B**	**E**	**F**
Time in	[0,0]	[1,5]	[2,10]	[5,17]	[10,24]	[14,34]	[20,44]	[28,56]
Time out	[1,5]	[2,10]	[5,17]	[10,24]	[14,34]	[20,44]	[28,56]	[41,71]

iii. Mean flow Time = $\frac{[1,5]+[2,10]+[5,17]+[10,24]+[14,34]+[20,44]+[28,56]+[41,71]}{8}$

$= \frac{[121,261]}{8}$ = [15.125, 32.625]

iv. Number of jobs waiting in process inventory are 8 during [0,0] - [1,5], 7 during [1,5] - [2,10], 6 during [2,10] - [5,17], 5 during [5,17] - [10,24], 4 during [10,24] - [14,34], 3 during [14,34] - [20,44], 2 during [20,44] - [28,56], 1 during [28,56] - [41,71].

Average in process inventory

$$= \frac{(8*[1,5])+(7*[-3,9])+(6*[-5,15])+(5*[-7,19])+(4*[-10,24])+(3*[-14,30])+(2*[-16,36])+(1*[-15,43])}{[1,5]+[-3,9]+[-5,15]+[-7,19]+[-10,24]+[-14,30]+[-16,36]+[-15,43]}$$

$$= \frac{[-207,589]}{[-69,181]}$$

= [-8.53, 3.25]

v. Lateness of various jobs are given by

Lateness of job D: [1, 5] - [24, 26] = [-25, -19]
Lateness of job H: [2, 10] - [49, 51] = [-49, -39]
Lateness of job A: [5, 17] - [14, 16] = [-11, 3]
Lateness of job C: [10, 24] - [13, 17] = [-7, 11]
Lateness of job G: [14, 34] - [44, 46] = [-32, -10]
Lateness of job B: [20, 44] - [8, 12] = [8, 36]
Lateness of job E: [28, 56] - [18, 22] = [6, 38]
Lateness of job F: [41, 71] - [38, 42] = [-1, 33]

Mean lateness = $\frac{[-111,53]}{8}$

= [-13.875, 6.625]

Maximum lateness = [8, 36] (job B) and [6, 38] (job E)

vi. Number of jobs actually late = 4.

II. WSPT Rule:

Jobs	Processing time (t_i)	Due date (d_i)	Importance weight (w_i)	$\frac{t_i}{w_i}$
A	[3,7]	[14,16]	[0.5,1.5]	[2,14]
B	[6,10]	[8,12]	[1,3]	[2,10]
C	[5,7]	[13,17]	[1,5]	[1,7]
D	[1,5]	[24,26]	[0.5,1.5]	$\left[\frac{1}{1.5}, 10\right]$
E	[8,12]	[18,22]	[1,3]	$\left[\frac{8}{3}, 12\right]$
F	[13,15]	[38,42]	[1,5]	$\left[\frac{13}{5}, 15\right]$
G	[4,10]	[44,46]	[1,3]	$\left[\frac{4}{3}, 10\right]$
H	[1,5]	[49,51]	[0.5,1.5]	$\left[\frac{1}{1.5}, 10\right]$

i. The Jobs are sequenced in increasing order of $\frac{t_i}{w_i}$.

Optimal sequence: C-D-H-G-B-E-A-F

ii. Completion time of the jobs

Job	C	D	H	G	B	E	A	F
Time in	[0,0]	[5,7]	[6, 12]	[7,17]	[11,27]	[17,37]	[25,49]	[28,56]
Time out	[5,7]	[6, 12]	[7,17]	[11,27]	[17,37]	[25,49]	[28,56]	[41,71]

iii. Mean flow time $= \frac{[140,276]}{8}$

$= [17.5, 34.5]$

Weighted Mean flow time

$$= \frac{([1,5]*[5,7])+([0.5,15]*[6,12])+([0.5,1.5]*[7,17])+([1,3]*[11,27])+([1,3]*[17,37]) +([1,3]*[25,49])+([0.5,1.5]*[28,56])+([1,5]*[41,71])}{[1,5]+[0.5,15]+[0.5,1.5]+[1,3]+[1,3]+[1,3]+[0.5,1.5]+[1,5]}$$

$$= \frac{[119.5,856.5]}{[6.5,23.5]}$$

$= [5.085, 131.76]$

iv. Number of jobs waiting in process inventory are 8 during [0,0] - [5,7], 7 during [5,7] - [6,12], 6 during [6,12] - [7,17], 5 during [7,17] - [11,27], 4 during [11,27] - [17,37], 3 during [17,37] - [25,49], 2 during [25,49] - [28,56], 1 during [28,56] - [41,71]

Average in inventory process

$$= \frac{(8*[5,7])+(7*[-1,7])+(6*[-5,11])+(5*[-6,20])+(4*[-10,26])+(3*[-12,32])+(2*[-21,31])+(1*[-15,43])}{[5,7]+[-1,7]+[5.11]+[-6,20]+[-10,26]+[-12,32]+[-21,31]+[-15,43]}$$

$$= \frac{[-160,576]}{[-65,177]}$$

= [-8.86, 3.25]

v. Lateness of various jobs are given by
Lateness of job C: [5, 7] - [13, 17] = [-12, -6]
Lateness of job D: [6, 12] - [24, 26] = [-20, -12]
Lateness of job H: [7, 17] - [49, 51] = [-44, -32]
Lateness of job G: [11, 27] - [44, 46] = [-35, -17]
Lateness of job B: [17, 37] - [8, 12] = [5, 29]
Lateness of job E: [25, 49] - [18, 22] = [3, 31]
Lateness of job A: [28, 56] - [14, 16] = [12, 42]
Lateness of job F: [41, 71] - [38, 42] = [-1, 33]

Mean lateness = $\frac{[-92,68]}{8}$ = [-11.5, 8.5]

Maximum lateness = [12, 42] (job A)

vi. Number of jobs actually late = 4

III. Slack Time Remaining Rule

Job	A	B	C	D	E	F	G	H
Processing time (t_i)	[3,7]	[6,10]	[5,7]	[1,5]	[8,12]	[13,15]	[4,10]	[1,5]
Due date (d_i)	[14,16]	[8,12]	[13,17]	[24,26]	[18,22]	[38,42]	[44,46]	[49,51]
Slack time (d_i-t_i)	[7,13]	[-2,6]	[6,12]	[19,25]	[6,14]	[23,29]	[34,42]	[44,50]

i. Use the ordering of intervals to obtain an optimal sequence. The optimal sequence is obtained by arranging the slack time in increasing order.
Optimal Sequence: B-C-A-E-D-F-G-H

ii. Completion time of these jobs

Job	B	C	A	E	D	F	G	H
Time in	[0,0]	[6,10]	[11,17]	[14,24]	[22,36]	[23,41]	[36,56]	[40,66]
Time out	[6,10]	[11,17]	[14,24]	[22,36]	[23,41]	[36,56]	[40,66]	[41,71]

iii. Mean Flow time = $\frac{[193,321]}{8}$ = [24.125, 40.125]

iv. Number of jobs waiting as in process inventory are 8 during [0,0]-[6,10], 7 during [6,10]-[11,17], 6 during [11,17]-[14,24], 5 during [14,24]-[22,36], 4 during [22,36]-[23,41], 3 during [23,41]-[36,56], 2 during [36,56]-[40,66], 1 during [40,66]-[41,71]

Average in process inventory

$$= \frac{(8*[6,10])+(7*[1,11])+(6*[-3,13])+(5*[-2,22])+(4*[-13,19])+(3*[-5,33])+(2*[-16,30])+(1*[-25,31])}{[6,10]+[1,11]+[-3,13]+[-2,22]+[-13,19]+[-5,33]+[-16,30]+[-25,31]}$$

$$= \frac{[-97,611]}{[-57,169]}$$

= [-10.72, 3.61]

v. Lateness of various jobs are given by
Lateness of job B: [6, 10] - [8, 12] = [-6, 2]
Lateness of job C: [11, 17] - [13, 17] = [-6, 4]
Lateness of job A: [14, 24] - [14, 16] = [-2, 10]
Lateness of job E: [22, 36] - [18, 22] = [0, 18]
Lateness of job D: [23, 41] - [24, 26] = [-3, 17]
Lateness of job F: [36, 56] - [38, 42] = [-6, 18]
Lateness of job G: [40, 66] - [44, 46] = [-6, 22]
Lateness of job H: [41, 71] - [49, 51] = [-10, 22]
Mean lateness = $\frac{[-39,113]}{8}$ = [-4.875, 14. 125]
Maximum lateness= [0, 18] (job E)

vi. Number of jobs actually late = 6.

IV. Earliest Due Date (EDD)

i. Use the ordering of intervals to obtain an optimal sequence. The optimal sequence is obtained by arranging the due dates of jobs in increasing order.
Optimal sequence: B-A-C-E-D-F-G-H

ii. Completion time of jobs

Job	**B**	**A**	**C**	**E**	**D**	**F**	**G**	**H**
In	[0,0]	[6,10]	[9,17]	[14,24]	[22,36]	[23,41]	[36,56]	[40,66]
Out	[6,10]	[9,17]	[14,24]	[22,36]	[23,41]	[36,56]	[40,66]	[41,71]

iii. Mean Flow time = $\frac{[191,321]}{8}$ = [23.875, 40.125]

iv. Number of jobs waiting as in process inventory are 8 during [0,0]-[6,10], 7 during [6,10]-[9,17], 6 during [9,17]-[14,24],5 during [14,24]-[22,36], 4 during [22,36]-[23,41],3 during [23,41]-[36,56],2 during [36,56]-[40,66], 1 during [40,66]-[41,71].

Average in process inventory

$$= \frac{(8*[6,10])+(7*[-1,11])+(6*[-3,15])+(5*[-2,22])+(4*[-13,19])+(3*[-5,33])+(2*[-16,30])+(1*[-25,31])}{[6,10]+[-1,11]+[-3,15]+[-2,22]+[-13,19]+[-5,33]+[-16,30]+[-25,31]}$$

$$= \frac{[-103,623]}{[-59,171]}$$

= [-10.56, 3.64]

v. Lateness of various jobs are given by
Lateness of job B: [6, 10] - [8, 12] = [-6, 2]
Lateness of job A: [9, 17] - [14, 16] = [-7, 3]
Lateness of job C: [14, 24] - [13, 17] = [-3, 11]
Lateness of job E: [22, 36] - [18, 22] = [0, 18]
Lateness of job D: [23, 41] - [24, 26] = [-3, 17]
Lateness of job F: [36, 56] - [38, 42] = [-6, 18]
Lateness of job G: [49, 66] - [44, 46] = [-6, 22]
Lateness of job H: [41, 71] - [49, 51] = [-10, 22]
Mean lateness = $\frac{[-41,113]}{8}$ = [-5.125, 14.125]
Maximum lateness = [0, 18] (job E)

vi. Number of jobs actually late = 6

V. Hodgson's Algorithm:

The Algorithm is applicable only if number of late jobs is more than 1.
Using EDD Rule, Number of late jobs could be found. As per EDD Rule, sequence of jobs will be B-A-C-E-D-F-G-H.

Job	Processing time (t_i)	Completion time(c_i)	Due date(d_i)	Lateness (c_i-d_i)
B	[6,10]	[6,10]	[8,12]	[-6,2]
A	[3,7]	[9,17]	[14,16]	[-7,3]
C	[5,7]	[14,24]	[13,17]	[-3,11]
E	[8,12]	[22,36]	[18,22]	[0,18]
D	[1,5]	[23,41]	[24,26]	[-3,17]
F	[13,15]	[36,56]	[38,42]	[-6,18]
G	[4,10]	[40,66]	[44,46]	[-6,22]
H	[1,5]	[41,71]	[49,51]	[-10,22]

Since job C is first late job and is in third position, examine first three jobs (B, A, C) to identify the one with longest processing time.
Here Job B has longest processing time of [6, 10]. Hence remove it and make the table again.

Job	Processing time (t_i)	Completion time(c_i)	Due date(d_i)	Lateness (c_i-d_i)
A	[3,7]	[3,7]	[14,16]	[-13,-7]
C	[5,7]	[8,14]	[13,17]	[-9,1]
E	[8,12]	[16,26]	[18,22]	[-6,8]
D	[1,5]	[17,31]	[24,26]	[-9,7]
F	[13,15]	[30,46]	[38,42]	[-12,8]
G	[4,10]	[34,56]	[44,46]	[-12,12]
H	[1,5]	[35,61]	[49,51]	[-16,12]

Now Job E is late. Since longest processing time up to E^{th} job (i.e.,) from Job A, C, E is job E. We will remove it.
Now, as per Hodgson's Algorithm

i. Optimal Sequence: A-C-D-F-G-H-B-E
ii. Completion time of these jobs.

Job	A	C	D	F	G	H	B	E
Time in	[0,0]	[3,7]	[8,14]	[9,19]	[22,34]	[26,44]	[27,49]	[33,59]
Time out	[3,7]	[8,14]	[9,19]	[22,34]	[26,44]	[27,49]	[33,59]	[41,71]

iii. Mean Flow time = $\frac{[169,297]}{8}$ = [21.125, 37.125]

iv. Number of jobs waiting as in process inventory are 8 during [0,0]-[3,7], 7 during [3,7]-[8,14], 6 during [8,14]-[9,19], 5 during [9,19]-[22,34],4 during [22,34]-[26,44], 3 during [26,44]-[27,49], 2 during [27,49]-[33,50], 1 during [33,59]-[41,71].

Average in process inventory

$$= \frac{(8*[3,7])+(7*[1,11])+(6*[5,1])+(5*[3,25])+(4*[-8,22])+(3*[-17,23])+(2*[-16,32])+(1*[-18,38])}{[3,7]+[1,11]+[5,1]+[3,25]+[-8,22]+[-17,23]+[-16,32]+[-18,38]}$$

$$= \frac{[-57,523]}{[-47,159]}$$

= [-11.13, 3.28]

v. Lateness of various jobs is given by
Lateness of job A: [3, 7] - [14, 16] = [-13,-7]
Lateness of job C: [8, 14] - [13, 17] = [-9, 1]
Lateness of job D: [9, 19] - [24, 26] = [-17, -5]
Lateness of job F: [22, 34] - [38, 42] = [-20, -4]
Lateness of job G: [26, 44] - [44, 46] = [-20, 0]
Lateness of job H: [27, 49] - [49, 51] = [-24, 0]
Lateness of job B: [33, 59] - [8, 12] = [21, 51]
Lateness of job E: [41, 71] - [18, 22] = [19, 53]
Mean lateness = $\frac{[-63,89]}{8}$ = [-7.875, 11.125]
Maximum lateness = [21, 51] (job B) and [19, 53] (job E)

vi. Number of actually late jobs = 2.

2. Consider an interval sequencing problem for 5 jobs on 2 Machines with the processing time as intervals are given in the following table.

Jobs	A	B	C	D	E
Machine M_1	[1,5]	[7,9]	[3,7]	[6,8]	[2,6]
Machine M_2	[2,6]	[9,11]	[5,7]	[3,7]	[7,9]

Solution:
To obtain an optimal sequence:

Min(M_1)	Min(M_2)	Min (M_1 , M_2)	Optimal Sequence				
[1,5]	[2,6]	[1,5]	A	-	-	-	-
[2,6]	[3,7]	[2,6]	A	E	-	-	-
[3,7]	[3,7]	[3,7]	A	E	C	-	D
[7,9]	[9,11]	[7,9]	A	E	C	B	D

Optimal Sequence: A-E-C-B-D
To obtain the minimum total elapsed time:

Job optimal sequence	Machine M_1		Machine M_2		Idle time (M_2)
	Time in	Time out	Time in	Time out	
A	[0,0]	[1,5]	[1,5]	[3,11]	[1,5]
E	[1,5]	[3,11]	[3,11]	[10,20]	[-8,8]
C	[3,11]	[6,18]	[10,20]	[15,27]	[-10,10]
B	[6,18]	[13,27]	[15,27]	[24,38]	[-12,12]
D	[13,27]	[19,35]	[24,38]	[27,45]	[-14,14]
Total					[-43,49]

Minimum Total Elapsed Time = [27, 45]
Idle time for Machine M_1 = [27, 45] – [19, 35] = [-8, 26]
Idle time for Machine M_2 = [-43, 49]
3. Consider an interval sequencing problem for 7 jobs on 3 Machines with the processing time as intervals are given in the following table.

Jobs	A	B	C	D	E	F	G
Machine 1	[1,5]	[7,9]	[6,8]	[2,6]	[8,10]	[7,9]	[6,8]
Machine 2	[2,6]	[1,5]	[1,3]	[3,7]	[0,2]	[2,6]	[1,5]
Machine 3	[4,8]	[6,8]	[3,7]	[10,12]	[3,7]	[4,8]	[11,13]

Solution:

Since the problem is a 3 machine problem. We convert it into a 2 machine problem. For that it has to satisfy any one of the following conditions:

i. Min (M_1) $\geq$ Max (M_2)

ii. Min (M_3) $\geq$ Max (M_2)

Here Min (M_1) = [1, 5]; Max (M_2) = [3, 7] = Min (M_3)

i. Min (M_1) $\not\geq$ Max (M_2)

ii. Min (M_3) = Max (M_2)

Therefore, the second condition is satisfied.
We convert this problem into 2 machine problem as H and K.
H = M_1 + M_2 and K = M_2 + M_3
The processing time of the 2 machines H and K for 7 jobs are as follows:

Machines	Jobs						
	A	B	C	D	E	F	G
H	[3,11]	[8,14]	[7,11]	[5,13]	[8,12]	[9,15]	[7,13]
K	[6,14]	[7,13]	[4,10]	[13,19]	[3,9]	[6,14]	[12,18]
Order of Cancellation	(2)	(6)	(3)	(4)	(1)	(7)	(5)

Optimal Sequence: A-D-G-F-B-C-E
To obtain Total Time Elapsed

Jobs	Machine M_1		Idle Time (M_1)	Machine M_2		Idle Time (M_2)	Machine M_3		Idle Time (M_3)
	Time in	Time out		Time in	Time out		Time in	Time out	
A	[0,0]	[1,5]	-	[1,5]	[3,11]	[1,5]	[3,11]	[7,19]	[3,11]
D	[1,5]	[3,11]	-	[3,11]	[6,18]	[-8,8]	[7,19]	[17,31]	[-12,12]
G	[3,11]	[9,19]	-	[9,19]	[10,24]	[-9.13]	[17,31]	[28,44]	[-14,14]
F	[9,19]	[16,28]	-	[16,28]	[18,34]	[-8,18]	[28,44]	[32,52]	[-16,16]
B	[16,28]	[23,37]	-	[23,37]	[24,32]	[-11,19]	[32,52]	[38,60]	[-20,20]
C	[23,37]	[29,45]	-	[29,45]	[30,48]	[-13,21]	[38,60]	[41,67]	[-22,22]
E	[29,45]	[37,55]	-	[37,55]	[37,57]	[-11,25]	[41,67]	[44,74]	[-26,26]
			[-11, 37]			[-13,37]			
Total			[-11, 37]			[-72,146]			[-107,121]

Minimum Total Elapsed Time = [44, 74]
Idle Time on Machine M_1 = [-11, 37]
Idle Time on Machine M_2 = [-72, 146]
Idle Time on Machine M_3 = [-107, 121]

4. Consider an interval sequencing problem for 4 jobs on 4 Machines with the processing time as intervals are given in the following table.

Jobs	Machines			
	M_1	M_2	M_3	M_4
A	[9,17]	[6,10]	[4,10]	[12,16]
B	[10,14]	[5,7]	[6,10]	[18,20]
C	[8,10]	[4,10]	[6,10]	[14,16]
D	[6,10]	[3,7]	[4,8]	[14,16]

Solution:
To find an Optimal Sequence, we convert the 4 Machine problem into a 2 Machine problem using Proposed Algorithm.

For this it has to satisfy any one of the following condition.

i) Min (M_1) ≥ Max (M_2 , M_3)
ii) Min (M_4) ≥ Max (M_2 , M_3)

Here Min (M_1) = [6, 10]; Min (M_4) = [12, 16];
Max (M_2) = [6, 10] = Max (M_3)
Max (M_2, M_3) = [6, 10]

Hence we have,

i) Min (M_1) = Max (M_2, M_3)
ii) Min (M_4) ≥ Max (M_2, M_3)

Here both the conditions are satisfied. We convert this problem into 2 machine problem as G and H.
G = M_1+ M_2+ M_3
H = M_2+ M_3+ M_4

Machines	Jobs			
	A	B	C	D
G	[19,37]	[21,31]	[18,30]	[13,25]
H	[22,36]	[29,37]	[24,36]	[21,31]
Order of Cancellation	(4)	(3)	(2)	(1)

Optimal Sequence: D-C-B-A
To Find Total time Elapsed:

Job	Machine M_1		Idle Time (M_1)	Machine M_2		Idle Time (M_2)	Machine M_3		Idle Time (M_3)	Machine M_4		Idle Time (M_4)
	Time in	Time out		Time In	Time out		Time in	Time out		Time in	Time out	
D	[0,0]	[6,10]	-	[6,10]	[9,17]	[6,10]	[9,17]	[13,25]	[9,17]	[13,25]	[27,41]	[13,25]
C	[6,10]	[14,20]	-	[14,20]	[18,30]	[-3,11]	[18,30]	[24,40]	[-7,17]	[27,41]	[41,57]	[-14,14]
B	[14,20]	[24,34]	-	[24,34]	[29,41]	[-6,16]	[29,41]	[35,51]	[-11,17]	[41,57]	[59,77]	[-16,16]
A	[24,34]	[33,51]	-	[33,51]	[39,61]	[-8,22]	[39,61]	[43,71]	[-12,26]	[59,77]	[71,93]	[-18,18]
						[-11,59]			[-21,77]			
			[20,60]			[10,54]			[0,50]			
Total			[20,60]			[-1,113]			[-21,127]			[-35,73]

Total Time Elapsed = [71, 93]
Idle time of Machine M_1 = [20, 60]
Idle time of Machine M_2 = [-1, 113]
Idle time of Machine M_3 = [-21, 127]
Idle time of Machine M_4 = [-35, 73]

Conclusion

In this paper, we discussed sequencing problem for 'n' jobs on single machine, 'n' jobs on two machines, 'n' jobs on three machines and 'n' jobs on 'm' machines. The processing time, due date, weights are considered as imprecise numbers and are described as intervals which are more realistic and general in nature. The numerical illustrations are more efficient to obtain an optimal sequence, completion time of jobs and total time elapsed time to process all jobs through machines. It helps to formulate uncertainty in actual environment and also serves as application for the decision makers in real life situation.

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RESEARCH ARTICLE

EVALUATION OF PHYTOCHEMICAL SCREENING AND ANTIBACTERIAL ACTIVITY OF *FICUS AURICULATA* LOUR. (MORACEAE) – AN TRADITIONAL MEDICINAL PLANT

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ABSTRACT

Ficus auriculata is a huge tropical, deciduous and evergreen tree is cultivated in India for its edible fruits and also this plant fruits have been used for the treatment of diabetes, asthma, male and female infertility by Malayali tribals in Yercaud hills. The main aim of this study was to screening of phytochemical properties of the fruit of this plant and also evaluated their potency. The investigation of phytochemical has been done by chemical tests and using some chemical reagents and it showed the presence of various classes of compounds such as carbohydrates, glycosides, phenolic compounds and Tannins, alkaloids, proteins and amino acids, flavonoids, saponins, terpenoids, phytosterols and fixed oils and fat and absence of Anthraquinones. This study summarizes the information concerning the bioactive constituents present in methanol fruit extract which may be responsible for various therapeutically effects. Phenol content of the fruit extract was 1.03mg/g dr.wt, flavonoids content of the fruit extract was 0.64mg/g dr. wt., and alkaloids content was 0.15 mg/g dr.wt. The antibacterial activity of the extracts was established by disc diffusion method and the extract showed a clear zone of inhibition against *Proteus vulgaris*, *Staphylococcus epidermidies, E. coli*, *Klebsiella pneumonia*, *Neisseria gonorrhoeae*, *Mycoplasma genetalium* and *Pseudonomos aeruginosa*. The methanolic fruit extract of the *F. auriculata* showed a wide range of activity against all the bacterial studied. The zone of inhibition increased with the increase in concentration. Highest activity was seen in *Mycoplasma genetalium* and *Staphylococcus epidermidies* in a concentration of 60 µg. the results provide justification for the use of *F. auriculata* in folk medicine to treat various infectious disease.

Keywords: *Ficus auriculata*, methanol fruit extract, bioactive constituents, antibacterial activity.

1. INTRODUCTION

Plants have been the most important source of medicines by human for the treatment of various diseases for more than 60 thousand years ago. As of record about 20,000 plant species are used for medicinal purposes across the globe and around 70 % of them are from Indian subcontinent [1]. In recent times, focus on medicinal plant research has increased all over the world and large body evidence has collected to shown enormous potential of medicinal plants used in various traditional systems. Medicinal potential of these plants lies in bioactive phytochemical constituents such as alkaloids, essential oils, flavonoids, tannins, terpenoids, saponins, phenolic compounds to act as an defense system against diseases or more accurately, to protect against diseases [2].

Ficus auriculata is a huge tropical, deciduous and evergreen tree is cultivated in India for its edible fruits. Various parts of this plant such as bark, root, leaves, fruit seed and latex are frequently used for the treatment of various illnesses, particularly this plant fruit have been used for the treatment of diabetes, asthma, male and female infertility by Malayali tribals in Yercaud hills [3]. *Ficus* species are rich source of polyphenolic compounds, flavonoids which are responsible for strong antioxidant properties that help in prevention and therapy of various oxidative stress related diseases such as neurodegeneration and hepatic diseases [4,5].

The present study is aimed at preliminary phytochemical screening of the methanolic fruit extract of *Ficus auriculata* and evaluation of the same for potential antibacterial activity. It efficacy as

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antibacterial activity will open new avenues to scrutinize rich natural resources for further analysis in order to develop the potential of herbal medicine. Such screening and scientific validation may provide the basics for developing novel antibacterial agents without possible side effect. These can be expected to be used on a large scale as their cost and availability will pose no problem and there will be no limitation factor as in case of synthetic drugs.

3. MATERIALS AND METHODS

2.1. Collection and authentication of plant material

The plant materials were collected from Yercaud hills of Salem district, Tamil Nadu. The plant specimens were verified with Botanical Survey of India (BSI), Coimbatore, Tamil Nadu, India (BSI/SRC/5/23/2016/Tech/832).

2.2. Preparation of plant powder

The fruits were washed thoroughly with tap water, shade dried, homogenized to fine powder and stored in air tight bottles for further studies.

2.3. Preparation of Extraction

The dried fruit powder of *F. auriculata* was subjected to methanolic extraction in the ratio of methanol : water as 80:20, adopting Soxhlet method. The extract was concentrated under few reduced pressure to yield semisolid mass which was dried in a desiccators and stored properly for further study.

2.4 .Preliminary phytochemical screening

2.4.1. Quality analysis

The quality analysis was carried out on the methanolic extracts of fruit of *Ficus auriculata* to determine the presences of various phytochemical constituents as per the standard protocol [6].

2.4.2. Quantitative estimation of chemical constituency

The total alkaloids content is estimated by the method of Anonymous [7]. The total phenolic content is tested by using Folin-Ciocalteau reagent by the method of Sidduraj and Becker [8]. The total flavonoids content is determined using the procedure described by Jia *et al*. [9].

2.5. Antibacterial Assay of methanolic fruit extract of Ficus auriculata Lour.

The antibacterial potential of methanolic fruit extract of *F. auriculata* Lour. was estimated by disc diffusion method. The disc diffusion is a simple and reliable test to find out the effect of a particular substance on a specific bacterium.

2.*5.1. Source of Microbial Strains*

The strains of common pathogenic microorganisms were used in this study such as *Proteus vulgaris*, *Staphylococcus epidermidies, E. coli*, *Klebesiella phemoniae*, *Neisseria gonorrhoeae*, *Mycoplasma genetalium* and *Pseudonomosa aeruginosa*. All the bacterial cultures were obtained from Microbial Type Culture Collection (MTCC), Institute of Microbial Technology, Chandigarh, India. The young bacterial broth cultures were prepared before the screening procedure.

2.5.2. Preparation of Muller Agar Media:

38g of Muller Hinton agar was dissolved in 1000ml of glass water. The pH was adjusted to 7 and autoclaved for 30 minutes in 15lb pressure.

2.5.3. Preparation of Culture Plates

20ml of sterile Muller Hinton agar medium was poured into petriplates under sterile condition and kept in laminar air flow chamber for solidification. After solidification the plates were dried for 30minutes in an oven to remove excess of moisture from the surface.

2.5.4. Preparation of Inoculums

Nutrient agar	- 1gm
Bacteriological peptone	- 0.5gm
Sodium chloride	- 0.25gm
Distilled water	-100ml

The above components were dissolved one by one in 100ml of glass distilled water and the pH was adjusted to 7. 10ml of medium was poured into test tube and the mouth of the tube was covered with sterile cotton. The test tubes were autoclaved for 30minutes in 15lb pressure. After autoclaving the test tubes were cooled in laminar air flow chamber and selected microorganisms were inoculated into the medium separately. The tubes were incubated overnight in 37ºC and used for inoculation.

2.5.5. Inoculation

The test microorganisms were inoculated in nutrient agar medium by spread plate method. About 10 µl (10^6 cells/ml) of nutrient broth of overnight bacterial cultural was spread evenly on the solidification medium. Sterile cotton swabs were dipped separately into inoculums of organisms and swabbed inside the wall of the tubes. The agar surface of the plates was streaked in three directions by turning the plates to 60º angle between each

streaking. The lid of the petriplates was on and kept at room temperature for 5-10 minutes to get confluent growth for accurate results.

2.5.6. Preparation and Application of Disc

Sterile discs (Hi Media) of 6mm were used to load the plant extract. Various concentration of extract such as 30, 40, 50, 60 mg were dissolved in Dimethyl Sulfoxide (DMSO) and loaded in the discs. The standard antibiotic generation was used as a control due to its broad spectrum of activity against various organisms.

The impregnated discs were incubated at 37ºC for an hour. The dried discs were placed over the surface of swabbed medium with equal distance to avoid the overlapping of the zones of inhibition. The discs were gently pressed on the surface of the medium and they were placed at least 25mm away from the edge.

2.5.7. Incubation

The plates were incubated at 37ºC for 16-18 hours in an incubator.

2.5.8. Measurement of Zone Inhibition:

The diameter of the zone of inhibition was measured in mm at the end of incubation period of 18 hours and recorded. Each experiment was done in triplicate.

2.5.9. Determination of Activity Index (AI):

The activity index of the crude plant extract was calculated by comparing the mean value of the extracts with the mean value of zone of inhibition of standard antibiotic, using the following formula,

$$\text{Activity index (AI)} = \frac{\text{Zone of inhibition of extract}}{\text{Zone of inhibition of Standard antibiotic drug}}$$

3. RESULTS AND DISCUSSION

3.1. Preliminary phytochemical screening of Methanolic fruit extract of Ficus auriculata Lour.

The preliminary phytochemical screening revealed the presence of carbohydrates, glycosides, phenolic compounds and Tannins, alkaloids, proteins and amino acids, flavanoids, saponins, terpenoids, phytosterols and fixed oils and fat. The detailed results of the analysis are given in Table 1. Ritu Mishra and Ashok Kumar Tiwari [10] reported that the preliminary phytochemical screening of extracts of *Ficus racemosa* Linn observed the presence of Carbohydrate, tannin, protein, resin and saponin whereas Shivani *et al.,* [11] reported that alkaloids, tannin, flavonoids, carbohydrates, terpenoids are present in leaves; flavonoids, carbohydrates, terpenoids in root and alkaloids, tannin, flavonoids are present in bark of *Ficus retusa* Linn. However alkaloids, glycosides, flavonoids, saponins, carbohydrates, phenolic compounds and tannin and steroids are found to be present in *Morus alba* as identified by Shikha Srivastava *et al.* [12]. While, Jasreet [13] investigated that alkaloids, carbohydrate, tannins, flavonoids, saponin, glycosides, steroids and triterpenoids are present in preliminary phytochemical investigation of *Ficus pumila* leaves. As in other plant of Moraceae *F. auriculata* contains alkaloids, flavonoids and phenolic compounds that may enhance the medicinal property as reported in other plants observe by Ajayi *et al*. [14]. Carbohydrates, alkaloids, saponins, resins, phenols, protein and aminoacids present in hexane, chloroform and methanol bark extract of *F. auriculata* [15] and a similar finding was also observed in our present study. The medicinal value of the plant depends on the phytochemicals such as alkaloids, flavonoids, phenolic and other nutrients like amino acids and protein [16]. Based on the earlier reports and the present study, we propose that the active principle in *F. auriculata*is because of having these phytoconstituents.

3.2. Quantitative phytochemical analysis

The phytochemicals present in the plant plays an important role in biological studies. The quantities analyzed by phytochemical analysis in *Ficus auriculata* Lour was given in table 2. Phenol content of the fruit extract was 1.03mg/g dr.wt, flavonoids content of the fruit extract was 0.64mg/g dr.wt, and alkaloids content was 0.15 mg/g dr.wt. The estimation of phytochemicals revealed that the quantities of secondary metabolites like phenol (1.03 mg/g dr. wt), flavonoids (0.64 mg/g dr.wt) and glycosides (0.61 mg/g dr.wt) were higher proportion. These results expose that the plant has quite a number of chemical constituents, which may be responsible for many pharmacological actions.

3.3. Antibacterial Assay of methanolic fruit extract of Ficus auriculata Lour.

The antibacterial activity of the extracts was established by disc diffusion method. The methanolic fruit extract of *Ficus auriculata* were active against seven different bacteria. Four concentrations of the extract were used (30, 40, 50 and 60 µl). The methanolic fruit extract showed a

Table 1. Qualitative phytochemical analysis of methanol extracts of *F. auriculata* Lour.

S. No	Constituents	Test	Colour	Reaction
1	Carbohydrates	Molisch's test	Violet	++
		Felhing's test	Brick red	+++
		Benedict's test	Red	+++
		Selivanoff's test	Cherry red	+++
2	Glycosides	Legal's test	Blood red	+++
		Keller-Killiani test	Blue	+++
		Conc. H_2SO_4	Red	-
		Borntrayer's test	Pink	++
3	Phenolic compound and Tannins	Ferric chloride test	Violet precipitate	+++
		Lead acetate test	White precipitate	+++
		Elagic acid test	Niger brown	++
4	Alkaloids	Mayer's test	White precipitate	-
		Dragendroff's test	Reddish brown precipitate	+++
		Wanger's test	Reddish brown precipitate	+
		Hager's test	Yellow precipitate	+
5	Proteins and free amino acids	Million's test	White	+++
		Biuret test	Violet	+++
		Nihydren reagent test	Violet	+++
		Xanthoproteic test	Orange	++
6	Flavanoids	Ferric chloride test	Blackish red	+++
		Conc. H_2SO_4	Yellow	+
		Alkaline reagent test	Yellow	+++
		Fluorescence test	Fluorescence green	+++
7	Saponins	Foam test	Foam	+
8	Terpenoids and Steroids	-	Green bluish	+++
9	Phlotannins	-	Red precipitate	+++
10	Phytosterols	Salkowasi test	Red brown	++
11	Fixed oils and fats	Filter paper test		-
		Saponification test	Formation of soap	+++
12	Anthraquinones	-	Pink to rose	-

Table 2. Quantities analysis of fruit powder of *F. auriculata* Lour.

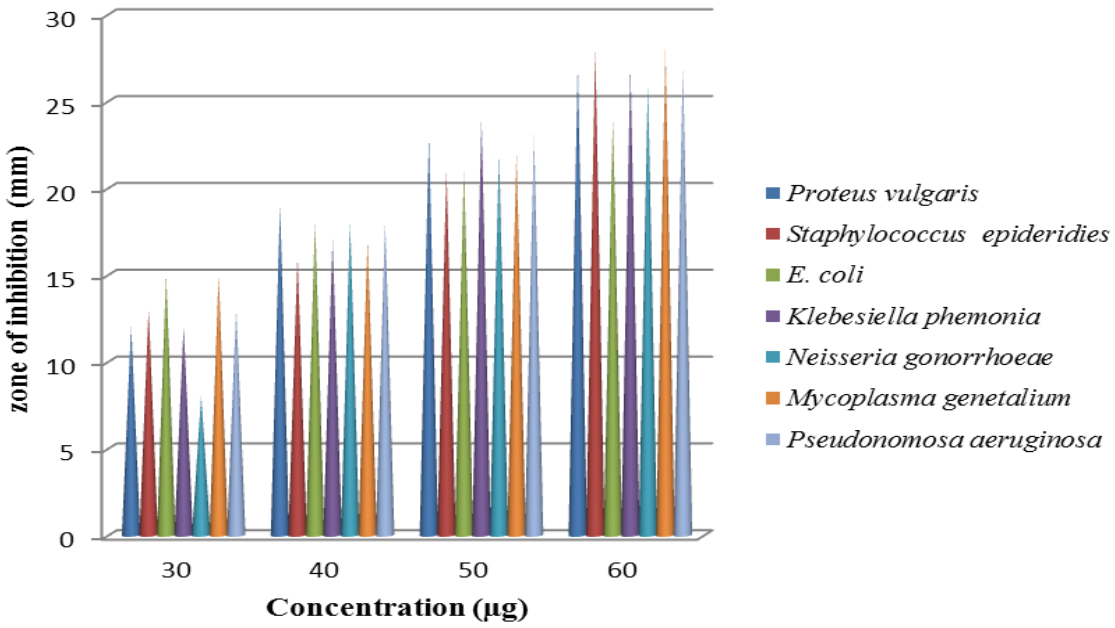
S. No	Name of the phytochemical content	Quantity mg/g (Dry weight)
1	Phenol	1.03
2	Flavonoids	0.64
3	Alkaloids	0.15

Table 3. Antibacterial activity of methanol fruit extract of *Ficus auriculata* Lour.

S. No	Organism Name	Control (Amoxicillin)	Concentration(µg)			
			30	40	50	60
			Zone of Inhibition (mm)			
1.	*Proteus vulgaris* (MTCC No: 1771)	17	12	19	23	27
2.	*Staphylococcus epidermidies* (MTCC No: 435)	16	13	16	21	28
3.	*E.coli* (MTCC No: 443)	17	15	18	21	24
4.	*Klebesiella phemonia* (MTCC No: 109)	21	12	17	24	27
5.	*Neisseria gonorrhoeae* (MTCC No: 19424)	17	08	18	22	26
6.	*Mycoplasma genetalium* (MTCC No: 2288)	16	15	17	22	28
7.	*Pseudonomosa aeruginosa* (MTCC.No: 2488)	14	13	18	23	27

Figure 1. *Ficus auriculata* Lour - Fruit

Figure: 2 Antibacterial activity of methanol fruit extract of *Ficus auriculata* Roxb.



clear zone of inhibition against *P. vulgaris*, *S. epidermidies, E. coli*, *K. phemonia*, *N. gonorrhoeae*, *M. genetalium* and *P. aeruginosa*. The methanolic fruit extract of the *F. auriculata* showed a wide range of activity against all the bacteria studied. Methanolic fruit extract showed significant antibacterial activity as compared to standard antibiotics (amoxicillin). The zone of inhibition increased with the increase in concentration as stated in table 3; figure 2). Among the various microorganisms, the methanolic fruit extract of *F. auriculata* was more active against *Mycoplasma genetalium* (28 mm) and *Staphylococcus epidermidies* (28 mm) in concentration 60 µg and lowest effect in *E. coli* (24 mm) in concentration 60µg.

There is an influence of certain microbial infection on male infertility. Several investigators have reported difference types of microorganisms in seminal fluid, Oligospermia and azoospermia are most common causes of male infertility which has been reported due to bacterial infections [17]. Based on this information, the above microorganisms were selected for this study and also Ali Hussein Al-Marzoqi e*t al*. [18] identified *P. vulgaris*, *S. epidermidies, E. coli*, *K. pneumonia*, *N. gonorrhoeae*, *M. genetalium* and *P. aeruginosa* in seminal fluid and associated with male infertility. Antibacterial assay revealed, the methanolic fruit extract of *F. auriculata* having capacity to control these bacterial infections. The antibacterial property was claimed to be conferred by phytochemicals present in the plant. Tannins and flavonoids have been reported to inhibit the growth of many fungi, yeast, bacteria and viruses [19], alkaloids widely well known to have anti diabetic and antimicrobial activity [20], terpenoids, steroids and saponins may also responsible for the antibacterial activity [21]. Methanol fruit extract of *F. auriculata* showed the presence of these compounds in preliminary phytochemical screening.

4. CONCLUSION

The present study concludes with the pharmacological standards of the *F. auriculata* Lour which helps in the identification and quality assessment of these plants. The pharmacological study established the antibacterial efficacy of the

extracts. The phytochemical studies on the *F. auriculata* revealed the presence of some phenol, flavonoids and other terpenoids in these extracts may be responsible for the pharmacological activity of the extract. The findings of phytochemical and pharmacological studies support the traditional knowledge of Malayali traditional healers and also support folkloric usage of the *F. auriculata* Roxb plant. These findings will take the drug research to the next level in upcoming years.

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RESEARCH ARTICLE

PREDICTIVE MODEL CONSTRUCTION FOR PREDICTION OF SOIL FERTILITY USING DECISION TREE MACHINE LEARNING ALGORITHM

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ABSTRACT

Agriculture sector is recognized as the backbone of the Indian economy that plays a crucial role in the growth of the nation's economy. It imparts on weather and other environmental aspects. Some of the factors on which agriculture is reliant are Soil, climate, flooding, fertilizers, temperature, precipitation, crops, insecticides, and herb. The soil fertility is dependent on these factors and hence difficult to predict. However, the Agriculture sector in India is facing the severe problem of increasing crop productivity. Farmers lack the essential knowledge of nutrient content of the soil, selection of crop best suited for the soil and they also lack efficient methods for predicting crop well in advance so that appropriate methods have been used to improve crop productivity. This paper presents different Supervised Machine Learning Algorithms such as Decision tree, K-Nearest Neighbor (KNN), Support Vector Machine (SVM) to predict the fertility of soil based on macro-nutrients and micro-nutrients status found in the dataset. Supervised Machine Learning algorithms are applied on the training dataset and are tested with the test dataset, and the implementation of these algorithms is done using R Tool. The performance analysis of these algorithms is done using different evaluation metrics like mean absolute error, cross-validation, and accuracy. Result analysis shows that the Decision tree is produced the best accuracy of 99% with a very less mean square error (MSE) rate.

Keywords: Agriculture, Machine learning, soil fertility, K-Nearest Neighbour, Support Vector Machine, Decision tree.

1. INTRODUCTION

Data mining could be a fairly immature and interdisciplinary sector of computer science, is that the process that attempts to mining patterns in large data sets. It utilizes methods at the connection of statistics, artificial intelligence, machine learning, and database systems. The data mining task aims to extract information from a knowledge set and transform it into a comprehensible form for further use. Predictive analysis is that the task of gathering information from soil datasets to seek out future outcomes. Machine learning facilitates methods and techniques for accurate diagnosis and analytical facilities within the agricultural domains. Agriculture is one of the crucial industrial sectors in India and also the country's economy relies heavily on that for the sustainability of its rural areas. Because of some factors [1] like climate change, unplanned rainfall, falling water levels, excessive use of pesticides, etc., the extent of agricultural production in India is dilapidated. Most farmers don't achieve expected crop yields for a spread of reasons. To acknowledge production levels, soil fertility is carried out which involves predicting the yield of the crop based on the existing data. Previously, crop yield estimates were supported farmer's specific crops and cultivation experience.

Data mining techniques are useful for predicting the fertility of the soil. Data processing software [2] is an analytical tool that permits users to categorize and assessing identified relationships still as analyzes data at various dimensions. A soil test is an analysis of a soil sample to determine nutrient content, composition, and other characteristics. Tests are usually performed to measure fertility and indicate deficiencies that require being resolved. Soil fertility depends on various factors [3] and depends on:

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- Geographical area
- Soil type (saline, alkaline, non-alkaline)
- Weather (Humidity, Temperatures, precipitation)
- Soil composition (pH, N, P, K, EC, OC, Zn, F)

Prediction models are essentially two main categories. 1. Statistical models, which utilize one forecast function that has all samples. 2. Machine learning, emerging technology to explore knowledge that connects input and output variable models. Machine learning has the potential to learn the machine without defined computer programming, so it enhances machine performance by detecting and characterizing the pattern of constraining data. Machine learning can be classified into three types according to the learning methods are supervised learning, unsupervised learning, and reinforcement learning. This kind of algorithm is used to build the most accurate and effective model. It involves the construction of a machine learning predictive model that's supported on labeled samples. The SVM, KNN, and Decision trees are used for soil fertility prediction.

This paper is organized as follows: Section II presents the related work, whereas the proposed method is discussed in Section III. Then, the experimental result analysis of agricultural data is described in Section IV. Finally, the conclusion is given in Section V.

2. RELATED WORK

Machine learning in Agriculture may Novel research field; an excellent deal of labor has been a tired field of Agriculture utilizing Machine learning. Agricultural scientists in Pakistan have demonstrated that endeavors of harvest yield amplification through expert pesticide state strategies have prompted a hazardously high pesticide use. These examinations have revealed a negative relationship between's pesticide use and harvest yield [4]. In their investigation, they have explained that how data mining incorporated farming information including irritation exploring, pesticide utilization and meteorological information help streamline of pesticide use. Topical data identified with agribusiness which has spatial properties was accounted for in one in every of the study [5]. Their research went for perceiving patterns in farming creation with references to the accessibility of information assets. K-means method was applied to hold out gauges of the contamination within the air [6], the k- nearest neighbor become connected for mimicking day by day precipitations and other climate elements [7], and numerous ability changes of the weather situations are dissected utilizing SVM [8]. Statistics mining techniques are often wont to have a glance at soil qualities. For example, the k-means method is employed for segmenting soils in a mixture with GPS-based technology [9]. A decision tree classifier for agriculture information changed into proposed [10]. This new classifier uses new facts expression and may address each entire records and in entire records. Inside the test, a 10-fold cross-validation technique is employed to test the dataset, horse-colic dataset, and soybean dataset. Their results showed the proposed selection tree is capable of classifying all varieties of agriculture records. A yield prediction version became proposed in one in the entire take a glance at [11] which makes use of mining techniques for category and prediction. This model worked on entering parameters crop name, land location, soil type, soil ph, pest information, climate, water stage, seed type, and this model anticipated the plant boom and plant diseases and so enabled to pick the good crop supported climate information and required parameters.

3. PROPOSED METHODOLOGY

In the proposed system, we use supervised learning to create a model, which provides predicted fertility of soil as Ideal or Not Ideal. The proposed system is described in the following stages like Problem study, data collection, dataset description, preprocessing step, parameter study, and applying machine learning techniques as shown in figure 1.

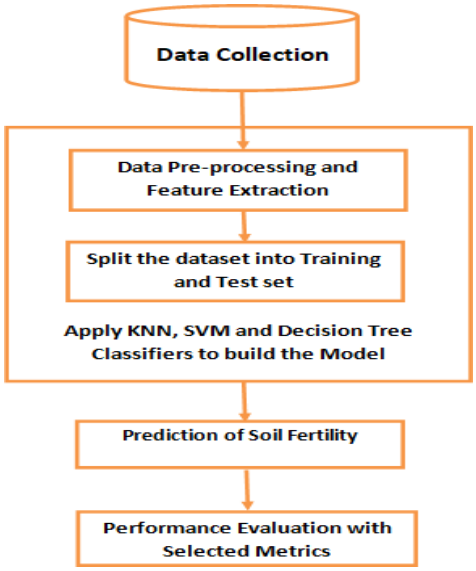

Figure 1. Flow diagram of Proposed Methodology

Problem study

A brief study of problems associated with maximization of the productivity and prediction of soil fertility has been done by hunting the related literature review, the brief discussions with soil analysts and broader view of research problem have been gained.

Data collection

After gaining insight into the research problem the related data has been collected from Soil Testing Laboratory, Melalathur, Vellore District. The dataset consists of 1000 samples. Further data has been divided for training and testing purposes. 700 samples are used for training and 300 data samples are used for testing purposes, Data has been preprocessed and has been transformed into two excel sheets one for training and one for testing purposes.

Preprocessing steps

This step could be very significant in machine learning. Preprocessing consists of inserting the missing values, the suitable data range, and extracting the functionality. Soil attributes like Sample no, Ph, EC, OC, N, P, K, S, Cu, Fe, Zn, Mn are taken as feature variables, and therefore the NULL values additionally as redundant values from the dataset are removed. The type of dataset is critical to the analysis process. During this work, we've used the anyNA method for the treatment of missing values.

Attributes description

The collected dataset consists of soil composition parameters and is one in all subsets for the prediction of yield. The dataset consists of 12 parameters out of Sample no, Ph, EC, OC, N, P, K, S, Cu, Fe, Zn, Mn, out of which 7 (Ph, EC, OC, N, P, K, S) are classified as Macro-Nutrients and remaining 4 parameters (Cu, Fe, Zn, Mn) are Micro-Nutrients and soil were classified into two class labels: Ideal and Not Ideal has been further used for the making decision. Table 1 shows an attribute description.

Table 1. Attributes & its description

Attributes	Description
Sample No	Sample Identification Number
pH	pH value of soil
EC	Electrical conductivity
OC	Organic Carbon
N	Nitrogen
P	Phosphorous
K	Potassium
S	Sulphur
Cu	Copper
Fe	Iron
Zn	Zinc
Mn	Manganese
FI	Class label (Ideal, NotIdeal)

Split the Dataset into Train and Test Set

The dataset is partitioned into training and testing set of input data. The loaded data is split into two sets like training data and test data, with a division ratio of 70% or 30%, such as 0.7 or 0.3. In an exceedingly learning set, a classifier is employed to make the available input data. During this step, create the classifier's support data and preconceptions to approximate and classify the function. During the test phase, test data were set used to test the trained model.

Applying Machine Learning Techniques

We have used three different supervised machine learning algorithms for soil fertility prediction which is given as follows

KNN Algorithm

KNN could be a nonparametric supervised learning technique that uses training sets to segment data points into given categories. In simple classifications, the word collects information from all educational cases and similarities supported the new case. Observe the training for the foremost similar (neighbor) K cases and predict the new instance (x) by summarizing the output variables for these K cases. Classification is the class value mode. A flow diagram of the KNN algorithm is shown in Figure 2.

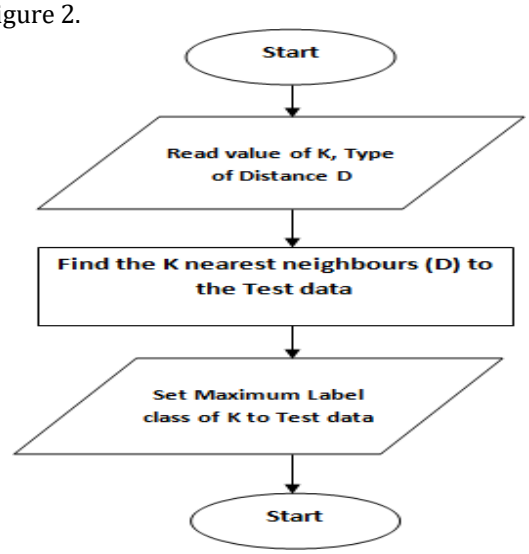

Figure 2. Flow chart for KNN algorithm

Support Vector Machines

Support vector machines (SVM) which is the most powerful and flexible supervised machine learning algorithms used both for classification and regression problems. SVM can extremely popular due to its capability to handle categorical and multiple continuous variables. SVM divides the given data into the decision surface. The decision surface further divides the information into the hyperplane of two classes. Training points define the supporting vector which defines the hyperplane. The hyperplane is generated iteratively by SVM so that the error can be minimized. Probably, a hyperplane with the maximum distance to the closest learning data point typically has better margins and bigger errors due to the larger margins, the generalization of classifiers is weak. The flow chart for SVM is given in figure 3, it shows the steps involved in the SVM algorithm.

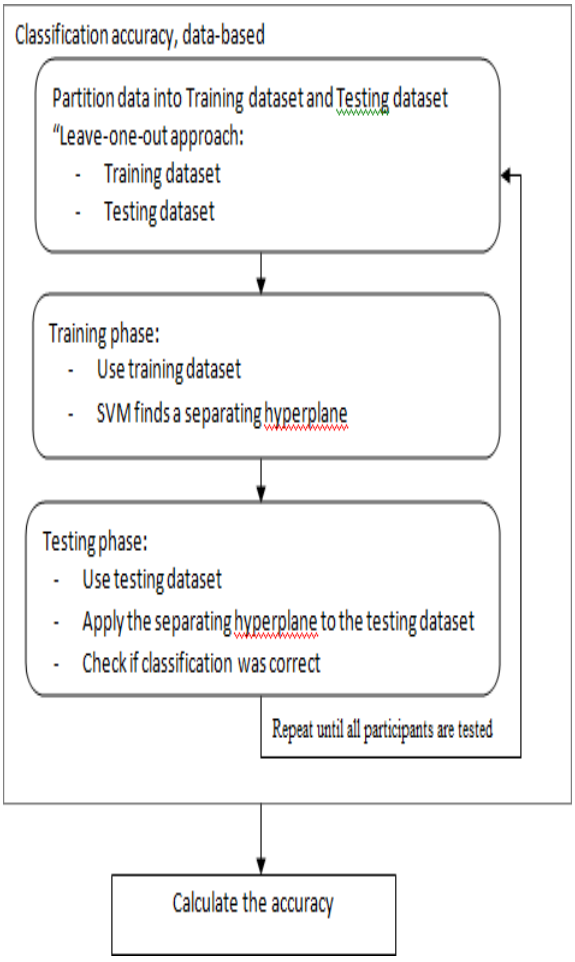

Figure 3. Flow chart for SVM algorithm

Decision tree

A decision tree can be a predictive model which works by checking condition at every level of the tree and proceeds towards the bottom of the tree where various decisions are listed. The condition depends on the appliance and also the outcome may well be in terms of the decision. There are various kinds of Decision tree algorithms like C4.5, CART, and ID3 algorithm. In this work, we used the C5.0 algorithm for model building. Information Gain is the most important measure used to create a decision tree because it was worn to choose the variable that best splits the data at each node of a Decision Tree. The variable with the highest IG is used to split the data at the root node. A C5.0 model works by dividing the sample based on the area that provides the highest information gain. Each subsample defined by the first split is then split again, usually based on a different field, and the task repeats until the subsamples can't be split further. Finally, the lowest-level splits are again reviewed, and those that do not contribute drastically to the value of the model are pruned. The C5.0 node can predict only a categorical target.

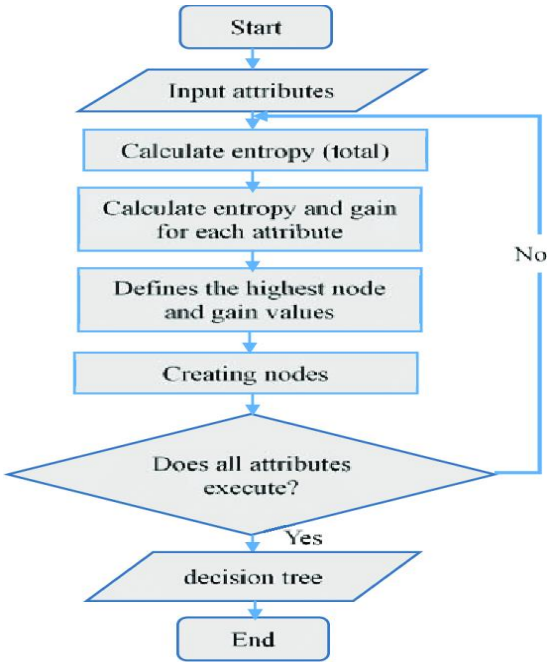

Figure 4. Flowchart of Decision tree

4. RESULTS ANALYSIS AND DISCUSSION

This section shows the result obtained after the implementation of the Machine learning algorithms on the collected dataset. Three Machine learning algorithms KNN, SVM, and Decision Tree have been applied to a trained dataset. The R Tool

version 3.5.3 has been used in this work. The Training data consists of 12 attributes based on the availability of Macro and Micro Nutrients present in the soil. In R Tool the training data with 1000 samples have been used to train the model separately by KNN, SVM, and Decision Tree classifiers. An efficiently trained model has been applied to the testing data set which is different from the training data set. The different evaluation parameters for these algorithms were mean squared error, accuracy, and cross-validation which are used to estimate the efficiency of the method as shown in table II.

Table 2. Comparison table for different parameters

Algorithms	Accuracy	MSE
Decisiontree	99	0.01
KNN	74	0.6897
SVM_linear	78.9	0.6552
SVM_rbf	73	0.559

Machine learning algorithms have been applied individually using the Cross-Validation techniques with 10 folds and the accuracy of prediction has been observed for each of them. In this paper the accuracy for SVM was calculated for two different kernels i.e, SVM _rbf, and SVM_linear among these two RBF kernels was showing more error rate. Among the three algorithms, Decision Tree proves to be a better classifier as compared to SVM and KNN which produced more accuracy with very little MSE. As shown in the graph the accuracy of the decision tree algorithm is more and also it is showing less error rate.

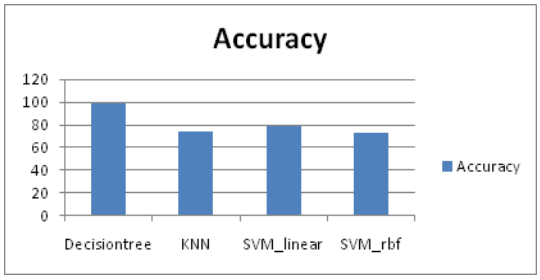

Figure 5. Comparison graph for Result Analysis based on Accuracy

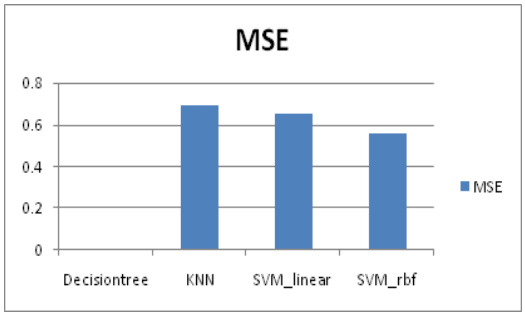

Figure 6. Comparison graph for Result Analysis based on MSE

5. CONCLUSION

Different machine learning algorithms have been implemented on agricultural data to evaluate the best performing method. In this work, we used three different supervised learning algorithms, such as SVM, KNN, and Decision tree. The data set consists of a variety of parameters that are useful for identifying the status of fertility and conducting supervisory training on data sets collected from the agriculture domain to divide information into multiple classes. This paper shows the performance evaluation of three different algorithms like Decision tree, KNN, and SVM. These algorithms were used to train the 0.7 or 70 percent of the input data and are tested with the remaining 0.3 or 30 percent of the test dataset and results of the algorithms were compared based on accuracy and mean square error. Here, the decision tree algorithm is produced the best accuracy of 99%, and also the mean square error for this algorithm is also very less. This article will provide the solution to equip the farmers with the required information that necessary to gain great yield and therefore improving their surplus and consequently will reduce difficulties. In the future, our goal is to analyze an extended soil dataset using artificial Neural Networks in machine learning under different climate conditions for obtaining better prediction with high accuracy.

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RESEARCH ARTICLE

DOWNTREND OF BANKING SECTORS USING TECHNICAL ANALYSIS

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ABSTRACT

The Banking industry plays a very significant role in the economy and the development of a country. It is important to our nation's economy as it caters to the need of credit for all the section of the nation. In this paper, we are focusing on the stocks of Yes Bank Limited, Axis Bank Limited and ICICI Bank Limited and analyze them technically. Using technical analysis, we could predict the future price movements of stocks by examining the present and the past price movements of stocks. It has many tools and indicators like SMA, EMA, RSI, MACD and P&L which are used for forecasting the future stock price and also identify the pattern, trend and it directs when to buy and sell stocks.

Keywords: Stock Analysis, stock price, bullish, bearish, SMA, EMA, RSI, MACD and P&L.

1. INTRODUCTION

Technical Analysis was developed by Charles Dow in 19th century to know the value of a stock by studying patterns and signals over a period of time. Technical Analysis is a means of examining and predicting price movements in the financial markets by using historical price charts. From technical analysis, we could analyse the statistical trends based on trading activities. Technical Analysis is used for short term trades. It uses some analytical chart tools to evaluate a stock's potential. Technical Analysts observe at price movements to forecast and predict stock prices.
Murphy in 1999 described three premises in Technical Analysis such as,

i. Market action discounts everything.
ii. Prices move in trends.
iii. History repeats itself.

Data in technical analysis context is information regarding the price variables namely open, high, low, close, volume etc.

2. PRELIMINARIES

Open [8]: When the markets open for trading, the first price at which a trade executes is called the opening price.

High [8]: High represents the highest price at which the market participants were willing to transact on the given day.

Low [8]: Low represents the lowest price at which the market participants were willing to transact on the given day.

Close [8]: Close is the most important price because it is the final price at which the market closed for a particular period of time.
If the close is higher than the open, then the trade day is considered as positive otherwise it is considered as negative.

Volume [8]: A stock's volume refers to the number of shares that are sold, or traded over a certain period of time. Volume gives an investor, an idea of the price action of a security. The more active the share, higher would be its volume.

Simple Moving Average: [8]

A simple moving average is formed by computing the average price of a security over a specific number of periods. Most moving averages are based on the closing prices. A 10-day simple moving average is the three day sum of closing prices divided by ten. It indicates signals to sell or buy and it make easier to view the price trend of a security.

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$SMA = \frac{\sum n}{n}$ where Σn - 10 period sum; n - Number of days.

Exponential Moving Average: [8]

An Exponential Moving Average is similar to SMA. EMA evaluate the trend direction over a period of time. EMA is the best indicator for investors who deal with intraday and fast moving markets. EMA can be calculated for 12 days, 26 days and so on.

EMA=[C-YEMA]*W.M+YEMA, where
C-Closing Price; YEMA- Yesterday's EMA; W.M - Weight Multiplier = 2 (n+1)

Moving Average Convergence and Divergence (MACD): [8]

The MACD was developed by Gerald Appel in 17th century. The MACD is an indicator in Technical analysis used to identify a new trend such as a bullish (or) bearish flux. MACD is about convergence and divergence of the two moving averages (12D EMA and 26D EMA). Convergence occurs when the moving averages move towards each other. Divergence occurs when the moving averages move away from each other. It oscillates above and below the zero line.

- Positive MACD indicates that the 12day EMA is above the 26day EMA. Here shorter EMA diverges from the longer EMA. This means upside momentum is increasing.
- Negative MACD indicates that the 12D EMA is below the 26D EMA. Here shorter EMA diverges below the longer EMA. This means downside momentum is increasing.

MACD = (12D EMA – 26D EMA)

Relative Strength Index (RSI): [8]

RSI was developed by J. Welles Wilder. RSI is momentum oscillator that measures the speed and change of price movements. It oscillates between 0 and 100.

$$RSI = 100 - \frac{100}{(1+100)}$$

$$\text{Relative Strength (RS)} = \frac{\text{Average gain}}{\text{Average loss}}$$

RSI is used to identify oversold and overbought price areas. Overbought implies that the positive momentum in the stock is so high that it may not be sustainable for long period. Oversold price area indicates that the negative momentum is high leading to a possible reversal. If RSI is above 50 then it is considered as bullish behaviour and if its value is below 50 then it is considered as bearish in nature.

Resistance: [8]

Resistance is a price level at which one can expect more sellers than buyers. It is something which stops the price from rising further. The resistance level is a price point on the chart where the traders can expect maximum supply (in terms of selling) for stock. Resistance level is always above the current market price. The resistance act as a trigger to sell.

Support: [2]

Support is the price level at which demand is thought to be strong enough to prevent the price from declining further. The price decline towards support and gets cheaper which let the buyers to become more inclined towards buy action and sellers to become less inclined towards sell action.

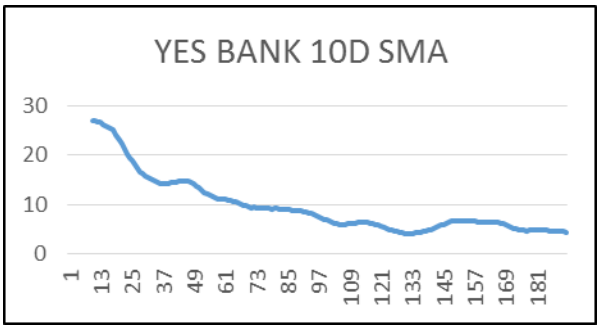
Graphical Representation using Technical Analysis:

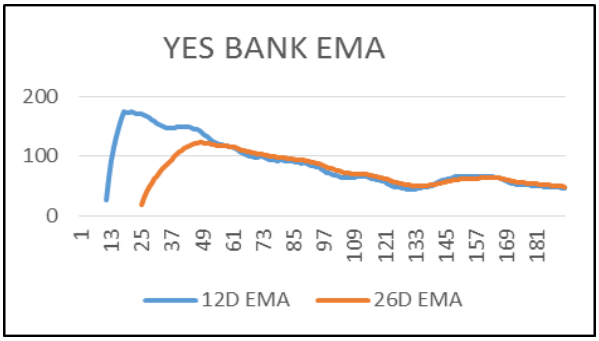
We have collected the historical price of Yes Bank Limited, Axis Bank Limited and ICICI Bank Limited for the FY19-20 till December and analysed technically. Some of the indicators like SMA, EMA, MACD, RSI and P&L used to forecast the future price movements of stocks.

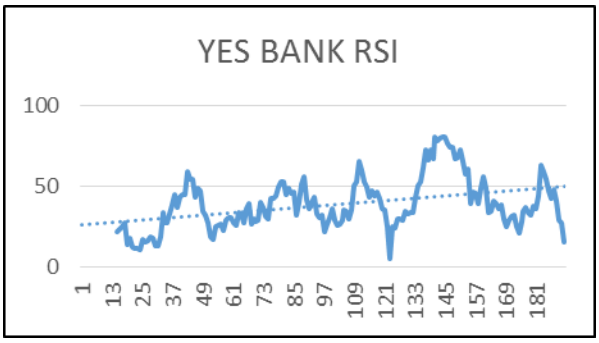
The following graphs are plotted using open, high, low, close values of stocks.

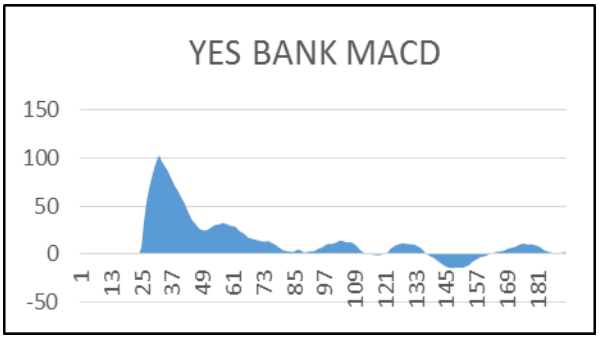
- SMA indicator is used to indicate buy and sell signals to traders and investors (i.e.,) Bullish and Bearish price actions. It is calculated using close price of a stock.
- EMA measures a trend direction over a period of time. When 12D EMA is above the 26D EMA, it shows the bullish trend and vice-versa is the bearish trend.
- MACD is calculated by using EMA.
- RSI indicates whether a market is considered to be overbought (or) oversold in relation to recent price trends. The values are bounded from 0 to 100.
- P&L ratio shows the profit and loss of a close price have made from an intraday

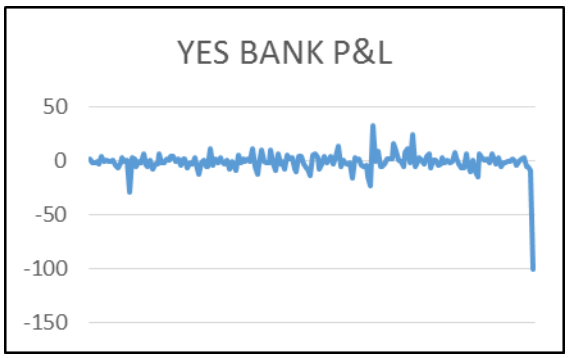
YES BANK LIMITED







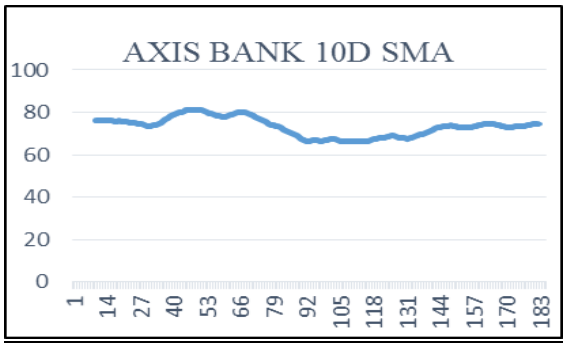


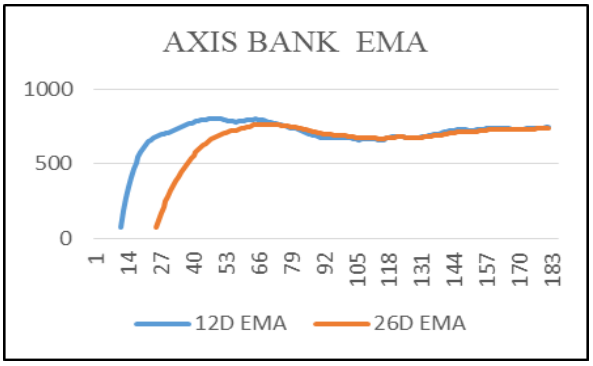


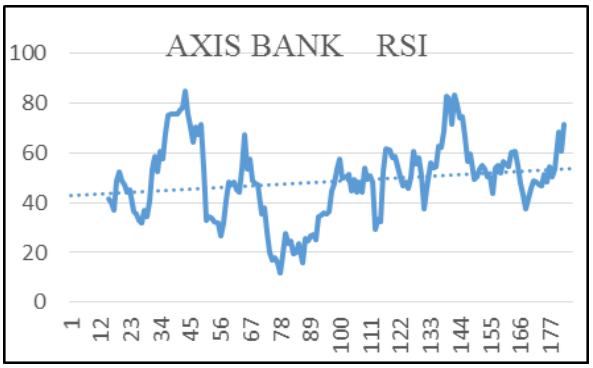
Interpretation

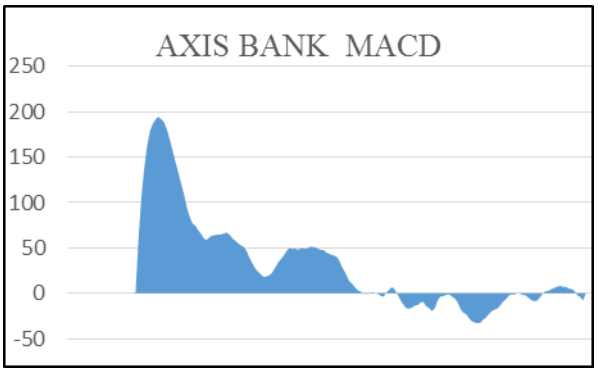
- SMA move downward with major decline. This shows that the price drop from Rs.205 to Rs.32 for a long period which shows the bear trend of the bank.
- Consecutively both the 12D EMA and 26D EMA where declined from June to December 2019 about Rs.175 to Rs.45. And faster moving average is below the slow moving average which shows that there was a great loss in its current market price (CMP).
- MACD falls below the signal line.
- RSI chart of Yes bank shows the bearish trend of the stock. Because it falls below the horizontal 20 level, it shows the weakness of the stock that is RSI fall at 15.9%.
- P&L shows that the bear trend that the close price fall on the critical level that it lies between +1 and −1.

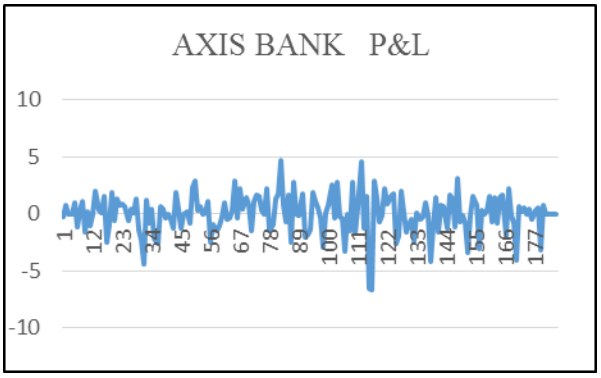
AXIS BANK LIMITED







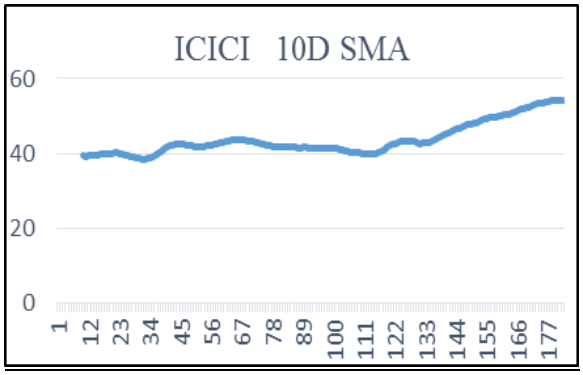


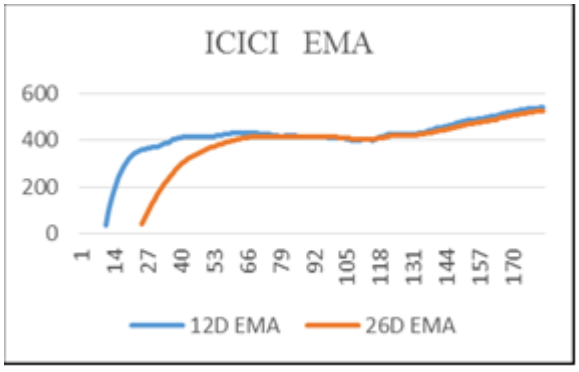


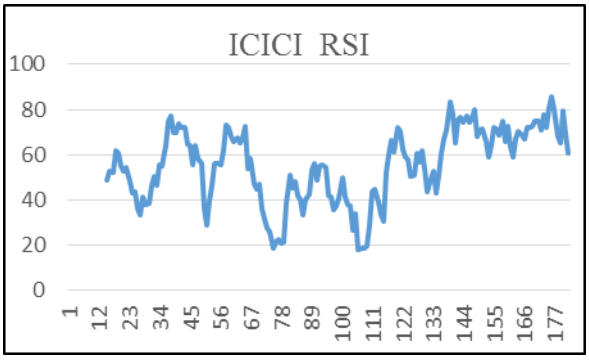
Interpretation

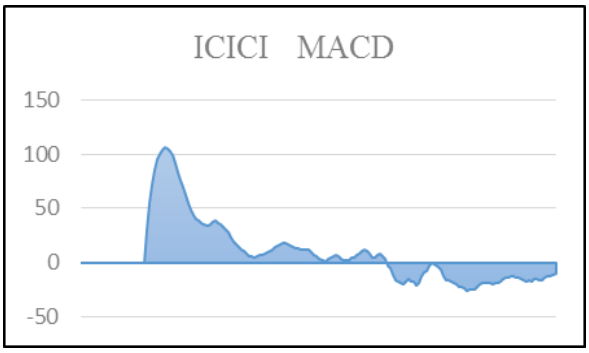
- SMA move moderately in the same direction. This shows that the price maintain the same level for a long period.
- The 12D EMA and 26D EMA are increasing gradually. The 12D EMA is slightly below the 26D EMA (i.e.,) faster moving average is below the slow moving average. Here the trend of Axis Bank is down trend.
- MACD values falls below the signal line that is −7.900. It forms a series of falling which shows the bearish divergence.
- RSI chart of Axis Bank shows the bullish behaviour of the stock. Because it moves above the horizontal 30 level. Here the stock hit more than 70 this indicates that RSI is in uptrend.
- P&L shows that the close price has maintained above the negative level.

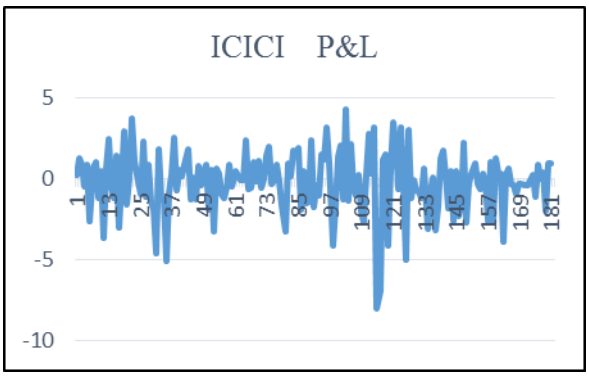
ICICI BANK LIMITED











Interpretation

- SMA move upwards without any major decline. This shows that the price grows from Rs.400 to Rs.550 for a long period which shows the bull trend.
- Both the 12D EMA and 26D EMA are increased from 400 to above 500. This shows the increase in prices. Faster moving average is above slow moving average which shows the bullish trend of ICICI Bank.
- Consecutive MACD values lie below the signal line still from 118 to 183.
- RSI chart of ICICI Bank stood 80.23. It shows that stock price falls in overbought position. This indicates that the stock is in bullish trend.
- P&L shows that the price was maintained moderately.

3. CONCLUSION

Technical Analysis shows the short term trend based on the historical data which helps the investors for the decision making. From this analysis we arrive at a conclusion that in Banking Sectors, Yes Bank was in a bearish trend because the stock price of the bank declined to Rs.46 from Rs.275 shows the drastic fall of the bank, where ICICI Bank and Axis Bank have behaved moderately.

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RESEARCH ARTICLE

FABRICATION OF POTABLE AND ECO-FRIENDLY SOLAR DISINFECTION (SODIS) UNIT AND ITS PERFORMANCE ANALYSIS

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ABSTRACT

Solar disinfection (SODIS) is a technique, which involves utilization of solar energy to make safe drinking water from biologically contaminated water. In the conventional SODIS method, the PET bottles are filled with polluted water and exposed to the sunlight for a certain period depending upon the local weather conditions. However much more effective disinfection system is needed to overcome the problems of inefficient utilization of available solar energy and the health risk posed by treating the water using chemicals during the purification process. Hence, the present work aims in designing a portable solar disinfection unit that can efficiently use solar energy by manually adjusting the unit according to sunlight availability. Along with it, incorporation of the additional eco-friendly unit with water purifying plants *Vetiveria zizanioides* (Vetiver) and *Hemidesmus indicus* (Nannari) is done to achieve high efficiency in producing potable water from biologically contaminated water. The contaminated water samples treated in the solar disinfection unit and eco-friendly water purifying unit are analyzed for the presence of total coliforms and *E-coli* by using the Most probable Number method and P/A analysis, respectively. A reduction in 99.74% of total coliform count and absence of E-coli was observed in the treated water samples. The physicochemical analysis was carried out to ensure the suitability of treated water for consumption and the results revealed a notable reduction in the parameters, and all the parameters came under the permissible range of IS drinking water characteristics. The designed system can be used to disinfect the contaminated water sample most efficiently, thereby making the water suitable for consumption.

Keywords: Solar disinfection, *Vetiveria zizanioides, Hemidesmus indicus,* coliforms, water

1. INTRODUCTION

Water is one of the basic necessity which is required in sufficient quantity and consumable quality for everyone. However, starting of this millennia saw one-sixth of the world's population, around 1.1 billion people without access to proper water supply and many more lacking access to safe consumable water [1]. According to a world water survey, 31% of Indians drew drinking water from unsafe sources, given no other choice, thereby suffering from waterborne diseases. Proper water supply systems are affected due to several factors ranging from lack of maintenance, unreliable public service operations or the water being subjected to secondary contamination during collection, transport and storage [2]. According to a world water survey, lack of potable water poses significant health risks and each year there are over 1.8 million deaths reported due to consumption of contaminated water out of which 90% are children under five years of age. Disease such as diarrhoea, cholera, typhoid fever, jaundice, hepatitis A, amoebic and bacillary dysentery and other diarrhoeal diseases can arise due to no access to good quality drinking water [3,4]. Established water supplies are rapidly at risk of pollution, and population growth creates an increased demand for clean water [5]. Adequate water treatment methods combined with good hygiene promotion and the avoidance of drinking water contamination are a must to prevent any illness and death for any population without access to safe drinking water.

Solar disinfection (SODIS) is a WHO-accepted economical, viable, user-friendly and environmentally safe, household water treatment method that can be used to overcome the problem of unavailability of safe drinking water [6]. The method involves the utilization of solar energy to make biologically contaminated water safe to drink by exposure to sunlight. The SODIS approach has

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shown significant antimicrobial effects in laboratory and experimental field tests and is currently being promoted more in developing countries [7]. During solar exposure, the water is usually heated by solar infrared radiation, depending on the irradiation rate, optimum temperature, and location (wind cooling, heat absorption background). At temperatures above 45-50°C, there is a synergistic effect of thermal inactivation and UV-A radiation which significantly increases the rate of inactivation of solar disinfection. In the case of bacteria, membrane enzymes, e.g. respiratory chain enzymes and F1F0-ATPase, are potentially the first targets of ROS. With constant irradiation, structural proteins and enzymes responsible for various cellular functions (e.g. transcription and translation mechanism, transport systems, amino acid synthesis and degradation, respiration, ATP synthesis, etc.) are also impaired, contributing to cell inactivation and death. [8].

The ultraviolet wavelength of solar radiation and the lower visible range act as the main mechanism behind the pathogen inactivation of sunlight [2]. Among which the prominent inactivation of pathogens is due to the UA-Apart (wavelength 320 - 400 nm), which has a lethal effect on human pathogens present in water. It directly interacts with the DNA, nucleic acids and enzymes of the living cells, changes the molecular structure and leads to cell death. UV radiation also reacts with oxygen dissolved in the water and produces highly reactive forms of oxygen (oxygen free radicals and hydrogen peroxides). These reactive molecules also interfere with cell structures and kill pathogens. Exposure to UV-A radiation induces damage of the cellular membrane and delay microbial growth [9].

The use of plants as water purifiers has been in use since ancient times. *Vetiveria zizanioides* (Vetiver) is a medicinal plant that has been used as a primary purifier of polluted water. The plant is known for its ability to absorb phosphates, nitrates, heavy metals and E-coli bacteria [10]. *Hemidesmus indicus* is a traditional medicinal plant with antibacterial property. An extract from this plant root can inhibit the growth of E-coli, streptococcus, corynebacterium and pneumonia-causing bacteria [11]. SODIS is an efficient method for reducing water pathogens like bacteria, virus, fungi etc. However, it has some limitations, especially regarding the inefficient utilization of locally available solar energy due to inappropriate design of the system and the unavailability of potable solar disinfection unit which can be installed and used for domestic purpose. Moreover, the quality of drinking water produced through solar disinfection is treated using harmful chemicals such as hydrogen peroxide and hence poses a health risk. In this regard incorporation of the eco-friendly unit containing medicinal herbs to treat the output of solar disinfected water helps in overcoming the health risk, which might result from the chemical treatment of water.

Hence the present work, an attempt is planned to design a potable SODIS unit that is suitable for capturing solar radiation available in the district of Coimbatore, thereby achieving disinfection with maximum efficiency. The potable water produced from the SODIS is further purified by incorporation of the additional unit containing eco-friendly natural water purifiers namely the roots of *V. zizanioides* (Vetiver) and *H. indicus* (Nannari) and to achieve high efficiency in producing potable water from biologically contaminated water.

2. MATERIALS AND METHODS

Designing of solar disinfection unit

PET (polyethylene Terephthalate) bottles were used to make a disinfection unit as they are photostable polymers and have a considerable lifetime, excellent strength, stiffness, impact resistance and resistance to high temperature. Since UV radiation is reduced with respect to increasing water depth, a water depth of 10 cm can account for a 50% reduction in UV radiation. Hence 1 litre transparent PET bottles are used. A rectangular box frame was built to aid the working of the proposed solar disinfection unit. Rectangular pipes welded together to form a 42x42 cm box structure, a metallic iron sheet of 2 mm thickness is welded to one of the horizontal frames to act as a platform to hold the PET bottles. Unique bottle holders are provided to hold the bottles in place. The iron platform is covered with aluminium foil to make it a reflective surface to enhance the disinfection process. SODIS unit was made ideal for capturing solar radiation available in the district of Coimbatore. For this, the horizontal frame was made manually adjustable to three different angles, according to the availability of sunlight which varies during different periods of a day. The angles of inclination for the platform was chosen by repeated trials at different angles and by noting the inclinations at which the maximum temperature rise in the samples was observed and chosen as the key angles for manual adjustment using a lever (Figure 1).

Deciding on the angle of inclination was a trial and error process. Starting with the top plate horizontally placed, assuming the most intense sunlight is received at midday and for the next 3 hours until 3 pm, the plate was adjusted at different angles to maximise the amount of the sun falling and reflecting on to the pet bottles. This process was repeated for the next two days starting with the platform at an inclination angle of 45^{o} in the morning and gradually moving to a horizontal at midday. To allow maximum sunlight exposure, the disinfectant unit is lifted and turned to the direction of the sun during the afternoon and late afternoon. The horizontal plate was lifted at 1^{o} -5 ^{o} increments to capture the sunlight every 20 minutes until 3 pm where the angle of the plate was at 45 ^{o} to the horizontal plane. This method was repeated during morning and afternoon time, with 45 ^{o} as the starting point at 9 am and gradually tilted to horizontal or 0 ^{o} at mid-day and 45 ^{o} at the end of the day at 3 pm. Temperature readings are taken before any changes in the angle, and the temperature changes were recorded. The maximum temperature was recorded at 5^{o} angle increments for every 20 minutes for both day time and afternoon sessions and these angular increments are followed throughout the experimental procedure.

The inclination was kept at 45 ^{o} from 10 - 11 am, then the platform was elevated to 25 ^{o} till noon, followed by horizontally placing it at 0 ^{o} from 12 - 2 pm. In the afternoon, the unit was placed facing the changed direction of the sun, and the platform was lowered to an angle of 25 ^{o} from 2-3 pm and to an angle of 45 ^{o} from 3-4 pm.

Sample collection and treatment (Solardisinfection)

The studies were conducted in Coimbatore, which lies between 12°13' to 12°50' north latitude and 75°55' to 75°27' east longitude. In the present study, contaminated water samples were collected in one-litre bottles from Ukkadam lake (Sample A) (Coimbatore, Tamil Nadu 10.992038, 76.972050) early in the morning in August 2020. The rainwater was allowed to fall for 40 minutes and collected in 1L bottles to treat as control (Sample B).

The collected samples A and B were filled up to two-thirds of the bottles, and they are shaken vigorously for 30 seconds to increase the initial level of dissolved oxygen for the solar-induced oxidative inactivation process. Climatic factors were analysed before exposure to sunlight. Solar disinfection unit holding experimental and control water samples were exposed to natural sunlight for 6 hours during the daytime. The aluminium frame, holding bottles were adjusted at various angles of inclination according to the availability of the sun.

The temperature of the water was recorded using a digital thermometer and noted down periodically. Trials were conducted in August 2020, at ambient temperatures ranging from 30-33 ^{o} C between 11 pm and 4 pm to ensure the highest sunlight intensity.

Treatment of solar disinfected water in Eco- friendly water purifying unit

Roots of medicinal plants, namely *V. zizanioides* and *H. indicus* were purchased, washed and cleaned. Their roots were kept in a water dispenser made of strong plastic of six-litre storage capacity. The top of the dispenser was closed using a plastic lid. 50 gm of each root were kept at the bottom of the container. Water samples treated in the solar disinfection unit was transferred separately into the container, and each sample was kept for 6 hours. The water outlet from the container is fixed 5 cm above the bottom level (Figure 2). Water samples were drained from the container for consumption after treatment with the medicinal herbs.

Figure 1. Solar disinfection unit at various inclinations

Figure 2. Ecofriendly water purification unit

Microbial analysis and Sample testing

Laboratory microbial analysis is carried out in the water samples treated in the solar disinfection unit and purified using the eco-friendly purification unit to find the rate of microbial disintegration. Samples were analysed for the presence of total coliforms and *E-coli* by using the Most probable Number method and P/A analysis respectively by using the method prescribed by APHA 2012 [12]. It is the most commonly applied test to ensure whether the water is safe in terms of bacterial presence. For untreated water double strength medium is dispensed to 10 tubes (10 mL) and single strength medium in 5 tubes and Durham tube is added in an inverted position and for treated water, the double strength medium is dispensed into 5 tubes, and 50 mL single strength medium in 1 bottle and Durham tube is added in an inverted position. It is followed by sterilization by autoclaving at 15 Ibs pressure (121°C) for 15 minutes. To find out the MPN of coliforms, for untreated polluted water,5 tubes of double strength and 10 tubes of single strength for each water sample is taken.10 mL,1 ML and 0.1 mL water is added using the sterile pipette to every 5 tubes containing 10 ML double strength and single strength mediums respectively. For treated unpolluted water 1 tube of single strength (50 ML) and 5 tubes for double strength (10 mL) for each water, the sample is taken, 50 mL of water is added to the tubes containing 50 mL single strength medium and 10 mL of water is added to 5 tubes containing 10 mL single strength medium. All the tubes were incubated at 37° C for 24 hrs. The number of tubes giving a positive reaction is compared to the standard table, and the number of bacteria present is recorded.

For E-coli P/A analysis, 100 mL of the water sample is filtered through a 47-mm, 0.45-µm pore size cellulose ester membrane filter that retains the bacteria present in the sample. The filter is mounted on a 5-mL MI agar plate or an absorbent pad saturated with 2-3 mL MI broth, and the plate is incubated for up to 24 hours at 35 °C. The bacterial colonies that emerge on the plate are examined for the appearance of blue colour from IBDG 's breakdown by E-coli. Enzyme $-glucuronidase and fluorescence under long-wave ultraviolet light (366 nm) from the breakdown of MUGal by TC enzyme $-galactosidase [13]. The water is analysed for other parameters. It is very essential that water must be tested for other physiochemical parameters before it is used for drinking purpose. Following different physicochemical parameters are tested for monitoring water quality. All the parameters were analysed by the standard method prescribed by APHA 2012 [12].

2. 5. Analysis of Physicochemical Parameters:
Temperature, pH and Turbidity:

The surface water temperatures were measured periodically using a digital thermometer, pH is indicated by using a digital pH meter (ELICO, L110), the odour is measured by threshold odour test, TDS by TDS meter and turbidity was measured by using turbidity meter.

Total Hardness and Alkalinity:

The total hardness of the water samples is estimated by titrating the samples against EDTA using Eriochrome Black-T(EBT) indicator. Alkalinity is measured by using sulphuric acid with a digital titrator. Sulfuric acid is added to the water sample in calculated concentrations until the three main forms of alkalinity (bicarbonate, carbonate and hydroxide) are converted into carbonic acid. At pH 10, the hydroxide (if present) reacts to form water.

Calcium and Magnesium:

It is measured by complex metric titration with standard EDTA solution using patterns and reader's indicators under pH conditions of more than 12.0. These conditions are achieved by the addition of a fixed amount of 4N Sodium Hydroxide. The concentration of calcium was obtained by titration of EDTA solution against the known volume of the sample. It is also calculated by complexometric titration with EDTA standard solution using Eriochrome Black T as an indicator under pH 10.0 buffer conditions. The buffer solution is composed of Ammonium Chloride and

Ammonium Hydroxide. The solution withstands pH differences during titration.

Sulphate and Chloride:

Sulphate is analysed by the nephelometric method. This approach is based on the fact that the sulphate ion can be precipitated by barium chloride in an acetic acid solution. Measurement of the light scattering of the resulting suspension is done using a nephelometer, and the sulphate concentration is measured by comparing it with the standard curve. In this procedure, chloride ions are measured by titrating directly with silver ions (silver nitrate) using fluorescein as an indicator. Fluorescein is a weak acid that is partly dissociated in water to form a fluorescein anion. The endpoint was determined by the colour change from yellow-green to red or pink.

Chlorine and Iron

It was measure by using the DPD titration method. In this method, DPD is oxidised to the magenta-colour species by chlorine (or iodine in the case of chloramines). The red colour is then titrated with a ferrous reducing agent to the colourless endpoint. Iron content is measured by the phenanthroline spectrometric method. In this procedure, Iron + II is reacted with o-phenanthrol to create a coloured complexion. The intensity of the coloured solution is measured using the spectrophotometer. The calibration curve (absorbance vs concentration) is developed for iron + II, and the concentration of the unknown iron sample is determined.

3. RESULTS

Microbial analysis

Total coliform bacteria are the indicator organisms that their presence indicate other disease-causing organisms present in water, and it is useful for analysing the pollution status of the ecosystem. The result of the microbial analysis of the samples after disinfection using the solar disinfection unit and further purification in the eco-friendly purification unit resulted in a drastic disintegration in the microbial population of total coliforms and the absence of E. coli.

The amount of total coliforms was present in the contaminated water before treatment was found to be 2400.00 MPN /100mL in sample A (Table 1). The data showed which showed significant disintegration after treatment in the solar disinfection unit which was found to be 750 MPN /100mL and again on carrying out further purification using medicinal herbs, the count was found to be 9.00 MPN/100mL. In control water sample B, the total coliforms count before and after solar disinfection was found to be 120.00 MPN /100mL and 47.00 MPN /100mL, and after treatment in the purification unit, the count was found to be 3. 00 MPN /100mL. In both the samples MPN of coliform bacteria came under IS drinking water characteristic count of <10 nos.in 100ml. P/A analysis of E-coli revealed that E-coli present in raw water sample A was completely absent in treated water samples, whereas in sample B the E-coli was absent in raw water.

Analysis of physicochemical parameters

Table 2 shows the data for the physicochemical characteristics of experimental and control water samples.

Temperature

The temperature difference before and after the solar disinfection of sample A showed a gradual rise from the initial value of 27.3°C at an inclination of 25◦C (10 am-11 am) to 36.8 °C at 45^0 inclination (11 am-12 pm) and attained a maximum rise to 52.2°C when kept horizontally during the period of 12 pm-2 pm and during afternoon showed a gradual decrease to 49.5°C (2 pm-3 pm) and further to 47.3°C (3 pm-4 pm) when kept at an inclination of 45°C and 25°C respectively, and that of sample B showed the similar pattern of temperature variation with a maximum value at 49.2°C (Table 3).

pH

The pH of samples was within the permissible range of IS drinking water characteristic. the pH of both water samples did not show any significant change after solar disinfection, and it increased slightly after treating in the eco-friendly purifying unit from 6.63 to 7.72 for sample A and from 6.80 to 7.20 in sample B.

Turbidity and Total Dissolved Solids (TDS)

The turbidity and TDS were extensively higher than the characteristic value in raw water sample A, and it decreased somewhat after solar disinfection and drastically decreased after treating in the eco-friendly unit. The TDS was decreased from 1190.0 mg/l to 830.0 mg/l after solar disinfection and further decreased to 450.0 mg/l after purification. The initial turbidity value of sample A (17.00 NTU) which was higher than the permissible range of 15.00

NTU decreased to 14.00 NTU after solar disinfection, and it showed a huge decrease to a value of 2.00 NTU after purification. In sample B, the water was relatively clear before disinfection, and the values decreased slightly after purification.

Table 1. The data shows the microbial analysis of water sample

S. No.	Parameters (units)	Sample A (Experimental)			Sample B (Control)		
		Raw Water Sample	Sodis Treated	Eco-friendly purified	Raw Water	SODIS Treated	Eco-friendly purified
1	MPN of Coliform Bacteria for 100 ml	2400 MPN/100 ml	750 MPN/100 ml	9.00 MPN/100ml	120 MPN/100 ml	47.00 MPN/100 ml	3.00 MPN/100 ml
2	E.coli P/A	Present	Present	Absent	Absent	Absent	Absent

Table 2. The data shows the Physiochemical parameters of disinfected water samples

Sl. No.	Physico-chemical Parameters (units)	Sample A (Experimental)			Sample B (control)		
		Raw Water	SODIS Treated	Eco-friendly treated	Raw Water	SODIS Treated	Ecofriendly purified
1	pH	6.60	6.63	7.72	6.80	6.80	7.20
2	Odour	Mild odour	No odour	NO Odour	No Odour	No Odour	No Odour
3	TDS (mg/l)	1190.0	830.0	450.0	28	27.6	12.3
4	Turbidity (NTU)	17.00	14.00	2.00	3.4	3.14	0.27
5	T. Alkalinity (mg/l)	340.00	338.00	72.00	31.00	30.4	6.5
6	Total Hardness (mg/l)	380.00	365.00	220.00	73.00	71.6	32.20
7	Calcium (mg/l)	68.00	67.00	48.00	9.40	9.38	7.2
8	Magnesium (mg/l)	50.00	50.00	24.00	1.2	1.18	0.7
9	Chloride (mg/l)	243.0	249.00	237.7	5.47	5.45	3.78
10	Sulphate (mg/l)	241.00	240.00	160.0	3.40	3.35	1.27
11	Chlorine (mg/l)	Nil	Nil	Nil	Nil	Nil	Nil
12	Iron (mg/l)	1.30	1.29	0.28	0.83	0.82	3.1

Table 3. Temperature of water samples during exposure in solar disinfection unit.

Water sample	Temperature (period and angle of inclinations)				
	10 am-11 am (25°)	11 am-12 pm (45°)	12 pm-2 pm (0°)	2 pm-3 pm (45°)	3 pm-4 pm (25°)
Sample A	27.3	36.8	52.2	49.5	47.3
Sample B	23.4	33.5	49.2	48.0	45.9

Total alkalinity and hardness

Total alkalinity and hardness of water sample A were higher than the permissible limit before treatment. It decreased slightly after solar disinfection from 340.00 to 338.00 mg/l and changed drastically to 72.00 mg/l and reached within the permissible limit after treating in purifying unit.

Calcium, magnesium, chloride and chlorine

In the sample, A magnesium, content didn't improve after SODIS treatment, but it decreased from 50 mg/l to 24 mg/l after purification. Chlorine was absent in both raw water samples A and B. Total calcium and chloride content was within the permissible range in raw sample A, and it showed a decrease in a small amount after SODIS treatment and in a large amount after purification.

Sulphate and Iron

Sulphate content was higher than the water characteristic, and it did not show any change after SODIS but changed from 240 mg/l to 160 mg/l after purification in the experimental sample. Total iron content was far higher than the permissible limit in raw water sample A, but it decreased drastically from 1.30 to 0.28 mg/l after purification.

In control water sample B, all parameters were within the permissible limit in the raw sample itself, and it did not show any notable change after SODIS but decreased drastically after treatment in eco-friendly water purifying unit.

4. DISCUSSION

The results of the performance analysis in the present study showed that the Eco-Friendly Solar Disinfection Unit prepared could efficiently purify the contaminated water, making them suitable for consumption. The solar disinfection unit was designed in such a way that it ensured the maximum availability of sunlight. The reflective surface provided using the aluminium sheet as the base boosted the amount of sunlight absorbed by the water. Aluminium is the only material that has a high reflectivity for ultraviolet rays in the wavelength spectrum ranging from 250 nm to 400 nm. An aluminium foil that is lightweight and has strong workability is ideal as an ultraviolet reflective material. Moreover, these are mechanically robust, water-proof, long-lasting and affordable [14]. Previously large number of works has been carried out using aluminium foil in solar equipment such as solar water heater [15], solar cooker [16], photovoltaic solar panel [17] etc.

In the present work, the design of a potable SODIS unit was made suitable for capturing solar radiation available in the district of Coimbatore. The placement and orientation of the solar disinfection unit is an important factor that the angle or tilt of the unit should able to harness the maximum intensity of sunlight. In this work, the angles at which maximum sunlight intensity was chosen by trial and error procedure followed by the manual adjustment of the reflective platform to different angles of inclination according to the sunlight availability during different periods of the day ensuring the maximum availability of sunlight. The incorporation of the additional unit containing eco-friendly natural water purifiers namely the roots of *V. zizanioides* and *H. indicus* to treat the output of disinfected water helped in achieving high efficiency in producing high purity potable water from biologically contaminated water.

The results of the microbial analysis revealed the significant microbial disintegration of E-coli and total coliforms. In sample A, before the treatment, the total coliforms count was found to be

2400 MPN/100 mL, and after the treatment, a drastic decrease of the coliform count was observed and was found to be 9.00 MPN/100mL. This equated to a reduction of 99.74% of the total coliform count, which is close to the value of 97.5 % of total coliform reduction in a control water sample, thereby indicating that the solar disinfection unit was efficient in treating the contaminated water and making it suitable for consumption. The total coliforms after solar disinfection were reduced to 750 MPN/100mL, and this significant reduction can be attributed to the effect of sunlight on the coliforms. Complete eradication of E-coli from raw water samples was observed after purification of solar disinfected water using herbs. It is available from the previous literature that sunlight can act as an effective agent for the removal of coliforms and E-coli from water samples [18, 19]. On further purification, by medicinal herbs, the total coliforms count reached within the permissible range. Studies carried out by Gerrad et al., [10] and Luqman et al., [20] proved that the roots of *V. zizanioides* has the ability to absorb E-coli bacteria and the work is done by Ganesan et al., [11] and Mamatha et al., [21] showed the ability of roots of *H. indicus* to inhibit the growth of E-coli. Investigation of the effect of vetiver grass in the purification of wastewater carried out by Mathew and the team revealed that the root has the potential to reduce the total coliform count in water up to 85% [22].

In a study conducted by Das et al., [23], the extracts from the roots of *H. indicus* inhibited the E-coli growth, and it was found that the presence of bioactive compounds such as steroids, tannins, saponins, glycosides, flavonoids, and polyphenols might contribute to this antibacterial activity. Work conducted to investigate the effect of roots extracts of *V. zizanioides* implied that the presence of tannins can be the active compound responsible for antibacterial activity against E-coli bacteria [24].

The reduction in coliforms and absence of the E-coli in experimental samples after disinfection and purification can be attributed to the following factors: i) Antibacterial effect posed by the roots of *V. zizanioides* and *H. indicus* inhibited the growth of E-coli. ii) Use of reflective surface in the disinfection unit aided the increased absorption of sunlight. iii) The manual adjustment of the unit according to the availability of sunlight during different periods in daytime resulted in the maximum capturing of available sunlight, and the effect of solar radiation resulted in the ROS formation and disruption of cellular activity and bacterial death.

The physicochemical parameters are crucial for estimating the water quality, as they provide information on the suitability of water for consumption. The temperature rise was maximum found to be 52.2, whereas there was no significant change in pH. After treatment, all the physicochemical and microbial testing parameters were within the permissible IS drinking water characteristics. The physiochemical parameters of both experimental and control water samples did not have any notable change after solar disinfection as SODIS cannot change the physical and chemical quality of water. Still, a significant reduction was observed in these parameters after treating in eco-friendly unit with medicinal herbs, and every parameter came under the IS drinking water characteristics.

Roots of *V. zizanioides* (Vetiver) contributed to the significant decrease in physiochemical characteristics of water samples. It can act as a water purifier and can reduce the turbidity, TDS, alkalinity, hardness of water and aid in the increase of PH of Water. In a study carried out to investigate the effect of vetiver grass in the purification of wastewater by Samuel and the team, it was found that the root can reduce the turbidity and TDS of water samples significantly [25]. The potential of vetiver grass in wastewater treatment was analysed by Maharajan and his team [26] and the results of the study showed that treating of waste water by vetiver grass can reduce the overall concentration of chloride nitrate total hardness and alkalinity by 42.90%, 93.93%, 46.4% and 22.2% respectively. It can also lower the parameters such as chloride, sulphate, calcium; magnesium and iron [26-28]. This could be the reason for the drastic change in the parameters of water after treatment. The discrepancy between the final values of physicochemical parameters of experimental and control samples was not very important for the purposes of the present study as tests were carried out to assess the efficacy of disinfection in terms of microbial percentage removal and not certain physical and chemical parameters.

5. CONCLUSION

An efficient, low cost, Eco-Friendly Solar Disinfection Unit for potable water was designed that can purify the contaminated water, making them suitable for consumption. The system designed is environmentally sustainable since it doesn't make use of electrical energy like commercial water purifiers and used natural plants as purifiers without the use of chemicals. The designed system

was able to overcome the major drawbacks of the conventional disinfection unit such as the unavailability of portable solar disinfection unit which can be installed and used for domestic purpose and the inefficient utilization of locally available solar energy due to inappropriate design of the system. The portable unit, which is specially designed for the Coimbatore district, allows maximum capturing of sunlight according to the incidence of radiations and ensured the maximum temperature rise in water samples thereby enhanced the disinfection of contaminated water. A notable reduction was observed in microbial content in the treated water sample. The disinfected water, which is further, purified by incorporating additional unit containing eco-friendly natural water purifiers, namely the roots of *V. zizanioides* and *H. indicus*. In conventional treatments, the output of solar disinfected water is treated using harmful chemicals such as hydrogen peroxide that poses a health risk. This concern was solved by using the roots of medicinal herbs. The roots selectively absorbed and inhabited the coliforms and E-coli and further enhanced water purification, making the contaminated water free from harmful microbes. The physicochemical parameters of water were significantly reduced after treating in the water-purifying unit, and all parameters came under the permissible range, thereby making the water suitable for consumption.

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RESEARCH ARTICLE

DOCUMENTATION OF ETHNOMEDICINAL AND ETHNOVETERINARY PLANTS USED BY PALIYAR TRIBES, KURANGANI HILLS, WESTERN GHATS, THENI DISTRICT, TAMIL NADU, INDIA

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ABSTRACT

A study on medicinal plant utilization in area revealed that the communities commonly used for maintaining their primary healthcare. The ethnomedicinal and ethnoveterinary documentation in the Kurangani forest of Tamil Nadu state was made for a period of two month from January to March 2021. The forest is a tropical evergreen with high species richness where the temperature and rainfall data indicates that it is suitable vegetation for the inhabitation of great number of species. In order to sort out health disorders or diseases based on the plants prescribed there are 8 ailment categories were classified. In present study, totally 50 plant species for ethnomedicine and 25 species of ethnoveterinary were encountered through the knowledge of indigenous tribal communities, Paliyar of Kurangani forest. Most of the treatments in both ethnobotany and ethnoveterinary practices with the use of herbs particularly leaf parts were perceived. For medicinal purposes, the family Malvaceae contributed majorly 5 species followed by Solanaceae with 4 species, Euphorbiaceae and Zingiberaceae contributed 3 species and afterward other family species solely mentioned for different ailments. In ethnoveterinary medicine documentation, 3 species belongs to the family Euphorbiaceae which is predominant, subsequently 2 species belong to Zingiberaceae. The mode of preparation and dosage, mode of application, duration of the treatment for each ailments have documented. This study highlights the traditional medicinal knowledge of the Kurangani tribal people, providing basic data for further research and protection of minority medicine. Thus, conservation of medicinal plants by local communities is emphasized in present study to avoid further loss. Moreover, phytochemical and pharmacological investigation is recommended with due consideration to frequently used medicinal plants.

Keywords: Kurangani, Ethnomedicine, Ethnoveterinary, Paliyar tribes, Traditional knowledge.

1. INTRODUCTION

India is one of the twelve mega-biodiversity countries in the world having rich vegetation with wide varieties of plants [1]. In India, medicinal plants are widely used by all sections of the population with an estimated 7,500 species of plants used by several ethnic communities and it is known that India has the largest tribal population in the world after Africa. With enormously diversified ethnic groups and rich biological resources, India represents one of the great emporia of ethnobotanical wealth. Even today, tribal communities in India still collect and preserve locally available wild and cultivated plant species and practice herbal medicine to treat a variety of diseases and disorder [2].

Ministry of Tribal affairs presents a list of tribal communities in India for each state and Tamil Nadu contains 36 types of tribal communities distributed in different districts in the forests and adjoining areas. It is estimated that tribal people of Tamil Nadu accounts 1.05% of the total state population and 0.77% of the total tribal population of the country. Out of 17,500 species of flowering plants described from India about 5640 species are recorded in Tamil Nadu [3]. World Health Organization estimated that nearly 80% of the earth's inhabitants still rely on ethnomedicine, as the mid-1990s, upwards of 80-90% of humans toughly to rely on ethno-veterinary care for livestock [4].

India has great heritage of medicinal plants. India is basically agricultural country; domesticated livestock's are backbone of farmers. To maintain these livestock there is phenomenal increase in the demand of herbal traditional medicine in developing

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country like India. Ethno-veterinary medicine practices cover the knowledge, skill, methods and belief about health care found among the members of community. Ancient records on animal health care are found in *Vedas, puranas* like *Ashwapuran, Garudapuran* and *Hastipuranam* which devoted to animal husbandry [5].

From the vedic period till the end of 19th century, much of the veterinary practice in India was based on the experiences gathered through generations and improved through informal experimentation this traditional system of medicine also referred to as ethno-veterinary medicine [6].

Ethnoveterinary medicine is mainly concerned with folk beliefs, knowledge, skills, methods and practices which are used in the healthcare of animals. It comprises traditional surgical techniques, traditional immunization, magico-religious practices and the use of herbal medicines to treat livestock diseases [7]. Ethnoveterinary medicine has become an elemental factor of primary health care, especially for marginalized and poor communities living in remote rural areas. Ethnoveterinary medicine often offers less expensive options than conventional medicines, products are locally available and more easily accessible, and are generally less toxic [8]. Knowledge of ethnoveterinary practices is declining due to inadequate documentation and verbal passage of plant heritage verbally. Documenting indigenous knowledge is important for the conservation and use of biological resources [9].

Indian government has inaugurated the plan to develop the Agriculture and farmers' welfare through Animal husbandry, Dairying and Fisheries by the Ministry of Tribal affairs, 2021. Hence, the Aims and Objectives of present study are proper documentation of indigenous knowledge about medicinal plants by ethnobotany and ethnoveterinary study. To know about the plant species of ancient medicinal properties and collect the data, the tribal people of the particular area have approached through the methods of questionnaire and direct conversation. This information may not be reaching the younger generations of tribal people because of their job and educational reasons and lifestyle.

A perusal of the literature reveals that, several ethnobotanical and ethnoveterinary studies among paliyar tribals have been reported from the various districts of Tamil Nadu except Theni district which has not yet been studied from ethnoveterinary point of view. Therefore, this study was undertaken in order to ascertain the detailed information on plants used by paliyar tribals for ethno-veterinary purposes in different places of Theni district. With the above fundamental reason, the ethnomedicine and ethnoveterinary study is planned to do with the following objectives.

1. To document the traditional knowledge about herbal plants.
2. To explore and document the traditional information regarding usage of ethnoveterinary medicinal plants utilized by rural farmers and traditional herbal healers.
3. To create awareness about its role in cultural, social and health of people
4. To initiate attempts to find the alternate and reliable drug discovery by tracing the traditional knowledge on medicinal plants.
5. To conserve our national heritage before its extinction and to encourage the conservation and sustainable utilization of traditionally important plants.

2. MATERIALS AND METHODS

2.1 Study area

Theni District lies at the foot of Western Ghats and is situated between 90º 53′ and 10º 22′ north latitude and 77 º 17′ and 77 º 67′ east longitude. The general geographical information of the district is diversified by several ranges and hills. The vegetation is classified as southern tropical forest in the plains and foot hills, dry deciduous forests, moist deciduous forests and evergreen forests in the high altitudes. In the present study, ethnobotanical and ethoveterinary surveys were carried out in Kurangani hills village of Theni District.

2.2 Tribal communities in the study area

The tribe found in the study area called Paliyars and Muthuvars. Compared to various tribal communities in Tamil Nadu, paliyars constitute a small group. The Paliyar tribals inhibit a narrow strip of Western Ghats in the hilly regions of Madurai, Dindigul, Theni, Thiruneveli and Virudhunagar Districts of Tamil Nadu and Idukki District of Kerala. They are also engaged in seasonal collection of minor forest products such as honey and bee wax. They cultivate edible plants such as tapioca, banana, millets, and cash crops such as pepper, coconut, arecanut and cashewnut.

2.3 Method of collecting information [10]

The fieldwork in the villages of Theni District took place between January to March 2021. The tribal settelements were located through field surveys in this region. A total of five tribal practitioners were identified to get the ethnomedicinal and ethnoveterinary information through direct interviews/oral conversations. A field datasheet has been prepared to record the plant details with ethnomedicinal information gathered from the traditional healers. The information has collected through questionnaires and discussions among the informants in their local language (Tamil). The questionnaire allowed responses on the plant prescribed, part of the plant used, medicinal uses for each part, mode of preparation (*i.e.*, decoction, paste, powder, and juice), form of usage (either fresh or dried) and additional plants used as ingredients. Information on local name of plant, plant parts used for curing, method of preparation.

Figure 1. Study area of Kurangani hills, Western Ghats, Theni district, Tamil Nadu, India

3. RESULTS AND DISCUSSION

3.1 Meteorological data

The climatic data for the study area was collected in Bodinayakanur Taluk Office, Theni district, for a period of three months from January 2021 to March 2021. The maximum temperature is ranging between 30°C to 35°C. Similarly the minimum temperature during the study period is ranging between 21°C and 28°C. The annual rainfall of the study area is 883mm. Most of the rainfall occurred during the period of south-west monsoon (July) as it is generally most effective part of Western Ghats. The relative humidity of the air was between 65% and 89%.

3.2 Documentation of indigenous ethnomedicinal knowledge

The present study revealed the use of 50 species of plants distributed in 48 genera belonging to 31 families which were commonly used by most of the Paliyar traditional healers for the treatment of different types of ailments.

In present study it has been identified that tribes regularly use 25 Herb species, 10 Shrub species, 5 Climbers species and 10 Tree species. The prominent family is Malvaceae which contributed 5 species, followed by Solanaceae with 4 species and followed by Zingeberaceae and Poaceae with 3 species (Figure 4). For each reported species, the botanical name of the plant, family, local name (Tamil), life form, parts used, ailments treated, method of preparation, mode of administration and its medicinal importance (Table 1) are provided.

Among the different plant parts used for the preparation of medicine and veterinary, the herb is predominant and leaves were most frequently used for the treatment of different ailments (Figure 2, 3 and 4). The preparation methods of categorized as raw material (raw plant), decoction, paste, juice, oil, gel, latex and soup. In these different methods of preparation, raw material is frequently used in this documentation by Paliyar tribes of Kurangani hills.

The medicinal uses of plants gathered in present study are compared with the previously published information from other parts of India. There were 20 plants such as *Gloriosa superba, Solanum torvum, Sida cardifolia, Alpinia officinarum, Melia azedarach, Ficus racemosa, Mimosa pudica, Bambusa vulgaris, Syzigium cumini, Eclipta alba, Cymbopogan citrates, Atalantia monophylla, Helicteros isora, Phyllanthus emblica, Vicia faba, Piper nigrum, Capsicum frutescens, Jasminium angustifolium, Elettaria cardamomum and Canna indica* are reported for the first time for the particular ailment from the study area. However, no plants are reported as a new medicinal plant but with different uses.

Table 1. Ethnomedicine information collected from Paliyar tribes of Kurangani Hills.

S. No.	Scientific Name	Family	Vernacular Name	Habit	Part Used	Ailments treated	Preparation and Mode of Applications
1	*Solanum nigrum* L.	Solanaceae	Milakuthakkali	Herb	Leaves	Mouth Ulcer	Decoction of fresh leaves taken in early morning to treat mouth ulcer. Also the decoction is used as mouth wash
2	*Amaranthus spinosus* L.	Amaranthaceae	Mullikeerai	Herb	Leaves, Stem	Jaundice	Decoction of fresh leaves and stem are taken orally twice a day for three days to cure indigestion
3	*Ocimum tenuiflorum* L.	Lamiaceae	Thulasi	Herb	Leaves	Cold, cough, fever	Fresh leaves are taken orally twice a day to get relief from cold, cough and fever.
4	*Achyranthus aspera* L.	Amaranthaceae	Nauruvi	Herb	Root, seed	Teeth pain, Snake bites	Fresh roots are used as toothbrush. Seeds are used as nutritive food.
5	*Circuma angustifolia* Roxb.	Zingiberaceae	Kooravathi	Herb	Rhizomes , Leaves	Bronchitis, Antifungal	Decoction of dried rhizomes are taken to cure Bronchitis. Fresh leaves are used orally to cure wound. Also leaves are used as antifungal, antibacterial agents.
6	*Gloriosa superba* L.	colchicaceae	Kanvali kilangu	Climbing herb	Leaves	Asthma	Decoction of fresh leaves are used to cure Asthma for children.
7	*Solanum torvum* Sw.	Solanaceae	Sundakkai	Shrub	Fruit, leaves	Antimicrobial, Anti-inflammatory	Fruits are widely used as vegetable and food ingredient. Leaves are used as antimicrobial, anti- inflammatory agents.
8	*Hibiscus-rosa-sinensis* L.	Malvaceae	Sembaruthi	Shrub	Leaves, Flower	Herbal Oil	From the flowers extract oil has been taken and used to enhance hair growth and used in hair fall treatment.
9	*Sida cardifolia* L.	Malvaceae	Kurunthuthi	Herb	Root	Urinary, Nervous disorders	Decoction of dried roots are taken orally in early morning to cure urinary problem.
10	*Psidium guajava* L.	Myrtaceae	Koyya	Shrub or small tree	Leaves	Edible	Fresh leaves are used to cure stomach pain. Fruits are edible.
11	*Lawsonia inermis* L.	Lythraceae	Maruthani	shrub	Leaves	Bile	Paste is prepared with the leaves along with turmeric orally to reduce the bile level. Mostly used in southern India.
12	*Alpinia officinarum* Hance.	Zingiberaceae	Sitharathai	Galangal	Rhizomes	Cold, Cough	Decoction of dried rhizomes are taken as orally in early morning to cure cold and cough.

13	*Melia azedarach* L.	Meliaceae	Malai vembu	Tree	Leaves	Eye-diseases, Headaches and Indigestion	Fresh leaves are taken as orally to cure indigestion and headaches. Also decoction is used to cure eye-diseases.
14	*Aristolochia bracteolata* Lam.	Aristolochiaceae	Aaduthinnapalai	Herb	Leaves	Stomach problems (tape warms)	A pinch of leaves are ground into paste and taken orally along with honey to treat stomach problems.
15	*Ficus racemosa* L.	Moraceae	Athimaram	Tree	Bark, leaves	Carterpillar Bristles, Injury	Fresh leaves paste are apply in skin for protect from mosquito bite. Also used to protect from carterpillar bristles lodged in skin. Latex from leaves are orally apply for the injury and fracture.
16	*Mimosa pudica* L.	Fabaceae	Thottal Sinugi	Herb	Leaves, Stem	Joint Pain	Decoction from dried leaves and stem are taken orally to cure joint pain.
17	*Bambusa vulgaris* Scrad	Poaceae	Moongil	Shrub	Bud	Thoracic Problem	Juice from buds are used to cure thoracic problem.
18	*Tridax procumbens* L.	Asteraceae	Vettukayapundu	Herb	Leaves	Anticoagulant, Antifungal	Paste from leaves are apply to heal wound. Also used as anticoagulant, antifungal.
19	*Barleria prionitis* L.	Acanthaceae	Kattu kanakambaram	Subshrub	Leaves	headache	Decoction of leaves is inhaled to get free from headache.
20	*Syzigium cumini* L.	Myrtaceae	Naval maram	Tree	Bark	Stomach clean	Soup from dried bark is used to clean stomach.
21	*Cissus quadrangularis* L.	Vitaceae	Pirandai	Herb	Leaves	Cold, Cough	Decoction from fresh leaves taken orally to cure cold and cough.
22	*Piper betle* L.	Piperaceae	Vetrilai	Creeper	Leaves	Headache, Bronchitis, antiseptic	Fresh leaves are taken orally and apply on head to cure headache. Leaves juices are taken for Bronchitis.
23	*Abutilan indicum* (Link) Sweet	Malvaceae	Thuthi	Herb	Leaves	Piles	Decoction from fresh leaves are taken orally to cure piles.
24	*Pergularia daemia* (Forssk). Chiov	Apocynaceae	Veliparuthi	Herb	Leaves	Skin disease, Rhumantism	Decoction from fresh leaves are used to cure skin diseases and rhumantism.
25	*Eclipta alba* (L.) L.	Asteraceae	Karappankulai	Herb	Leaves	Vitilligo	Fresh leaves are taken orally to cure vitilligo.
26	*Andrographis paniculata* (Burm.f) Nees	Acanthaceae	Siriyanangai	Herb	Leaves	Fever, Poisonous bites	Leaves are mixed with the root of *Aristolochia indica* and ground into paste. The paste obtained is applied over the body to treat fever. Decoction of fresh leaves is taken orally for two days thrice a day to treat poisonous bites.
27	*Aloe vera* (L.) Burm.f.	Asphodelaceae	Sothu kathalai	Herb	Succulent	Stomach issue	Gel is used to cure stomach issue. Also used

							to treat diabetes and used for skin remedy.
28	*Cymbobogan citrates* (DC.) Stapf	Poaceae	Bothaipul	Herb	Leaves	Antioxidants, antimicrobial,	Fresh leaves are taken orally and inhaled for 2 to 3 minutes to cure headache.
29	*Atalantia monophylla* (Roxb.) A.Dc.	Rutaceae	Kattu elumichai	Shrub or small tree	Leaves, fruits	diabetes	Fruits are edible. Fresh fruits are taken orally to cure diabetes.
30	*Helicteros isora* L.	Malvaceae	Valamberikai	Shrub or small tree	Fruit	Herbal oil	Oil is taken from dried fruit and used as herbal oil and reduce the body heat.
31	*Phyllanthus emblica* L.	Phyllanthaceae	Malai nelli	Tree	Fruit	Diabetes	Dried fruits are ground into powder. The powder decoction is taken twice in a day to cure diabetes.
32	*Vicia faba* L.	Fabaceae	Kattu mochai	Shrub or small tree	Fruit	Edible, nutrients	Fruits are commonly edible. Also used as highly nutrient value.
33	*Piper nigrum* L.	Piperaceae	Karu milagu	Climber	Fruit	Edible, antimicrobial	Fruits are edible and used as ingredient. Also used as antimicrobial.
34	*Capsicum frutescens* L.	Solanaceae	Kana milagai	Subshrub	Fruit	Edible	Highly medicinal valued and edible.
35	*Jasminum angustifolium* (L.) Willd.	Oleaceae	Kattu malli	Shrub	Flower	Chronic ulcers	Mild anesthetic, astringent, and used as chronic ulcers.
36	*Elettaria cardamomum* (L.) Maton.	Zingiberaceae	Elakkai	Herb	Seed	teeth decay, bad breath	The seeds are taken orally daily morning to cure teeth decay, bad breath.
37	*Canna indica* L.	Cannaceae	Kalvalai	Herb	Fruit	Diabetes, kidney stone	Fresh fruits are taken orally as food and cure diabetes, indigestion. Also pseudostem is used to cure kidney stone.
38	*Leucus aspera* (Willd.) Link	Lamiaceae	Thumbai	Herb	Leaves	Skin allergy	Juice extracted from the leaves is mixed with honey and taken orally to treat skin allergy
39	*Bombox ceiba* L.	Bombacaceae	Ilavamaram	Tree	Prickles	Pimples	The broad and thick prickles of the plant are rubbed on pimples to disappear.
40	*Urena lobata* L.	Malvaceae	Ottuthuthi	Herb	Root	Stomach pain	Paste made from the root is taken orally thrice a day for two days to get relief from stomach pain.
41	*Persea Americana* Mill	Lauraceae	Avocado	Tree	Fruit, leaves, seeds	Cholesterol, nutritious, dysentery and	The fruit used as food, good source of potassium and vitamin D. Also fruit is used to lower cholesterol levels. The seeds, leaves,

						diarrhea	and barks are used for dysentery and diarrhea
42	*Aegle marmelos* (L.) Correa.	Rutaceae	Vilvamaram	Tree	Leaves	Cough, eye problems	Decoction of fresh leaves is taken orally twice a day for a week to treat cough, breast inflammation, eye problems and to keep the body in cool.
43	*Asperagus racemosus* Willd.	Liliaceae	Thanneervitan kilangu	Herb	Tuber	Urinary problem	Fresh tuber is ground with water and taken orally with milk twice a day for a week to cure urinary problems.
44	*Cassia auriculata* (L.) Roxb.	Ceaselpiniaceae	Aavarampoo	Herb	Flowers	Kidney problems	Fresh flower petals are made into a paste and taken orally with honey once a day before going to bed for month to treat kidney problems.
45	*Cynodon dactylon* (L) Pers.	Poaceae	Arukampul	Herb	Plant parts	Normal blood circulation	Fresh plant parts are ground with hot water and make into a paste and taken orally in empty stomach to ensure the normal blood circulation.
46	*Solanum trilobatum* (L.)	Solanaceae	Thoothuvalai	Herb	Leaves	Cold and cough	Fresh leaves are boiled with black pepper and tender coconut and the paste thus obtained is taken orally thrice a day for two days to get relief from cold and cough. Also leaves are mixed with egg and taken as food for twice a day for one week to get relief from cold and cough.
47	*Santalum album* (L.)	Santalaceae	Santhanamaram	Tree	Bark, essential oil	Cosmetic, skin cancer	The powder from bark is used as cosmetic and skin texture, essential oil is taken orally to prevent from the skin cancer
48	*Euphorbia tirucalli* (L.)	Euphorbiaceae	Thirukalli	Tree	Latex	Dandruff	Milky latex is dipped in cotton. After drying of cotton, burn it and the obtained ash is mixed with coconut oil and applied over the head skin to get rid of dandruff.
49	*Citrullus lanatus* (Thunb.) Matsum. & Nakai	Cucurbitaceae	Kumatikai	Climbers	Fruits	Rheumatism	Fresh fruits are made into paste and heated with neem oil and the paste thus obtained is tied over the painful places with cloth to treat rheumatism.
50	*Momordica charantia* L.	Cucurbitaceae	Kaatupagarkai	Climbers	Fruits	Diabetes	Fruits are edible. Fruits are used as ingredients. Also Fruits used to treat diabetes.

Table 2. Ethnoveterinary Information collected from Paliyar tribes of Kurangani Hills

S. No.	Botanical Name	Family	Vernacular name	Habit	Parts Used	Mode of application	Disease cured	Animals treated	Preparation and application
1	*Bryophyllum pinnatum* (Lam.) Pers.	Crassulacaceae	Ranakalli	Herb	Leaves	Paste	Mastitis	Goat	Fresh leaves given orally two times for goat to cure Mastitis.
2	*Azadirachta indica*A. Juss.,	Meliaceae	Veppilai	Tree	Seed	Paste	Flu repellent Maggot Wound	Goat	Oil paste is applied externally to the goat's foot heal for Maggot wound ie. In wound, worms will be produced over the period where once in a day at the empty stomach for 2 days orally given.
3	*Abutilan indicum L.*	Malvaceae	Thuthi	Shrub	Leaves	Decoction	Diarrhoea	Goat	Fresh leaves given two or three times a day to diarrhoea
4	*Acacia nilotica (*L.*)*Delile	Mimosaceae	Karuvelam	Tree	Fruit	Paste	Stomach worms	sheep	Mature fruits are given as feedstuff daily for 4-5 days to the sheep and goats to kill the stomach worms.
5	*Acalypha paniculate* Miq	Euphorbiaceae	Kattukuppameni	Herb	Leaves	Paste	Skin diseases wound	Goat	Fresh leaves crushed and made into extract which is applied directly to the goat and cattle externally once in a day for 2 days.
6	*Acalypha indica* L.	Euphorbiaceae	Kuppameni	Herb	Leaves	Paste	Wound	Goat	Fresh leaves crushed applied directly, to the goat and cattle, superficially once in a day for 2 days.
7	*Aloe vera (*L.) Burm. F.	Liliaceae	Kathalai	Herb	Leaves	Juice	Mastitis	Goat	Juice is mixed with neem juice and given orally to the goat and cattles for once a day to cure Mastitis
8	*Andrographis paniculate* nees.	Acanthaceae	Nelavembu	Herb	Leaves	Decoction	Fever	Goat	Fresh leaves are ground with the seeds of *Cuminum cyminum,* seeds of *Piper nigrum,* leaves of *Piper betel* are made into paste and it is applied on the tongue of goat for fever, twice in a day for 2 days.
9	*Aristlochia indica* L.	Aristlochiaceae	Aduthinna-palai	Climber	Leaves	Paste	Poison bit	Goat	Leaves are crushed and applied on the infected position twice a day until cure.

10	*Calotropis procera*R.Br.	Asclepediaceae	Earukku	Shrub	Latex	Paste	Wound	Goat	The latex collected from the branch is directly applied on wound. Leaf sticks are used to apply the latex.
11	*Cannabis sativa* L.	Cannabinaceae	Ganja	Herb	Seed	Decoction	Dysentery	Goat	Matured leaves paste given twice in a day for 2 days.
12	*Cardiospermum helicacabum*L.	Sapindaceae	Mudukkatan	Climber	Leaves	Paste	Rheumatic pain	Goat	Young leaves crushed and mixed with coconut oil are used as dressing on pain area and cut injury once in a day.
13	*Carica papaya* L.	Cariaceae	Papali	Tree	Leaves	Juice	Fever	Goat	Fresh mature leaf juice with equal quantity of ginger is given twice/day for a week.
14	*Cissus quandrangularis*L.	Vitaceae	Pirandai	Climber	Stem	Paste	Bone fracture, wound	Goat	Aerial parts paste is used as poultice. It is also used to control maggots and ticks, to prevent secondary wound infection due to tick bites. In case of lumpy skin disease, the stem is crushed with red soil and pork fat smear over the whole body.
15	*Circumaamada*Roxb.	Zingeberaceae	Mansalinji	Herb	Rhizome	Paste	Bone fractured	Goat	Young rhizomes crushed and mixed with coconut oil is dressed up on bone fracture area and cut injury once in a day.
16	*Circuma longa* L.	Zingeberaceae	Inji	Herb	Rhizome	Decoction	Throat pain, Ear pain	Cow	Leaves extract mixed with salt and pepper which is given to animals with the help of drenching tubes in tymphany.
17	*Datura metel*L.	Solanaceae	Umathai	Herb	Leaves	Paste	Poison bite	Goat	Matured leaves are crushed and pure extract applied on bite area.
18	*Jatropha curcas* L.	Euphorbiaceae	Katamanakku	Shrub	Latex	Paste	Wound infection	Goat	Latex mixed with curcuma powder, 1 table spoon paste prepared and used to dressing on infestation and for fly repellent once in a day.
19	*Lawsoniainermis*L.	Lytheraceae	Maruthani	Tree	Leaves	Powder	Fertiliza-tion	Goat	Matured leaf powder is given with any fodder to maintain pregnancy just after fertilization for one week.
20	*Mangifera indica* L.	Anacardiaceae	Mamaram	Tree	Stem	Decoction	Indiges	Goat	Bark extract made decoction which

					Bark		-tion		is given to goat for fever and bloody diarrhoea. Fruits and bark are crushed with water and given to animals against diphtheria.
21	*Nerium oleander* L.	Apocynaceae	Aralli	Shrub	Latex	Raw material	Poison bite	Goat	Latex applied on poisoned area and orally for insect and snake bite.
22	*Piper nigrum* L.	Piperaceae	Milaku	Climber	Fruit	Tea	Fever Cough	Goat	Fruits and ginger decoction is drenched daily once to buffaloes to treat fever and cough.
23	*Psidiujm guajava* L.	Myrtaceae	Koya	Tree	Leaf	Juice	Dysentery	Goat	Fresh young leaves of the extract mixed with 1 spoon of table salt are given 2 times in a day for 2 days.
24	*Tribulus terrestris*L.	Zygophyllaceae	Nerunji	Herb	Whole plants	Powder	Urinary problem	Goat	Whole plant extract made with water is given orally twice a day for 2-3 days to goats for curing urinary problem.
25	*Vitex negundo* L.	Verbenaceae	Notchi	Shrub	Leaves	Paste	Foot and mouth disease	Goat	Mature leaf paste is applied over the wounds once in a day until heal.

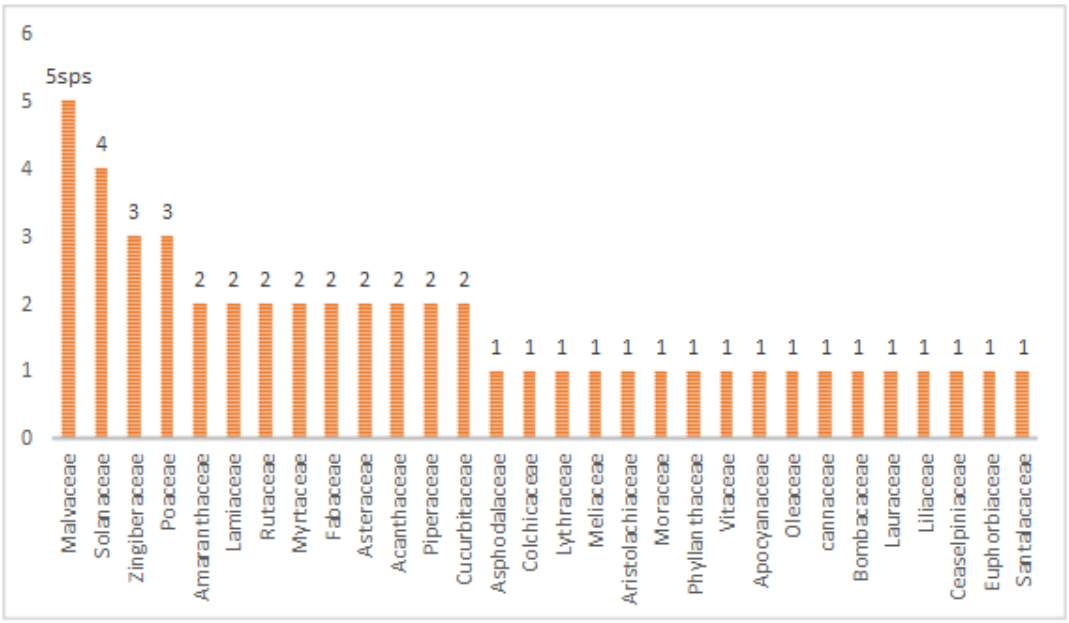

Figure 2. Family distribution of Ethnomedicinal plants used by Paliyar Tribes.

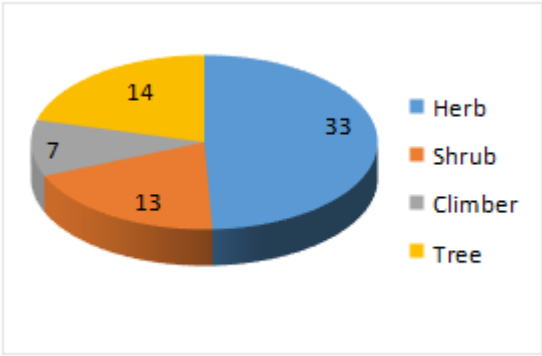

Figure 3. Contribution of various life forms in ethnomedicinal and ethnoveterinary herbs studied at Kurangani forest

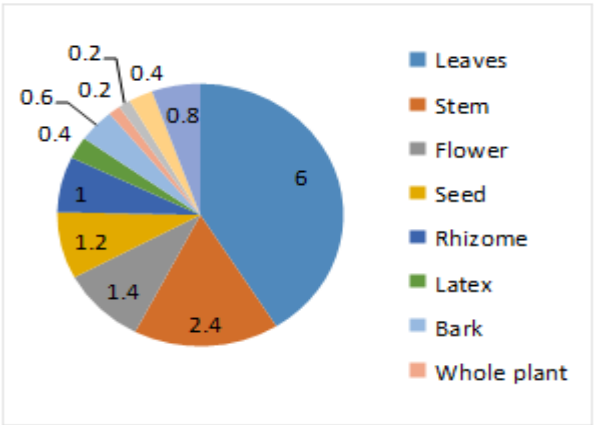

Figure 4. Percentage of ethnomedicinal and ethnoveterinary plant parts used for the preparation of medicine

Loganathan and Selvam (2018) reported that a total of 82 plant species and belonging to 40 families in Vathalmalai Hills of Dharmapuri, Tamil Nadu [12]. They are most frequently used plant parts leaf and most of the medicine prepared in the form powder and paste. The important disease cure for cold, diarrhoea, chicken pox, smallpox, cough, headache, and stomach ache. In a previous report, a total of 86 plant species belonging to 75 genera and 45 families were reported with ethnomedicinal uses. In terms of the number of medicinal plant species, *Acanthaceae* and *Cucurbitaceae* are dominant families [13]. In another report, a total of 65 plant species belonging to 37 families are described among Paliyar tribes in Theni district along the method of drug preparation, mode of administration, probable dosage and duration of treatment for skin diseases [14].

An ethnobotanical survey was carried out to collect information on the use of medicinal plants in Southern Western Ghats of India (Madurai district, Tamil Nadu). A total of 60 ethnomedicinal plant species distributed in 32 families are documented in this study. The medicinal plants used by paliyars are listed with Latin name, family, local name, parts used, mode of preparation and medicinal uses. Generally, fresh part of the plant was used for the preparation of medicine [15].

3.3 Documentation of indigenous ethnoveterinary knowledge

The present investigation indicates a high level of consensus of traditional Ethno-veterinary medicine knowledge of medicinal plants within paliyar's community. The results of this study shows that a large number of medicinal plants are traditionally used by the tribal community of Kurangani hill for the treatment of various ethnoveterinary diseases or health disorders of animals. In this study, 25 plant species are reported and arranged alphabetically by the botanical name. Vernacular names (Tamil), parts used, ailment and their administration have also been tabulated (Table 2 & Figures 3 and 4).

In ethnoveterinary documentation, it has been identified that the tribes frequently used Herb plants (10) followed by Tree species (6), Shrub species (5) and Climber species (4) for the ethnoveterinary ailments (Figure 6). In this study, the 25 species have reported belongs to different genera with highest representative the family Euphorbiaceae (3 species), and 2 species belong to the family Zingiberaceae and other genera from Piperaceae, Apocyanaceae, Meliaceae, Malvaceae, Mimosaceae, Liliaceae, Acanthaceae, Aristolachiaceae, Asclepidiaceae, Cannabinaceae, Sapindaceae, Cariaceae, Vitaceae, Solanaceae, Lythraceae, Anacardiaceae, Myrtaceae, Zygophyllaceae, Verbenaceae and Crassulacaceae are documented (1 species each) (Figure 5).

In a previous study carried out in southern districts of Tamil Nadu, ethnoveterinary medicine for the treatment of 44 veterinary health hazards is enumerated. A total of 113 plant species belonging to100 genera and 46 families are used by rural peoples in the treatments including anthrax, bone fracture, bloat, bronchitis, blackquarter, corneal opacity, dog bite, enteritis, foot and mouth diseases. The medicinal plants are listed with their scientific name, family, local name (Tamil) and mode of utilization [16]. An ethnobotanical survey was conducted in selected sites of Villupuram district. Twenty six plant species belonging to fourteen families were documented in the present study, to cure different diseases in animals [17].

These observations would serve as data base to formulate plant derived compounds in herbal veterinary drugs which could serve as better alternative to allopathic medicines that cause side effects in livestock. The study focuses the adoption of folk medicines for immediate action on animal care along with livestock related social realities.

The use of plants among the *Paliyars* reflects their interest in ethnomedicine and further investigation on these species may lead to the discovery of novel bioactive molecules. In the case of safety and effectiveness, they can be refined and processed to produce natural drugs. At the same time the traditional healers are dwindling in number and there is a grave danger of traditional knowledge disappearing soon as the younger generation is not interested to carry on this traditional work.

4. CONCLUSION

The ethnomedicinal and ethnoveterinary documentation in the Kurangani forest of Tamil Nadu state was carried out. This study highlights the need for more comprehensive documentation of medicinal plants used for treating different ailments and it is providing basic data for further research and protection of minority medicine. The traditional medicinal systems of indigenous cultural communities are sources of knowledge for bioprospecting which is most important by linking this ethnomedicinal knowledge with modern

medicine system. More ethnobotanical studies should be encouraged before the traditional knowledge of indigenous people vanishes. This wealth of traditional knowledge of tribals should be transmitted in its entirety to the younger generation and make its importance to reach wider. Our results reinforce the need for complete documentation of indigenous traditional knowledge related to various ailments before it becomes lost and forgotten. It is also essential to recognize the role of indigenous knowledge for future drug discovery and development, sustainability and conservation of plant genetic resources and making tribal youths aware about its benefits and opting this as a carrier option.

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RESEARCH ARTICLE

SYMBIOTIC RELATIONSHIP OF AM FUNGI WITH ROOT OF PHYLLANTHUS AMARUS IN WESTERN GHATS, OF TAMIL NADU

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ABSTRACT

The mutually association between a fungus and root of a higher plants are called as Mycorrhiza, when the fungal hyphae live on root surface is called Ectomycorrhiza and when penetrate the root and grows inside the root tissue is called Endomycorrhiza. The different type of Arbuscular Mycorrhizal fungi (AMF) were evaluated for the symbiotic relationship with *Phyllanthus amarus* in Western Ghats. *Glomus fasciculatum, Gigospora margarita*, etc., are isolated in the forest rhizosphere soil. In the presence of AMF in root tissues generally had greater plant height, biomass, stem diameter, number of leaves and phosphorus content where rich in amount compared to other plant species.

Keywords: Arbuscular Mycorrhizal fungi, *Phyllanthus amarus, Glomus fasciculatum, Gigospora margarita*

1. INTRODUCTION

Mycorrhiza is the most dominant organism among the many microbial community of the rhizosphere. It has been known to form a symbiotic relationship with the fine roots of plants [1] while enhancing plant capabilities to absorb nutrients [2]. The importance of mycorrhiza has been acknowledged in the fields of agriculture forestry and other hand use [3]. AMF are soil fungi colonizing most of the plant roots and forming an association called Endomycorrhiza. More than 90% of plant and 80% of plant families in all terrestrial environment from the association [4] with these obligate fungi belonging to the group Glomeromycota [5]. These fungi are known to improve the nutritional status of host, particularly that of phosphorous and there by enhance their growth, development and yield [6,7].

The current day emphasis is on sustainable agriculture, which uses less of chemical inputs like fertilizer and pesticides having adverse effect on the soil health, fertility and environment. The mycorrhiza plays an important role in sustainable agriculture [7]. The taxon *Phyllanthus* has about eight herbaceous species represented in South India, of which grown in TamilNadu. *Phyllanthus amarus* is a medicinal plant with numerous medicinal properties. It is a small herbal plant grow up to 60-75 cm in the tropical and sub tropical rain fed crop. Every part of *Phyllanthus amarus* has medicinal use and is used for treating anti-viral, hepatitis, jaundice, gonorrhea, frequent menstruation, skin sores, swelling, itchiness, and diabetes. The whole plant (root, stem, leaf area) is used in Ayurvedic formulations [8].

The objective of the study reveal that the status and diversity of AMF on medicinal plants of *Phyllanthus* species.

2. MATERIALS AND METHODS

Study area

The study area of the Western Ghats, which lies between 10˚13' to 10˚33' N in latitude and 76˚ 49' and 77˚ 21' E. The vegetation of this region, harbor may endemic species and is a unique ecological tract rich in biodiversity.

Experimental Soil

The physicochemical characteristics of the exprimental soil used for experiment were tested in Department Soil Science testing laboratories at Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India.

Rhizosphere Effect [9]

The quantitative rhizosphere effect of the plants was calculated using the formula:

$$R/S = \frac{\text{Number of microorganism per gram of rhizosphere soil}}{\text{Number of microorganism per gram of non-rhizosphere soil}}$$

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Arbuscular Mycorrhizal Inoculation

AM fungal spores were isolated from the forest soil, following the wet sieving and decanting method [10]. The spores were identified by using the manual written by Schenck and Perez [11]. The Genera of *Acaulospora*, *Gigaspora*, *Glomus*, *Scutellospora* and *Sclerocystis* were isolated from 100g rhizosphere soil samples. Ten kg of the experimental soil was collected from forest and filled in each pot after sterilization. The AM fungal spore inoculum was added (10g/each pot).

Establishment of test plant and greenhouse experiments

The studies were conducted under greenhouse conditions with temperature ranges from 28-31˚C. AM fungal treatments were given on a layer below the germinated randomized. All the pots are maintained greenhouse condition.

Mycorrhizal Status

Results were processed using Phillips *et al*. [12] technique to study the percent of root colonization.

Phosphorus Content

The phosphorus content in the shoots was determined by the vanado-molybdate phosphoric acid yellow color method outlined by Jackson [13].

3. RESULTS AND DISCUSSION

The different type of Arbuscular Mycorrhizal fungi (AMF) were evaluated for the symbiotic relationship with *Phyllanthus* in Western Ghats of Tamil Nadu. *Glomus vesiculiferum, Glomus fasciculatum, Gigospora margarita, Scutellispora nigra, Acaulospora sporocarpa* etc., are isolated in the forest rhizosphere soil. In the presence of AMF in *Phyllanthus species* root tissues generally had greater plant height, biomass, stem diameter, number of leaves and phosphorus content where rich in amount compared to other plant species. The results are as follows, forest black soil with pH 7.1, Moisture 4.86%. Total organic carbon 1.71, Nitrogen 0.08%, Phosphorus 4.52%, Potassium 7.94%, Magnesium 0.121%, Calcium 0.472%, Copper 0.03 ppm, Zinc 3.86 ppm, Manganese 0.97 ppm and Iron 8.24 ppm (Table 1 and 2). In general, all the recoded parameters showed gradual increase parallel to the increase in plant age as 30, 60, and 90 days of plant growth. Arbuscular Mycorrhizal Fungi species showed a significant increase in plant height, biomass, stem diameter, number of leaves and phosphorus content of *Phyllanthus amarus* Schum. & Thonn. [8] and *Allium cepa* L.

Table 1. Showing the different type of AMF species.

Plant name	Type of infection			AMF Spore density (100g/soil)	AMF species
	Hyphae	Vesicles	Arbuscular		
Phyllanthus amarus Schum. & Thonn	+	+	_	420	*G. deserticola, G. citricola, G. macrocarpum, G. canadenae, A.sporocrpa, A lacunosa,*
Allium cepa L.	_	+	+	450	*Gi.margarita, S.alborosea G. delhiense, G. deserticola G. boreale* and G*. versiculiferum*

Table 2. Showing the root infection of AMF inoculated *Allium cepa* L.

S. No	Number of days	Shoot Length(cm)	Root length (cm)	Type of infection			% of infection
				Hyphae	Vesicles	Arbuscular	
1	30	6.98 ±0.73	5.57 ±0.55	+	_	+	63
2	60	7.6 ±1.01	6.6 ±1.07	+	+	_	82
3	90	8.24 ±0.67	6.85 ±0.55	+	_	+	96

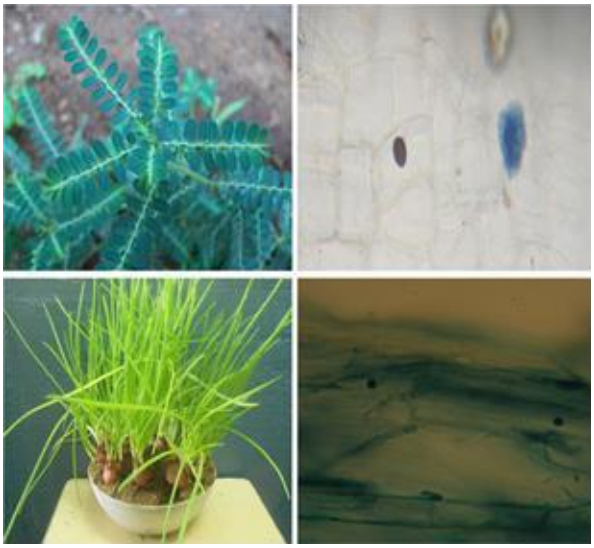

Figure 1. Showing the habit and root infection of *Phyllanthus amarus* Schum. & Thonn and *Allium cepa* L.

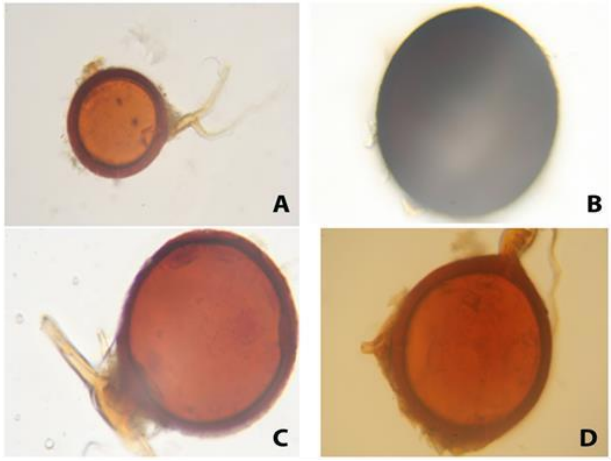

Figure 2. Showing the different type of AMF spore.

A-*Glomus vesiculiferum,* B-*Scutellispora nigra,* C-*Acaulospora sporocarpa,* D-*Gigaspora margarita*

In this study highest mycorrhizal percent colonization was observed in plants treated with *Glomus* species. Highest number of mycorrhizal spores was found in root zone soil. Least number of spores occurred in the uninoculated root zone of plants [14]. Host preference among AM fungi has been reported by earlier workers [15]. The plant biomass (shoot+root) was enhanced due to *Glomus* species inoculation with the *Allium cepa* L. (Figure 1 and 2) has been reported in aromatic plants like *Palmarosa*, *Eucalyptus*, *Bergamot mint* and Sweet basil.

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RESEARCH ARTICLE

FREE RADICAL SCAVENGING ABILITY OF A POTENT THERAPEUTIC PLANT *MUSSAENDA LUTEOLA* DELILE (RUBIACEAE)

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ABSTRACT

The aim of present study was to investigate the *in vitro* antioxidant potential and total extractive yield of *Mussaenda luteola* Delile leaves. Antioxidant activity was assessed by using 2,2- diphenyl-1-picryl-hydrazyl (DPPH•) assay, reducing power activity and [2,2'-azino-bis (3-ethylbenzthiazoline-6-sulphonic acid)] ABTS•+ assay. Here ascorbic acid (ASA) and rutin were used as standard antioxidants. The results of the study indicates that the chloroform extracts of the leaf of *Mussaenda luteola* possesses significant scavenging activity against DPPH• (17.56) and reducing power activity (0.759) at 700nm absorbance. The ethanolic leaf extracts holds high free radical scavenging activity (ABTS•+) at 735nm (94.59). The free radical scavenging and antioxidant activities may be attributed to the presence of adequate phenolic and flavonoid compounds. The ethanolic leaf extract of *M. luteola* yields maximum extractive yield percentage (37.08%). This study revealed that the leaf extracts of *Mussaenda luteola* has demonstrated significant antioxidant activity.

Keywords: *Mussaenda luteola*, total phenolic, flavonoids, DPPH• assay, ABTS•+ assay

1. INTRODUCTION

Natures are sources of medicinal agents and produces enormous number of new drugs based on their use in traditional medicine. Medicinal plants typically contain combinations of different chemical substances that may act individually, additively or in synergy to improve the quality of health. Traditional medicines are found to be fundamentally preventive, protective, nutritive and curative. They are safe and harmless and could treat patients without side effects. In spite of the phenomenal progress in the area of development of new drugs from synthetic sources and appearance of antibiotics as major therapeutic agents, plants continue to provide basic raw material for some of the most important drugs [1]. Phytoconstituents are becoming a great source of interest in the present because of its wide applications in pharmaceutical industry. While finding the prior plants with high potent medicinal values, it can be used to treat various ailments. In such case we could prevent and save the present and future generations from health hazards, new novel diseases and various unknown health deteriorating ailments. The main aim of this study is to find plants with strong antioxidant assay which could serve as good candidate for the development of quality phytomedicine. The *Mussaenda* genus has been instrumental in the discovery of medicinal natural products. The plants are members of the Rubiaceae (madder or coffee family) and are native to the Old World tropics, from West Africa through the Indian sub-continent, South-East Asia and to Southern China [2]. There are more than 200 species of *Mussaenda* known. Some species of *Mussaenda* have been used in Chinese and Fijian traditional medicine.

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2. MATERIALS AND METHODS

Extractive yield

The extract yield contains different phytoconstituents. Extractive value is the measure of the chemical constituents in a plant material. The powdered plant material (crude drug) contains active chemical constituents which are responsible for its biological activity. Total soluble quantity of the drug in any particular solvent or mixture is referred to, as its extractive value. Extractive values of crude drugs are useful for their evaluation, especially when the constituents of a drug cannot be readily estimated by other means.

The percentage yield (recovery) of evaporated plant extracts were calculated as follows:

$$\text{Yield (\%)} = \frac{[\text{Extract + container (g)}] - [\text{Empty container (g)}]}{\text{Sample weight (g)}} \times 100$$

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Determination of in vitro antioxidant activity

DPPH radical scavenging activity

Free radical scavenging activity of the plant extracts was assessed accordance with Blois [3], the stable DPPH▪ method. A solution of radical was prepared by dissolving 2.4mg of 0.1mM DPPH▪ in 100mL methanol. The test samples (5µg/mL) were mixed with 3.9 mL of methanolic DPPH▪ solution. The reaction mixture was shaken vigorously, incubated in dark at room temperature for 30 min and the absorbance of the reaction mixture was measured at 517 nm spectrophotometrically. The radical scavenging capability were compared with the activity of rutin, quercetin, BHA and BHT. Per cent DPPH▪ discoloration of the samples was calculated using the formula:

DPPH radical scavenging activity (%) = [(Control OD – Sample OD)/Control OD] ×100.

Antioxidant capacity of the extracts to decrease the initial concentration of DPPH were expressed as inhibitory concentration (IC_{50}), these values were calculated from the linear regression of the % of DPPH scavenged versus concentration of the extracts [4].

ABTS▪+ antioxidant assay

$ABTS^{▪+}$ radical scavenging activity was performed according to the method suggested by Siddhuraju and Manian [5]. The radical cation ($ABTS^{▪+}$) was pregenerated by adding 5 mL of 14mM $ABTS^{▪+}$ solution to 5mL of 4.9 mM potassium persulphatesolutionand was incubated in dark for 12-16 h at room temperature. Before initiating the reaction, the solution was suitably diluted with ethyl alcohol (about 1:89 v/v) to obtain an absorbance of 0.700 ± 0.02 at 734 nm and then used for initiating the antioxidant assay. 50 µL/mL of sample was added to 950µL of diluted $ABTS^{▪+}$ solution and vortexed for 10 seconds. After 30 min of incubation, the reduction in absorbance was recorded at 734 nm. Trolox (50 µg/mL) was used as a reference compound.

Determination of Reducing power [6]

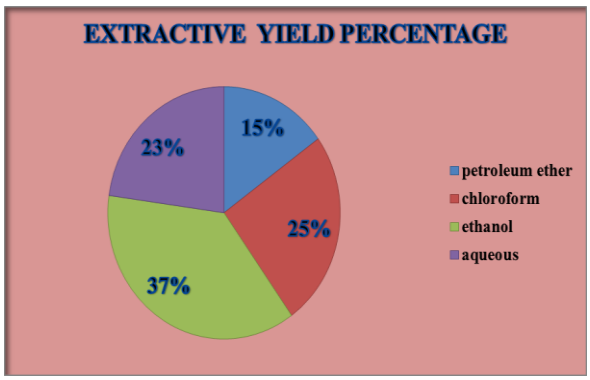
Different concentrations of *Mussaenda luteola* extract (100– 1000 µg) in 1 ml of distilled water were mixed with phosphate buffer (2.5 ml, 0.2 M, pH 6.6) and potassium ferricyanide [$K_3Fe(CN)_6$] (2.5 ml, 1%). The mixture was incubated at 50°C for 20 min. A portion (2.5 ml) of trichloroacetic acid (10%) was added to the mixture, which was then centrifuged at 3000 rpm for 10 min. The upper layer of the solution (2.5 ml) was mixed with distilled water (2.5 ml) and FeCl3 (0.5 ml. 0.1%) and the absorbance was measured at 700 nm. Increased absorbance of the reaction mixture indicated increased reducing power. Ascorbic acid was used as the standard. Phosphate buffer (pH 6.6) was used as blank solution. The absorbance of the final reaction mixture of two parallel experiments was taken and is expressed as mean ± standard deviation.

3. RESULTS

For the present study *M. luteola* leaves were collected for total extractive yield and antioxidant activities.

Extractive yield

The total extractive yield of *M. luteola* leaves was estimated in all the four selective solvents through standard procedures and it results in the separation of medicinally active portions of plant leaves. The results of the extractive yield from *M. luteola* was measured and calculated and it ranged between 15.03% - 37.08% respectively and their results were depicted in the Figure 1. The ethanolic leaf extract of *M. luteola* yields maximum yield percentage (37.08%) followed by chloroform (25.09) and aqueous (22.80%). The minimum extractive yield percentage was found in the low polarity solvent petroleum ether (15.03%). This result shows that the ethanolic leaf extract under the observed study proves that most of the phytoconstituents are found active in the leaves of *M. luteola.*



In vitro antioxidant analysis

DPPH radical scavenging activity in different solvent extracts of M. luteola leaves

The antioxidant activity of *M. luteola* was evaluated using various solvent extracts such as petroleum ether, chloroform, ethanol and aqueous. The radical scavenging activity based on the DPPH assay was determined and found the percentage of inhibition with the increase in concentration.

Ascorbic acid is used as a control. Among the solvent extracts chloroform (17.56) holds the highest IC_{50}valuefollowed by petroleum ether and ethanol. The minimum IC_{50} was recorded in aqueous (2.67) (Table 1).

ABTS radical scavenging activity

The total antioxidant activity of *M. luteola* was assessed by ABTS cation as the percentage of inhibition at 743 nm. In the present investigation ethanol extract registered the highest amount 94.59µmol/ml and followed by aqueous and chloroform. The lowest value was occurred in the petroleum ether 55.17µmol/ml (Table 2).

Determination of Reducing power [6]

Different concentrations of *M. luteola* leaf extract (100– 1000 µg/g) were taken to estimate the radical scavenging activity based on the reducing power and the absorbance was measured at 700 nm. Increased absorbance of the reaction mixture indicates the increased reducing power. In this case the ascorbic acid was used as the standard. Phosphate buffer was used as blank solution. The absorbance of the final reaction mixture is calculated and revealed that chloroform (0.759 $\mu l/ml$) in different concentration has the higher absorption and the minimum is calculated in ethanol (0.440 $\mu l/ml$) (Table 3).

Table 1. DPPH antioxidant activity in different solvent leaf extracts of *Mussaenda luteola*

S. No.	Solvents	IC_{50} Value (µg/ml)
1.	Petroleum Ether	7.77
2.	Chloroform	17.56
3.	Ethanol	4.72
4.	Aqueous	2.67
5.	Standard	1.8

Values are mean ± SD of three independent experiments. Values not sharing a common letter in a column are significantly different (P<0.05).
*Values expressed as TEAC (Trolox equivalent antioxidant capacity) in µmol/ml extract.

Table 2. ABTS radical scavenging activity in different solvent leaf extracts of *Mussaenda luteola*

S. No.	Solvents	ABTS* RADIAL SCAVENGING ACTIVITY (µmol/ml)
1.	Petroleum Ether	55.17
2.	Chloroform	90.46
3.	Ethanol	94.59
4.	Aqueous	91.10

Table 3. Reducing power assay in leaf extracts of *Mussaenda luteola*

S. No	Solvents	Concentration (g/ml)	OD value	Mean value $(\mu l/ml)$
1	Petroleum ether	10	0.354	0.606
		20	0.661	
		30	0.687	
		40	0.722	
2	Chloroform	10	0.656	0.759
		20	0.793	
		30	0.772	
		40	0.815	
3	Ethanol	10	0.426	0.440
		20	0.483	
		30	0.425	
		40	0.427	
4	Aqueous	10	0.761	0.748
		20	0.734	
		30	0.725	
		40	0.772	

4. DISCUSSION

Medicinal plants are a crucial source of natural antioxidants they produce a diverse range of secondary metabolites with antioxidative properties that have therapeutic potential. Antioxidants can be effective in preventing free radical formation by scavenging them or increasing their decomposition rate and suppressing disorders [7]. Currently, there is a growing interest towards natural antioxidants of herbal resources. In the present study the free radical scavenging ability of various solvent extracts of *M. luteola* leaf were analyzed using DPPH, ABTs and reducing power assay and was depicted in Table

1-3. It was noted that ethanol leaf extract exhibited remarkable scavenging ability than other solvent. Whereas, in reducing power assay chloroform extract exhibited antioxidant property. The reducing ability is generally associated with the presence of reductants which employ antioxidant potential through breaking down the free radical chain by donating a hydrogen atom or preventing peroxide formation [8]. These results are in accord with high levels of phytochemical contents in *M. luteola* leaf. The presence of bioactive compounds in the ethanol extracts of the studied species positively correlated with their antioxidant potential, confirming their major role in antioxidant activity.

5. CONCLUSION

Plants are being widely used in the production of new natural products in various fields such as pharmaceuticals, nutraceuticals and food production. Antioxidant studies pave the way to claim the traditional medicinal property of plants. Hence it is also proved in the current investigated plant *M. luteola.* The plant that is taken under studies shows that it could serve as a potent therapeutic plant. To find the action mechanism of antioxidants further studies can be done in *M. luteola* by way of isolation and characterization of antioxidant compounds, and also by *in vivo* study models.

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RESEARCH ARTICLE

TIME SERIES ANALYSIS AND FORECASTING OF INDIAN ECONOMY

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ABSTRACT

India being an entity of highly populated nation across the globe, stands as a developing country with a perceptible economic status relative to the other countries. Integrals such as socio-political activities exert influence on the ups and downs of the economic development of any country. India was the sprightly growing economy in the early 2000's but at the neoteric time, it is said that the economical maneuver of India has been directing towards the downhill. Prepending to the outbreak of Covid-19, the GDP discern to deflate below 0% at the onset but has shown a substantial upward movement post lockdown period. Thus, it can be ensured that the economical movement of India is progressing in a consistent approach despite the decline. In this paper, we aim at analyzing the historical movement of Indian economy in view with the recent up and downs and thereby also forecast the future economic movement with the help of time series.

Keywords: Economy, GDP, GST, Inflation, Repo and Reverse repo rates, National Income, Covid-19, Trend line, Extrapolation, Time series, Investment

1. INTRODUCTION

An economy is the larger set of all resource hub relating production and consumption activities that aid in determining the wealth perspective of any country. Being constituted by the major arenas that support to the sectorial development of the nation, India is ranked the seventh largest economy at present, holding the ascendancy of the country towards a developing nation. One of the influential sectors of the Indian economy remains Agriculture. Its share in the GDP of the country has declined in the past few years but aims to double farmer's income by 2022 through various schemes introduced in the union budget. The other support hold of Indian economy is the Industry sector, the potential of which has been increased since 1991. Forbye the developments, it is exigent to consider that in order to hold the highest potential of the economy, an optimal level of coaction is required throughout the sectors. Hence appending strength to the union of federal structure, thereby also reinforcing India's economy with initiatives as of Goods and Services Tax (GST), Insolvency and Bankruptcy Code (IBC), Start-up India, Digital India and hence framing a new portrait to its enlightening outwork in the nation's financial status, have aided the Indian economy jump to reach a determined outcome in the recent times and have cemented India's prominence as major silver lining of global economy.

India is one among the fastest growing major economies, underpinned by a stable macro-economy with declining inflation and improving fiscal and external balances. In this paper, the Gross Domestic Product (GDP) of our country collectively has been taken as the population for our study, the Goods and Service Tax (GST) and the Gold rates serve as the samples. We analyze their movements for the past 5 years and further forecast their movements for the upcoming year. We also take into consideration, the impact of the Covid-19 pandemic and the lockdown imposed during this study. It further restrained India's economy to a decline rate at extremities but on the other hand, the downswing has later started to reshape and progress with an accelerating momentum, which in turn makes sure that the economic growth of India is steady. Thus, this study stands as the supportive evidence for the fact that economic status of our country is moving in a standard manner, irrespective of the external factors.

2. Preliminaries

In this section, we shall mention the basic terminologies relevant to our study.

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Economy

An economy constitutes numerous activities related to the production and consumption and aid to determine the financial status and hold to serve the citizens of the country.

Capital and investment

The financial assets, constituting the funds in deposit accounts and similarly obtained from other financing sources are known as Capital.

The fixed capital assets, produced in an economy as the creation of capital goods over a time period is known as investments.

GDP

GDP the Gross Domestic Product is a mark for the economic production of the country and is the final value of goods and services produced within the territory over a period of time.

GST

GST, the Goods and Service Tax is a value added tax that is paid by the consumers on the goods and services sold for domestic consumption and needs.

Inflation [1]

Inflation refers to the persistent rise in general price level in the country over a period of time. Inflation could be monetary or price inflation. During periods of inflation, there is an increase of the money supply.

Repo rate [1]

It is the rate at which the Reserve Bank of India (RBI) lends short term money to the banks against securities. When the repo rate increases, borrowing from the RBI becomes more expensive and when the repo rate decreases, borrowing becomes cheaper.

Reverse repo rate [1]

It is the rate, at which banks park short-term excess liquidity with the RBI. An increase in the reverse repo rate means that the RBI is ready to borrow money from the banks at higher rate of interest.

Moving Average

A simple technical analysis tool that helps us to arrive at the price data graph by updating the average price constantly taken over a period of time is known as Moving Average.

Trend line

A line drawn over pivot-high or pivot-low values to depict the current movement in direction of price is known as Trend line. The pattern of line describes the direction, speed of price and price contraction.

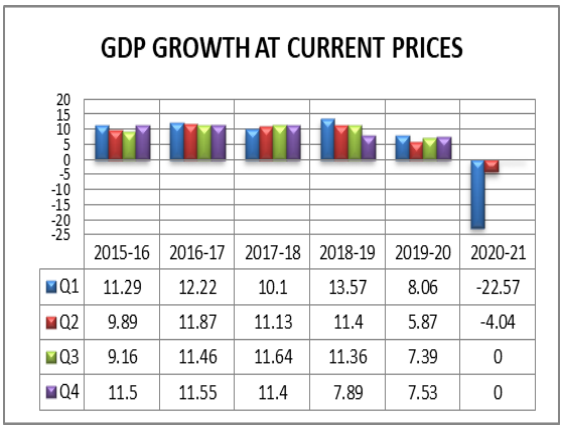
Extrapolation

The process of attaining a conclusion of something by assumption of the current method or the existing trend hoping it to continue further is known as Extrapolation.

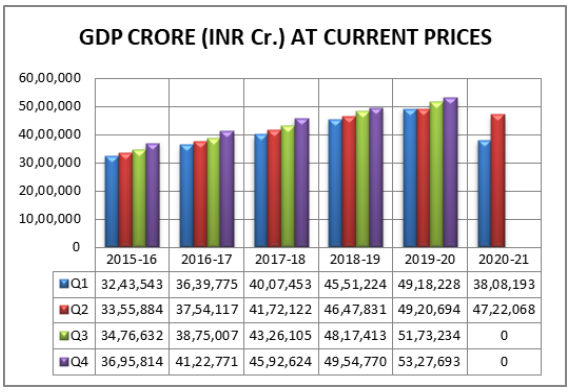
3. GDP Movement:

As the Gross Domestic Product (GDP) holds for the total value of goods and services produced, it serves as an indicator to assess the economic growth of any country. India now stands as the 11th largest across the world by its nominal GDP. The GDP of India is calculated from the functioning of various sectors including Agriculture, Trading, Industries, Forestry, Financing and several other public services. The Indian government usually releases the GDP value for each quarter of the financial year.

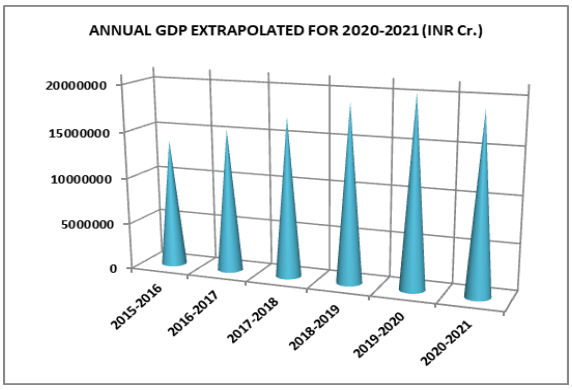
The data from the financial year 2015-2016 to the current year 2020-2021 has been collected for our study. The growth rate and the value of GDP are tabulated below and the same has been plotted in the graph. This can be used to elucidate that the India's economy had been decelerating even before the advent of the Covid-19 crisis. The rate of GDP growth went along the downside at a deeper note in the year 2019-2020. Before even making an attempt to recover from this deep fall, the impact of Covid-19 and the subsequent lockdown further let the GDP to reach the lowest low.

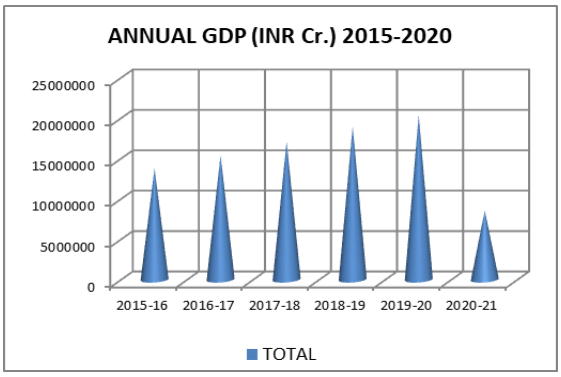


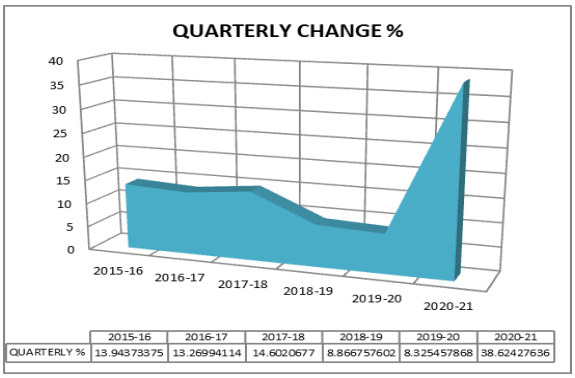
	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21
Q1	11.29	12.22	10.1	13.57	8.06	-22.57
Q2	9.89	11.87	11.13	11.4	5.87	-4.04
Q3	9.16	11.46	11.64	11.36	7.39	0
Q4	11.5	11.55	11.4	7.89	7.53	0



	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21
Q1	32,43,543	36,39,775	40,07,453	45,51,224	49,18,228	38,08,193
Q2	33,55,884	37,54,117	41,72,122	46,47,831	49,20,694	47,22,068
Q3	34,76,632	38,75,007	43,26,105	48,17,413	51,73,234	0
Q4	36,95,814	41,22,771	45,92,624	49,54,770	53,27,693	0

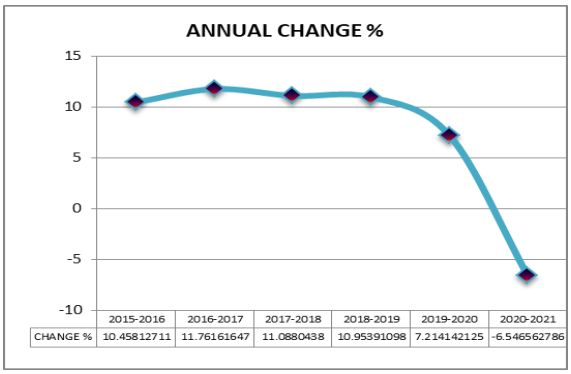






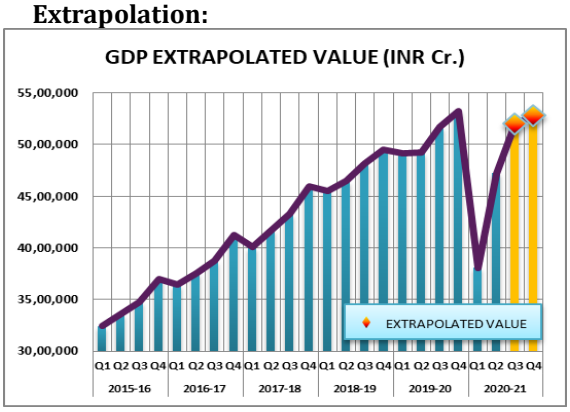
	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21
QUARTERLY %	13.94373375	13.26994114	14.6020677	8.866757602	8.325457868	38.62427636

The above graphs show the higher contraction of GDP to around -23% in the Q1 (April-June) of the current financial year 2020-2021. This is reported to be the substantial contraction ever since the beginning of quarterly calculation of GDP in 1996. This downtrend reflects the unprecedented discontinuation of economic activity in the particular quarter which is certainly due to the effect of the restrictions imposed following the Covid-19 pandemic. Despite this downfall, it can be seen that the GDP has eventually increased in the successive quarter (July-September) soon after the relaxation of lockdown.



	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020	2020-2021
CHANGE %	10.45812711	11.76161647	11.0880438	10.95391098	7.214142125	-6.546562786

Extrapolation:

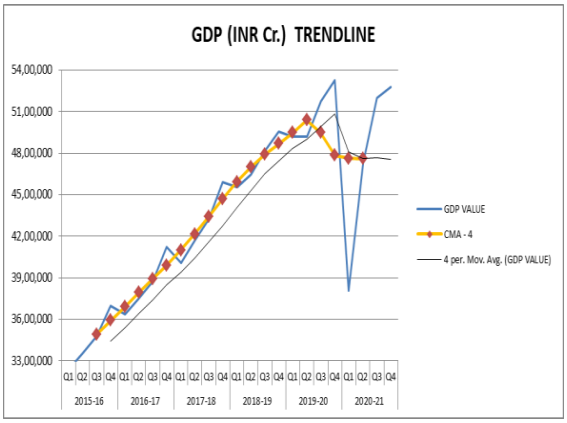


The method of Extrapolation is nothing but an estimation that can be highly useful in the prediction of the forth coming values of a system.

The GDP value has been statistically extrapolated for the next quarter and it has been shown in the above graphs. The quarterly change percentage from Q1 to Q4 for each year and the subsequent annual change percentage have also been depicted.

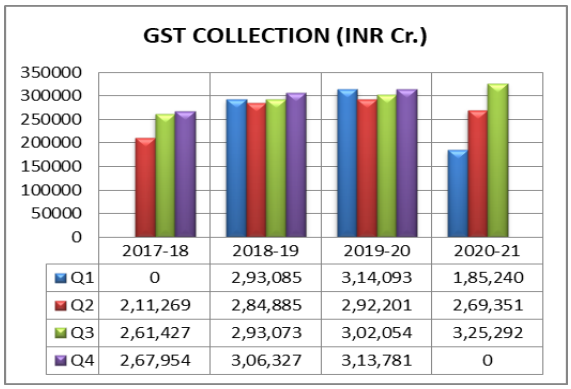
Trend line:

A Trend Line can be seen as a technical bounding line that is drawn over a chart to easily recognize the direction of any specific price or rate.

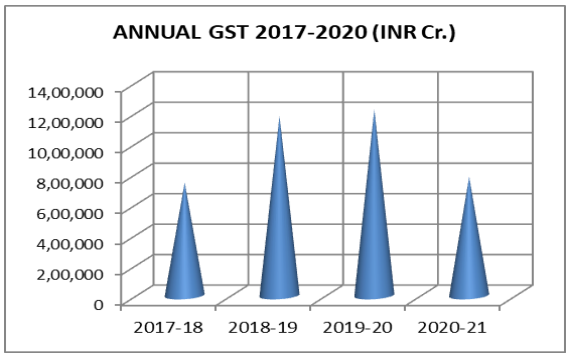


The Trend Line considered here is the 4 period Moving Average line that connects the GDP value of Q1 of 2015-2016 to Q4 of 2020-2021. The single line drawn on the Centered Moving Average (CMA) for a period of 4 indicates the movement of GDP.

4. GST – The Economic Booster



	2017-18	2018-19	2019-20	2020-21
Q1	0	2,93,085	3,14,093	1,85,240
Q2	2,11,269	2,84,885	2,92,201	2,69,351
Q3	2,61,427	2,93,073	3,02,054	3,25,292
Q4	2,67,954	3,06,327	3,13,781	0

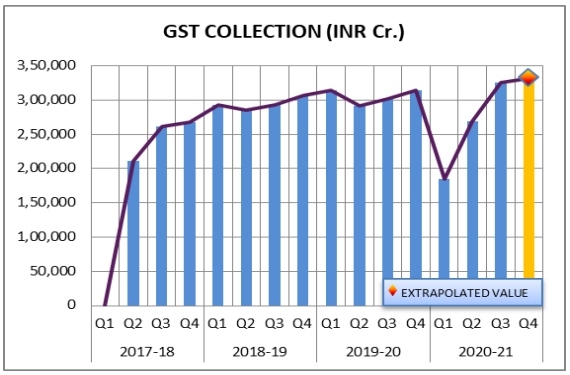


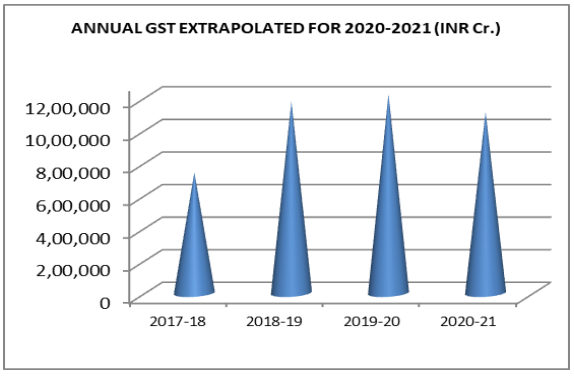
GST is basically an indirect tax system that is imposed on the supply of goods and services, implemented in July 2017. The Council has assigned different GST rates to different goods and services.

The data has been taken from the implemented fiscal year 2017-2018 to the current year 2020-2021. The quarterly and the annual collection of GST has been listed and represented in the above graph. The GST revenue collections were seen falling down for the first quarter (April-June) of this fiscal year, with the lowest record collection since 2017. This is due to the consequences of the Covid-19 lockdown in the country.

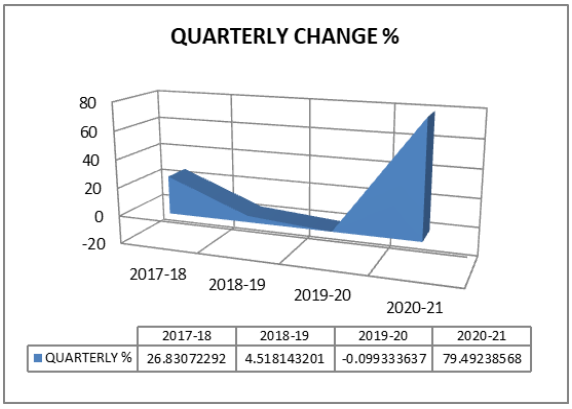
Soon after the relaxation of lockdown, GST revenue has begun to rise since September 2020. Particularly, during the month of December 2020, the GST revenue collection has created a history by making the highest collection of Rs.1.15 lakh Crore, ever since 2017. Thus, in spite of beginning at a lowest position, the revenue has just stood up enormously, indicating the positive direction of our country's economic movement.

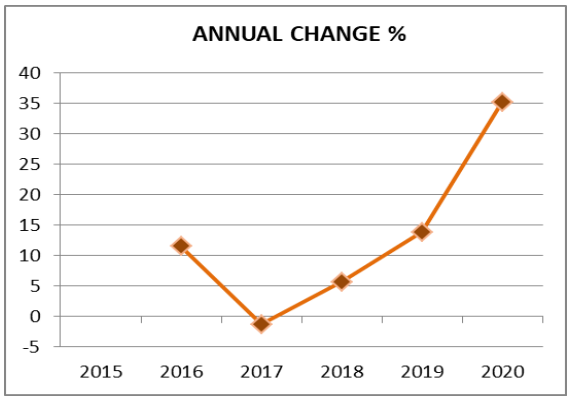
Extrapolation:



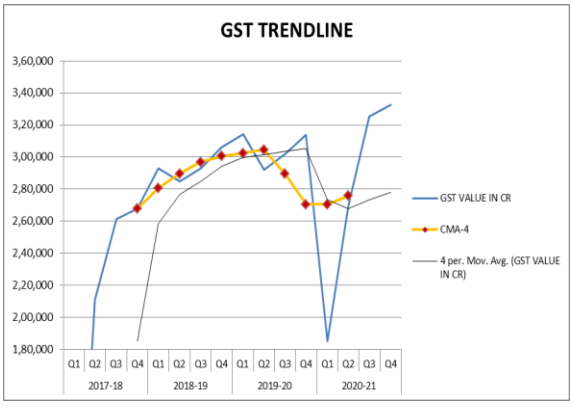


By the method of Extrapolation, the GST revenue for the fourth quarter of this financial year has been calculated. Further, it helped us to find the quarterly and the annual change percentage. The quarterly change between Q1 and Q4 for the year 2020-2021 was also calculated in the same way ad we notice that the change happens to be nearly around 80% which is quite unbelievable.





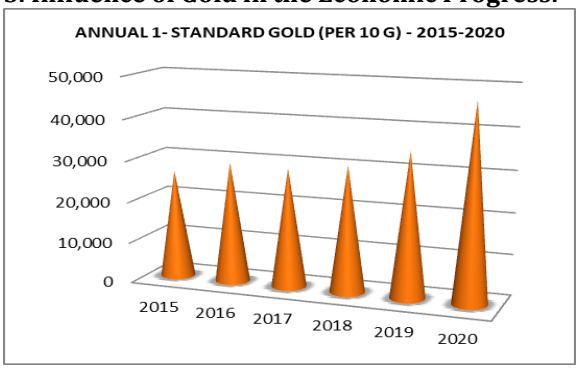
Trend line:



The values of GST revenue since 2017 has been plotted in a line graph, on which the CMA-4 and 4-period moving average are drawn. The trend line for the CMA can be seen from the above graph, which clearly shows the up and down trends in the collection of the revenue.

Further, this trend line reveals that the price movement is approaching an upward momentum, indicating that the revenue shall still tend to increase, thereby boosting the Indian economic status.

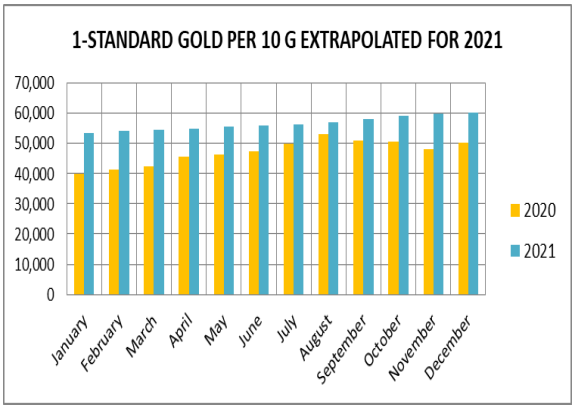
5. Influence of Gold in the Economic Progress:

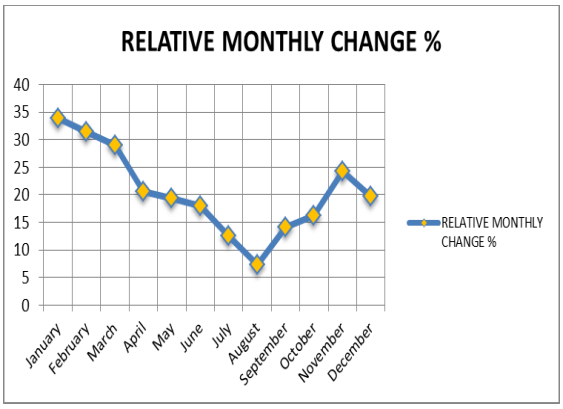


Our country is one of the leading consumers of the Yellow metal, which constitutes an integral portion of our total import goods. Gold is often relied upon to be the safest investment and hence it is considered as an alternate investment option for equity. So whenever the stock market falls, the Gold investment abruptly increases and causes a great demand among the investors.

From the historical data, we can observe that the 10 gram gold rate during 2012 was somewhere around Rupees 25,000 but it has now claimed up-to nearly Rupees 50,000. Thus to make a 100% growth, it has merely taken around 7 to 8 years. From the above graph, we can notice that the gold rate has increased around 80% from 2015 to 2020, which represents the enormous growth rate of this precious metal.

Extrapolation:

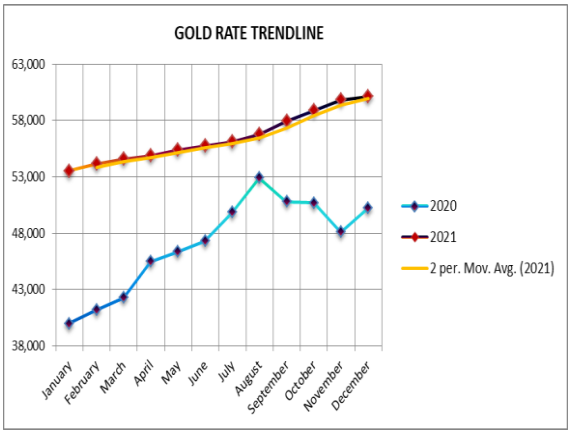




The price of 1-Standard Gold per 10 Gram has been extrapolated for the next year 2021 using the time series data of 2020. The comparison of the same can be seen from the above graph.

The graph clearly depicts the relative monthly change percentage for each month belonging to the years 2020 and 2021 respectively. The varying percentage tends to fall at the mid year while both at the beginning as well as at the end of the year, it has shown a reasonable progress.

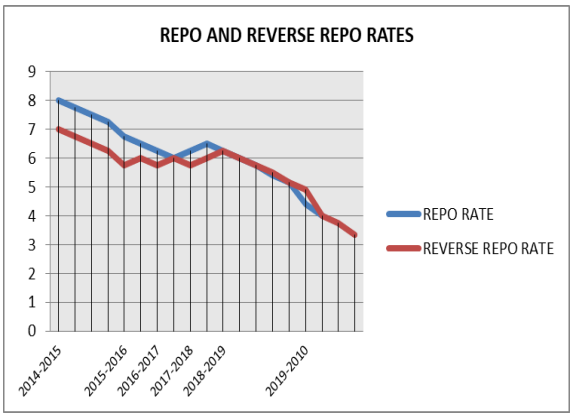
Trend line:



The trend line for the gold rate distinctly represents the relative price movement during the years 2020 and 2021. The 2 period moving average line shows the futuristic progression of the gold rate in India, which is expected to reach a new height.

6. Repo Rate and Reverse Repo Rate Trend:

Both the repo rate and the reverse repo rate, being related to the RBI, have a considerable effect on the economy. It can be understood that an increase in these rates decreases the flow of money in the economy, while the decrease in the rates increases the cash-flow. The repo rate and the reverse repo rates since 2015 to till date have been collected and the same has been represented graphically. Both the rates were dropped down from nearly 8 to 3.2 over the past five years.



7. Analysis and Forecasting

As per the statistical data and our analysis, we observe that the Indian economy was already in a negative acceleration even before seven to eight quarters. Drastically, it touched the lowest low ever in the history, due to the global pandemic caused by the corona virus. Thus, the outbreak of Covid-19 has further declined the GDP of India. But on the lighter note, the pharmaceutical sector and the IT sector have really performed well despite the negative impact of Covid-19, extending their hands for the gradual recovery of GDP in the recent quarters. The same conclusion has been obtained from the extrapolation examination as well.

Despite the major fall back, the Indian economy has started to regain its momentum since the second quarter of this fiscal year. This is evident from the colossal collection GST in December 2020 which is the highest collection ever since the implementation of GST in 2017. It is satisfactory to see that around 1.5 lakh Crore Rupees has been collected as revenue in December 2020. This is almost 12 per cent higher than the same period a year ago. The explanation for this massive growth in GST collections could be due to the increase in economic activities. In the recently released report by the Finance Minister of India, it is reported that the collection of GST due to domestic transactions added up to 8 percentage of growth while the imports raised the rate by 27 per cent.

It is always dependable to invest in the ever safe commodity which is Gold, even during the economic slowdown. The downtrend of the economy and the rising inflation rates have thus boosted up the Gold price in India. The same has been observed from our analysis. The prices are believed to be in a rising movement due to the social and psychological impact of the pandemic among the people. Thus the inflation of gold rate will further add up to the economy of our country.

Thus, from our time series analysis, we can forecast that the movement of current Indian economy can adapt itself to the unprecedented times and can also regain its position to hold the nation in a developing path.

8. Conclusion

Economic growth can not only be seen as the increased rate of the production and consumption of economic goods but also to occupy a significant position which can act accordingly to maintain the stability. The increased innovations and investments, increased employments, tackling the environment challenges and decrease in the poverty and illiteracy can also account for the development of a country's economy.

Beaten up by Covid-19, there are reports that the economies across the globe are expected to shrink to a rate like never before. Since the uncertainties of the pandemic continue to sustain, some changes like building a social capital and a stronger economic infrastructure can aid in saving the huge economic decline.

Keeping this in view, our Indian government has implemented several schemes that aid in holding back the economy of our country. The major schemes include the Atmanirbhar Bharat Abhiyan (Self-reliant India Mission), Garib Kalyan Rojgar Abhiyaan, Way for the Robust and Resilient Agricultural Sector and many other applicable schemes to tackle the impact of the pandemic on the economic growth. Further, encouraging and providing financial support for the Self Help Groups (SHG), small scale industries, handmade artistic works by the tribal, etc., is a commendable activity to increase the economy. This kind of implementations and innovations can thus bring forth the ability to maintain a stable economy.

Considering the poverty line of India, the reports propose that the poverty rate of our country has convincingly reduced, declining from 54.7% in the year 2005 to 68.8% in the year 2020. Thus the Indian economy could be counted on to retain this steady progression since the opportunities in the investment, financial, industrial, pharmaceutical and agricultural sectors will remain the same at any cause.

Thus, by the analysis across the globe and also from our forecasting, India which has been repulsed to the world's sixth largest economy in 2020, will again outstrip the United Kingdom to appear as the fifth largest in the year 2025 and race to the third place by the year 2030. The Centre for Economics and Business Research (CEBR) predicts that the economy of India will inflate by 9 percentage in the year 2021 and by 7 percentage in the year 2022. It is clear that our study is also in the same trend.

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RESEARCH ARTICLE

MAJOR REASONS BEHIND THE WHITEWASH OF LAKSHMI VILAS BANK FROM THE INDIAN STOCK MARKET – AN ANALYSIS WITH MATHEMATICAL APPROACH

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Department of Mathematics, Kongunadu Arts and Science College (Autonomous), Coimbatore – 641 029, Tamil Nadu, India

ABSTRACT

Banks play a pivotal role in India's economic development. They sustain the country's GDP growth through turning people's static money into capital for investment and thus directing cash flow via dynamic market systems. Bank deposits provide secured and fixed return unlike the share market that holds higher risk of investment and offer a variable return which is uncertain. Whenever an individual or a company is at financial crisis, Banks lend their hands and offer loans and help them as much as possible to cut down the financial burden. But on the other hand, when the financial health of a bank itself is very weak which in turn will certainly affect the entire movement of the banking sector in the stock market and further that would lead to unreliable market circumstances. In this paper, we will be analyzing the major reasons behind the complete wash out of Lakshmi Vilas Bank from the Indian Stock Market and try to figure out the alarming indicators so as to be more cautious in the mere future to avoid such financial breakdown caused due to the bankrupted scenario.

Keywords: Lakshmi Vilas Bank, Technical Analysis, GDP, NSE, Nifty 50, Banking Sector, Stock Analysis, Statistical Methods.

1. INTRODUCTION

Stock market constitutes businesses, investors, and trading of stocks and shares. Businesses attract investors by offering lucrative projections in their growth margins. Stock and shares represent value of the capital poured into businesses by investors. Rise and fall of the value of stocks and shares entail the interplay of various market factors including the ongoing profit and loss of businesses. Big businesses cannot thrive without the existence of such an expansive network investment and benefit sharing. Indian economy is one of the largest and fastest expanding economies of the world in the twenty first century. Banks catalyze wealth generation by transforming static money into capital for investment, lending loans to entrepreneurial ventures, providing secure returns to fixed deposits and therefore play a critical role in augmenting the economic growth. Stock market underlies the fundamental fabric of our commercial systems, dynamic markets and drive the engines of economic prosperity throughout the world. Financial achievements of a bank, as well it's contribution to the economic boom is partly influenced by its performance in the stock market. Banking sectors being the backbone to the economy plays the role of lending loan. Fixed deposits in banks provide secure returns and maintain the cash flow. As Banks play a crucial role in structuring the economy, invariably stock market also has a significant position. The nature of financial health of a bank entirely reflects in its functioning in the stock market. The stock market is designed on the Demand and Supply principle, which can underlie changes in the whole of the economy. So stock market has a significant influence in structuring the economy, as does the banks. In this paper, using technical analysis and fundamental analysis as a tool, we analyze the data obtained from the stocks of Lakshmi Vilas Bank Private Limited, to find "The Major Reasons behind the whitewash off Lakshmi Vilas Bank from the Indian Stock market" and understand the major factors influencing the dynamic of this process.

2. PRELIMINARIES

Profit and Loss Statement (P&L)

A P&L statement is also called an income statement. It is a financial statement that reports a company's revenues and expenses for a given

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period of time and also shows the profitable of a Company for a time period. P&L ratio shows all the company's income and expenses including revenues, cost of goods (or) services sold, operating expenses and financial expenses.

Relative Strength Index (RSI)

The Relative Strength Index is a leading momentum indicator that helps in identifying a trend reversal. It shows the internal strength by signaling during non –trending ranges.

RSI = 100 – 100/ 1+RS

Simple Moving Average (SMA)

The Simple Moving Average is the easiest moving average to construct. It is simply the average price over the specified period. A simple moving average (**SMA**) calculates the average of a selected range of prices, usually closing prices, by the number of periods in that range.

$$SMA = \sum\left(\frac{N}{n}\right)$$

Exponential Moving Average (EMA)

The Exponential Moving Average is a technical chart indicator that tracks the price of an investment (like a stock or commodity) over time. The EMA is a type of Weighted Moving Average (WMA) that gives more weighting or importance to recent price data.

EMA = (Close price – Previous day EMA) * (WMA + Previous day EMA)

Moving Average Convergence and Divergence (MACD)

MACD is about the convergence and divergence of the two moving averages. Convergence occurs when the two moving averages move towards each other, and a divergence occurs when the moving averages move away from each other. Moving average convergence divergence (**MACD**) is a trend-following momentum indicator that shows the relationship between two moving averages of a security's price. The **MACD** is calculated by subtracting the 12-period exponential moving average (EMA) from the 26-period EMA.

MACD = 12D EMA – 26D EMA

3. FUNDAMENTAL ANALYSIS OF LAKSHMI VILAS BANK

Fundamental analysis (FA) is a method of measuring an intrinsic value by examining related economic and financial factors. Fundamental analysts study anything that can affect the security's value, from macroeconomic factors such as the state of the economy and industry conditions to microeconomic factors like the effectiveness of the company's management. The end goal is to arrive at a number that an investor can compare with a security's current price in order to see whether the security is undervalued or overvalued.

3.1. BALANCE SHEET (in thousands)

	16-Mar	17-Mar
SHARE CAPITAL	17,94,616	19,14,467
RESERVES	1,58,41,325	1,94,48,950
BORROWINGS	72,30,078	1,77,31,321
OTHER LIABILITIES	75,29,167	78,18,932
TOTAL LIABILITIES	28,67,04,801	35,24,47,205
FIXED ASSETS	35,91,190	36,69,987
INVESTMENTS	6,54,54,046	8,65,17,303
OTHER ASSETS	74,57,265	88,10,833
TOTAL ASSETS	28,67,04,801	35,24,47,205

18-Mar	19-Mar	20-Mar
25,59,938	19,14,467	33,67,138
2,07,16,745	1,57,26,731	89,30,912
4,01,27,803	92,12,590	75,57,000
77,92,945	95,28,868	99,28,160
40,42,92,260	33,04,61,629	24,42,15,151
40,24,535	46,99,543	46,34,213
10,76,77,483	8,43,01,653	5,38,38,295
1,47,58,589	1,87,36,712	1,87,36,712
40,42,92,260	33,04,61,629	24,42,15,151

PROFIT & LOSS STATEMENT

	16-Mar	17-Mar
REVENUE	2,87,28,315	3,34,94,253
EXPENSES	2,69,25,957	2,69,25,957
FINANCIAL PROFIT	18,10,448	25,60,765
OTHER INCOME	30,45,324	50,27,678
NET PROFIT	18,10,448	25,60,765
NET PROFIT %	6.3	7.6
EPS in Rs	10.05	14.07

18-Mar	19-Mar	20-Mar
3,38,84,295	3,09,02,118	2,55,80,302
3,97,32,956	3,98,43,089	3,39,40,748
-5226018	-1,56,52,218	-2,40,13,328
34,68,078	25,03,179	35,13,447
-52,26,018	-1,56,52,218	-2,40,13,328
-15.42	-50.65	-93.87
-28.29	-34.66	-25.16

CASH FLOW STATEMENT

	16-Mar	17-Mar
CASH FOR OPERATING ACTIVITY	11,05,706	22,70,654
CASH FOR INVESTING ACTIVITY	-6,74,841	-3,99,614
CASH FOR FINANCIAL ACTIVITY	68,038	6,81,612
NET CASH FLOW	4,98,903	25,52,652

18-Mar	19-Mar	20-Mar
-4,73,11,390	-17,05,980	-42,49,938
-10,23,596	-11,72,534	-7,67,995
62,49,499	44,20,006	17,28,049
-4,20,85,487	-15,41,492	-32,89,884

INTERPRETATION

(i) The Total Asset & Liabilities decreased from Rs.28,67,04,801 in 2016 to Rs.24,42,15,151 in 2020. The values have increased initially till 2018 to Rs.40,42,92,260 and has reduced down.

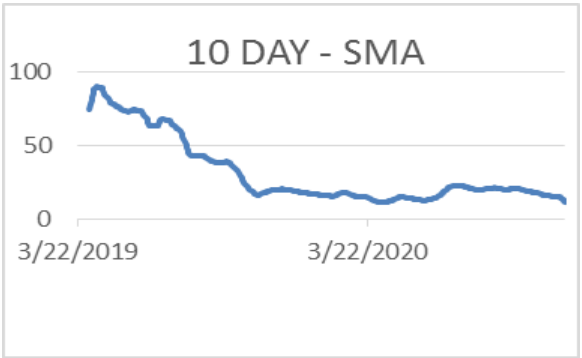
(ii) The investments of the company has been increased from FY – 16 to FY – 18 and has declined towards FY -20.

(iii) The Net Profit of the company has gradually decreased from FY- 16 and has drip down completely in FY-20, which shows the functioning of the company and the trouble encountered.

(iv) The EPS has decreased from Rs.10.05 in FY – 16 to Rs. -25.16 in FY – 20, which clearly shows the fall of the company.

(v) The Net Cash flow decreases to a negative trend, from Rs.4,98,903 in FY – 16 to a negative cash flow of Rs. -32,89,884 in FY-20.

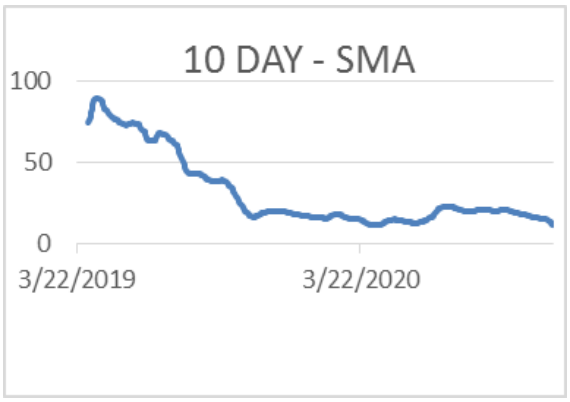
4. TECHNICAL ANALYSIS OF LAKSHMI VILAS BANK



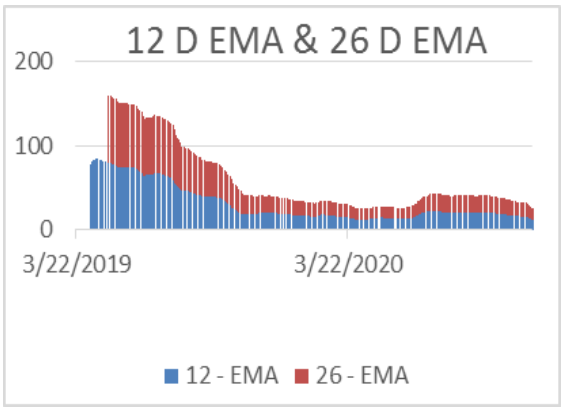
Technical analysis seeks to predict price movements by examining historical data. It helps traders and investors navigate the gap between intrinsic value and market price by leveraging techniques like statistical analysis and behavioral

economics. Technical analysis helps to guide traders to know what is most likely to happen given past information.

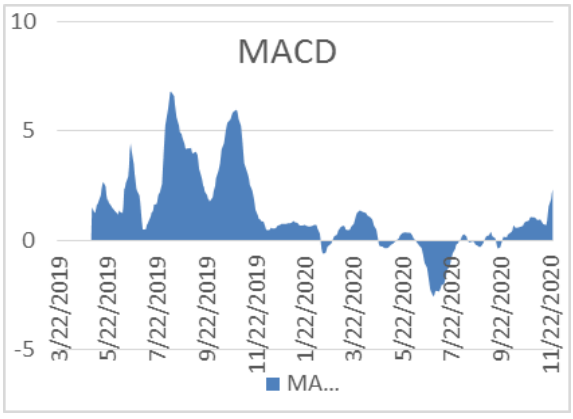
10D – SMA



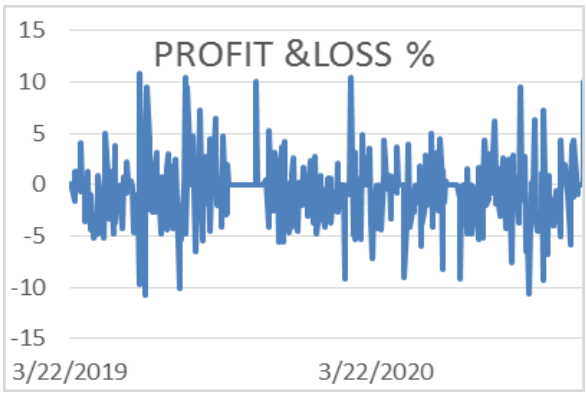
12D - EMA & 26D – EMA



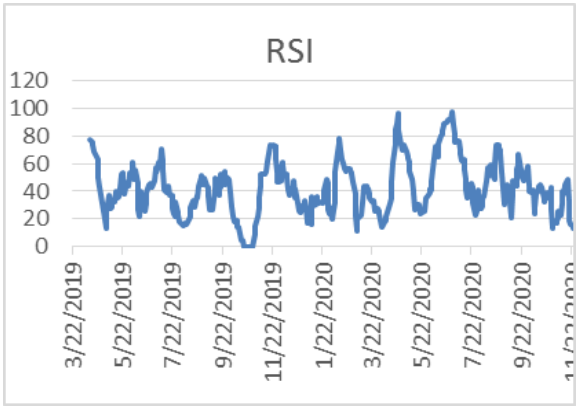
MACD



PROFIT & LOSS %



RSI



INTERPRETATION

(i) SMA has fallen drastically over the period from April to October and has followed the moderate downtrend till December.

(ii) Both 12 D EMA and 26 D EMA where declined drastically from April to October, and both have maintained equalized position, where 26 D EMA catch up the 12 D EMA.

(iii) MACD value has resulted the reduction of price value as since after the sudden fall above the signal line during November, and continuous swing up and down the signal line during January to December.

(iv) P / L shows the average movement of the close price, as of its continuous variation of profit and loss. But it faced the major loss starting from April.

(v) RSI chart of Lakshmi Vilas Bank shows a bullish trend. It shows that stock price neither falls under over brought position nor in oversold position.

5. CONCLUSION

The NAV of the company has variedly dropped down since FY-2018, and the Net Profit Percentage has declined drastically from 6.3% in FY-16 to -93.87% at the recent year. This interprets the unstable functioning of the Bank. Eventually the market price has reached down to Rs.166.40 in FY-16 to Rs.10.95 in FY-20. Clearly looking at the progression of last five years of data, and with our fundamental and technical analysis we can distinctly seek the downline progression of the bank with respect to the stock market and the influential factors falling apart on the negative trend set. The inferences acquired from our Technical analysis and Fundamental analysis clearly conveys that the whitewash off Lakshmi Vilas Bank, Pvt Ltd from the Indian Stock Market is inevitable. Hence the depositors and investors should track the balance sheet, income statement and the cash flow of the respective bank which they are interested in and they should notice the technical indicators like RSI and MACD. Fluctuation is quite common in the market but when the bearish behaviour prolongs and it tends to go out of control, then that should be considered as the alarm and further investment and deposit in that company should be truncated from there on to prevent oneself from heavy loss.

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