International Journal of
SCIENCE AND HUMANITIES

EDITORS-IN-CHIEF

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Some Properties of Intuitionistic Fuzzy sets of Cube Root Type

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Abstract

In this paper, we introduce a new class of Intuitioistic Fuzzy Sets , called Intuitionistic Fuzzy Sets of Cube Root Type (IFSCRT). We also present some of the properties of IFSCRT

AMS Subject Classification: 60K10

Keywords: Intuitionistic Fuzzy Sets, .

1.   Introduction

Fuzzy sets were introduced by Lofti A. Zadeh in 1965 as a generalization of classical (Crisp) sets. Further the Fuzzy sets are generalized by Krassimir T.Atanassov in which he has taken non membership values also into consideration and he introduced Intuitionistic Fuzzy Set (IFS) and its extension Intuitionistic Fuzzy Set of Second Type (IFSST). Palaniappan and Srinivasan have introduced Intuitionistic Fuzzy Sets of Root Type (IFSRT) and studied some of its properties. In this paper, we define Intuitionistic Fuzzy Sets of Cube Root Type (IFSCRT), some operations and relations over IFSCRT and state few of their properties.

2.   Preliminaries

In this section, we give some definition of various types of IFS.

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Definition 2.1 Let X be a non empty set. An IFS A in X is defined as an object of the form

$$A = \{\langle x, \mu_A(x), \gamma_A(x)\rangle : x \in X\}$$

where the functions $\mu_A(x) : X \to [0,1]$ and $\gamma_A(x) : X \to [0,1]$ denote the membership and non-membership function of A respectively, and

$$0 \leq \mu_A(x) + \gamma_A(x) \leq 1 \text{ for each } x \in X$$

Remark. An ordinary fuzzy set can also be generalized as

$$A = \{\langle x, \mu_A(x), 1 - \mu_A(x)\rangle : x \in X\}$$

Definition 2.2 Let X be a non empty set. An Intuitionistic Fuzzy Set of Second Type (IFSST) A in X is defined as an object of the form

$$A = \{\langle x, \mu_A(x), \gamma_A(x)\rangle : x \in X\}$$

where the functions $\mu_A(x) : X \to [0,1]$ and $\gamma_A(x) : X \to [0,1]$ denote the membership and non-membership function of A respectively, and

$$0 \leq [\mu_A(x)]^2 + [\gamma_A(x)]^2 \leq 1 \text{ for each } x \in X$$

Remark. It is obvious that for all real numbers $a, b \in [0,1]$ if $0 \leq a + b \leq 1$ then $0 \leq a^2 + b^2 \leq 1$

Definition 2.3 Let X be a non empty set. An Intuitionistic Fuzzy Set of Root Type (IFSRT) A in X is defined as an object of the form

$$A = \{\langle x, \mu_A(x), \gamma_A(x)\rangle : x \in X\}$$

where the functions $\mu_A(x) : X \to [0,1]$ and $\gamma_A(x) : X \to [0,1]$ denote the membership and non-membership function of A respectively, and

$$0 \leq \frac{\sqrt{\mu_A(x)}}{2} + \frac{\sqrt{\gamma_A(x)}}{2} \leq 1 \text{ for each } x \in X$$

Definition 2.4 Let X be a non empty set. An Intuitionistic Fuzzy Set of Cube Root Type (IFSCRT) A in X is defined as an object of the form

$$A = \{\langle x, \mu_A(x), \gamma_A(x)\rangle : x \in X\}$$

where the functions $\mu_A(x) : X \to [0,1]$ and $\gamma_A(x) : X \to [0,1]$ denote the membership and non-membership function of A respectively, and

$$0 \leq \frac{\sqrt[3]{\mu_A(x)} + \sqrt[3]{\gamma_A(x)}}{\sqrt{3}} \leq 1 \qquad \text{for each } x \in X$$

Remark. It is obvious that for all real numbers $a, b \in [0, 1]$, if $0 \le a + b \le 1$ then

$$0 \le \frac{\sqrt[3]{a} + \sqrt[3]{b}}{\sqrt{3}} \le 1$$

Definition 2.5 Let X be a non empty set. Let A and B be two IFSCRTs such that

$$A = \{\langle x, \mu_A(x), \gamma_A(x) \rangle : x \in X\}$$

$$B = \{\langle x, \mu_B(x), \gamma_B(x) \rangle : x \in X\}$$

We define the following relations and operations

(i) $A \subset B$ if and only if $\mu_A(x) \le \mu_B(x)$ and $\gamma_A(x) \ge \gamma_B(x) \ \forall \ x \in X$

(ii) $A \supset B$ if and only if $\mu_A(x) \ge \mu_B(x)$ and $\gamma_A(x) \le \gamma_B(x) \ \forall \ x \in X$

(iii) $A = B$ if and only if $\mu_A(x) = \mu_B(x)$ and $\gamma_A(x) = \gamma_B(x) \ \forall \ x \in X$

(iv) $A \cap B = \{\langle x, \min(\mu_A(x), \mu_B(x)), \max(\gamma_A(x), \gamma_B(x)) \rangle : x \in X\}$

(v) $A \cup B = \{\langle x, \max(\mu_A(x), \mu_B(x)), \min(\gamma_A(x), \gamma_B(x)) \rangle : x \in X\}$

(vi) The complement of A is defined by $\overline{A} = \{\langle x, \gamma_A(x), \mu_A(x) \rangle : x \in X\}$

Definition 2.6 The degree of non determinacy (uncertainty) of an element $x \in X$ to the IFSCRT A is defined by

$$\pi_A(x) = (1 - \sqrt[3]{\mu_A(x)} - \sqrt[3]{\gamma_A(x)})^3$$

Definition 2.7 For every IFSCRT A, we define the following operators.
The Necessity measure on A

$$\Box A = \langle x, \mu_A(x), (1 - \sqrt[3]{\mu_A(x)})^3 \rangle : x \in X$$

The Possibility measure on A

$$\Diamond A = \langle x, (1 - \sqrt[3]{\gamma_A(x)})^3, \gamma_A(x) \rangle : x \in X$$

Definition 2.8 For every two IFSCRTs A and B we define the following relations:

(i) $A@B = \{\langle x, \dfrac{\sqrt[3]{\mu_A(x)} + \sqrt[3]{\mu_B(x)}}{2}, \dfrac{\sqrt[3]{\gamma_A(x)} + \sqrt[3]{\gamma_B(x)}}{2} \rangle : x \in X\}$

(ii) $A\$B = \{\langle x, \sqrt{\sqrt[3]{\mu_A(x)}\sqrt[3]{\mu_B(x)}}, \sqrt{\sqrt[3]{\gamma_A(x)}\sqrt[3]{\gamma_B(x)}} \rangle : x \in X\}$

It is easy to verify the correctness of the defined relations.

3.   Properties of IFSCRT

In this section, we prove some properties of IFSCRT.

Proposition 3.1 For every IFSCRTs A and B,we have

(i) $A@A = A$

(ii) $A\$A = A$

(iii) $\overline{\overline{A}@\overline{B}} = A@B$

(iv) $\overline{\overline{A}\$\overline{B}} = A\$B$

(v) $\Box(A@B) = \Box A@\Box B$

Proof.

(i) $A@A = \left\{ \left\langle x, \dfrac{\sqrt[3]{\mu_A(x)} + \sqrt[3]{\mu_A(x)}}{2}, \dfrac{\sqrt[3]{\gamma_A(x)} + \sqrt[3]{\gamma_A(x)}}{2} \right\rangle : x \in X \right\}$

$= \left\{ \left\langle x, \sqrt[3]{\mu_A(x)}, \sqrt[3]{\gamma_A(x)} \right\rangle : x \in X \right\} =$A

(ii) $A\$A = \left\{ \left\langle x, \sqrt{(\sqrt[3]{\mu_A(x)})^2}, \sqrt{(\sqrt[3]{\gamma_A(x)})^2} \right\rangle : x \in X \right\}$

$= \left\{ \left\langle x, \sqrt[3]{\mu_A(x)}, \sqrt[3]{\gamma_A(x)} \right\rangle : x \in X \right\} =$A

(iii) $\overline{A}@\overline{B} = \left\{ \left\langle x, \dfrac{\sqrt[3]{\gamma_A(x)} + \sqrt[3]{\gamma_B(x)}}{2}, \dfrac{\sqrt[3]{\mu_A(x)} + \sqrt[3]{\mu_B(x)}}{2} \right\rangle : x \in X \right\}$

$\overline{\overline{A}@\overline{B}} = \left\{ \left\langle x, \dfrac{\sqrt[3]{\mu_A(x)} + \sqrt[3]{\mu_B(x)}}{2}, \dfrac{\sqrt[3]{\gamma_A(x)} + \sqrt[3]{\gamma_B(x)}}{2} \right\rangle : x \in X \right\}$

$= A@B$

(iv) $\overline{A}\$\overline{B} = \left\{ \left\langle x, \sqrt{\sqrt[3]{\gamma_A(x)}\sqrt[3]{\gamma_B(x)}}, \sqrt{\sqrt[3]{\mu_A(x)}\sqrt[3]{\mu_B(x)}} \right\rangle : x \in X \right\}$

$\overline{\overline{A}\$\overline{B}} = \left\{ \left\langle x, \sqrt{\sqrt[3]{\mu_A(x)}\sqrt[3]{\mu_B(x)}}, \sqrt{\sqrt[3]{\gamma_A(x)}\sqrt[3]{\gamma_B(x)}} \right\rangle : x \in X \right\}$

$= A\$B$

(v) $\quad A@B = \left\{ \left\langle x, \dfrac{\sqrt[3]{\mu_A(x)} + \sqrt[3]{\mu_B(x)}}{2}, \dfrac{\sqrt[3]{\gamma_A(x)} + \sqrt[3]{\gamma_B(x)}}{2} \right\rangle : x \in X \right\}$

$\square(A@B) =$

$$\left\{ \left\langle x, \dfrac{\sqrt[3]{\mu_A(x)} + \sqrt[3]{\mu_B(x)}}{2}, \dfrac{(1 - \sqrt[3]{\mu_A(x)}) + (1 - \sqrt[3]{\mu_B(x)})}{2} \right\rangle : x \in X \right\}$$

and

$$\square A = \{ \langle x, \mu_A(x), (1 - \sqrt[3]{\mu_A(x)})^3 \rangle : x \in X \}$$

$$\square B = \{ \langle x, \mu_B(x), (1 - \sqrt[3]{\mu_B(x)})^3 \rangle : x \in X \},$$

so that

$\square A @ \square B =$

$$\left\{ \left\langle x, \dfrac{\sqrt[3]{\mu_A(x)} + \sqrt[3]{\mu_B(x)}}{2}, \dfrac{(1 - \sqrt[3]{\mu_A(x)})^3 + (1 - \sqrt[3]{\mu_A(x)})^3}{2} \right\rangle : x \in X \right\}$$

This completes the proof. ∎

Proposition 3.2 For every IFSCRT A, B and C we have

(i) $(A \cup B)@C = (A@C) \cap (B@C)$

(ii) $(A \cap B)@C = (A@C) \cup (B@C)$

(iii) $(A + B)@C \subset (A@C) - (B@C)$

(iv) $(A \cap B)\$(A \cup B) = A\$B$

Proof. The proof is simple and hence omitted. ∎

4. Conclusion

We have made an attempt to establish some operations and relations over IFSCRT. It is still open to check whether there exist an IFSCRT in case of operator already defined on an IFS.

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Fuzzy Optimization of Single Period Model with Special Reference to Christmas Tree Problem

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Abstract

In this paper single period inventory model where demands are considered as bifuzzy variables is enumerated by the particular example, of Christmas tree problem where seller has to decide how many Christmas trees should be purchased for the season otherwise at the end of the period, the items become obsolete. A method for the ordering of fuzzy numbers with respect to their total integral values is adopted to find the optimal quantity of maximizing the expected profit function. If the profit gained from selling one units is less than the loss incurred for each item left unsold, then the inventory policy should be conservative to reduce the leftover. On the contrary, if the profit gained is greater than the loss incurred, then the inventory policy should be aggressive to satisfy the possible demand. When the profit gained is equal to the loss incurred, the order quantity should be equal to the most likely demand and correspond to the quantity with membership grade 1.

Keywords: Fuzzy variable, bifuzzy model, single period inventory.

1.   Introduction

Single period inventory problems where only a single procurement is made, has a varied significance in day-to-day life .But the major setback by the decision maker is to forecast the demand, as uncertainty plays a great role as to how many items, customers will buy during single period. Applications of fuzzy sets within the field of inventory management for the most part considered as fuzzification of the crisp set of theories of inventory control .Under conditions of risk and uncertainly probabilistic models cannot deal with vagueness inherent in imprecise determination of preference constraints and objective functions.

Fuzzy set theory has been well developed and applied in wide variety of real problems since its introduction in 1965 by Zadeh [1]. The term fuzzy variable was first introduced by Kaufmann [6], then it appeared in Zadeh [5, 10] and Nahmias [11]. Possibility theory was proposed by Zadeh [5] and developed by many researchers such as Dubois and Prade [12, 13]. Some extensions of fuzzy set have been made in the literature, for example, Type 2 fuzzy set was introduced by Zadeh [10] as a fuzzy set whose membership grade are also fuzzy sets. The intuitionistic fuzzy set was proposed by Atanassov [9] as a pair of membership functions whose sum takes values between 0 and 1; Two fold fuzzy set was derived by Dubois and Prade [14]. Bifuzzy variable was initialized by Liu [15] as a function from a possibility space to the set of fuzzy variables.

In this paper, we discuss a type of two-fold uncertainty: bifuzzy variable, Roughly speaking, a bifuzzy variable is a bifuzzy variable defined on the universal set of fuzzy variables or a fuzzy variable taking "Fuzzy Variable" values, i.e a bifuzzy variable is a function from a possibility space to collection of fuzzy variables. Here, fuzzy means the degree of uncertainty. Based on the concept of bifuzzy variables, we develop a bifuzzy model applicable to the single period inventory problem with special reference to Christmas tree problem.

2.   Preliminaries

Definition 2.1 *If X is the universe of discourse and let $\mu_A : X \to [0, 1]$, denote the membership of the elements 'x' of X, then the fuzzy set $\tilde{A}$ is defined as*

$$\tilde{A} = \{< x, \mu_A(x) >: x \in X\}.$$

Each fuzzy set is completely and uniquely defined by one particular membership function. The significance of fuzzy variables is that they facilitate gradual transitions between states and consequently possess natural capability to express and deal with observation and measurements and uncertainties.

Definition 2.2 *Fuzzy sets defined by membership function in terms of closed interval of real number identified by lower and upper bounds are called interval-valued fuzzy sets. They are of the form $A : X \to \varepsilon([0, 1])$ where $\varepsilon([0, 1])$ denotes the family of all closed intervals of real number in $[0, 1]$. Interval valued fuzzy sets can further be generalized by allowing their intervals to be fuzzy. Each interval now becomes an ordinary fuzzy set defined within the universal set $[0, 1]$. Since membership grades assigned to elements of the universal set by these generalized fuzzy sets are ordinary fuzzy sets, these sets are referred to as fuzzy sets of type 2. The membership functions have the form*

$$A : X \to \mathrm{F}([0, 1])$$

where $\mathrm{F}([0,1])$ *denotes the set of all ordinary fuzzy set that can be defined within universal set* $[0,1]$.

Bifuzzy variable

Let X denote a universal set. Then a fuzzy subset $\tilde{A}$ of X is defined by its membership function

$$\mu_{\tilde{A}} : X \to [0,1],$$

which assigns to each element $x \in X$ a real numbers $\mu_{\tilde{A}}(x)$ in the interval $[0,1]$ where the value of $_{\tilde{A}}(x)$ at x represents the grade of membership of x in $\tilde{A}$. For example, if F is fuzzy number (set) with degree of membership $_{\tilde{F}}(x)$ of an element x in F, then $_{\tilde{F}}(x)$ represents the degree of possibility that a parameter has a value x. Thus, the nearer the value of $_{\tilde{A}}(x)$ to unity, the higher the grade of membership of x in $\tilde{A}$.

Definition 2.3 *The set of elements that belong to the fuzzy set* $\tilde{A}$ *at least to the degree of membership* α *is called the* $\alpha-$*level set, denoted by*

$$\tilde{A}_{\alpha} = \{x \in X : _{\tilde{A}}(x) \geq \alpha\}. \tag{2.1}$$

Definition 2.4 *A Fuzzy variable is a function from a possibility space* $(\theta, \mathscr{P}(\theta), \mathrm{Pos})$ *to the real line* $\mathbb{R}$.

Definition 2.5 *A bifuzzy variable is a function from a possible space* $(\theta, \mathscr{P}(\theta), \mathrm{Pos})$ *to a collection of fuzzy variable.*

Definition 2.6 *Let* $f : \mathbb{R}^{\ltimes} \to \mathbb{R}$ *be a function and* ξ_i *bifuzzy (or fuzzy) variables defined on* $(\theta, \mathscr{P}(\theta), \mathrm{Pos})$, $i = 1, 2, \ldots, n$, *respectively. Then* $\xi = f(\xi_1, \xi_2, \ldots, \xi_n)$ *is a bifuzzy (or fuzzy) variable defined on the product possibility space* $(\theta, \mathscr{P}(\theta), \mathrm{Pos})$ *as*

$$\xi(\theta_1, \theta_2, \ldots, \theta_n) = f(\xi_1(\theta_1), \xi_2(\theta_2), \ldots, \xi_n(\theta_n))$$

for any $(\theta_1, \theta_2, \ldots, \theta_n) \in \theta$.

The ordering of fuzzy numbers

Definition 2.7 *A fuzzy number $\tilde{A}$ is a function on the set of the real line $\mathbb{R}$ whose membership function $\mu_{\tilde{A}}(x)$ has the following characteristics with $-\infty \leq a_L \leq \underline{a} \leq \overline{a} \leq a_R \leq +\infty$:*

$$\mu_{\tilde{A}}(x) = \begin{cases} \mu_l(x), & a_L \leq x \leq \underline{a} \\ 1, & \underline{a} \leq x \leq \overline{a} \\ \mu_r(x), & \overline{a} \leq x \leq a_R \\ 0, & \text{Otherwise} \end{cases}$$

where $\mu_L : [a_L, \underline{a}] \rightarrow [0,1]$ is continuous and strictly increasing; $\mu_R : [\overline{a}, a_R] \rightarrow [0,1]$ is continuous and strictly decreasing.

Definition 2.8 *Let $\tilde{A}$ be a fuzzy number whose membership function is given via (3) and $\lambda \in [0,1]$ a predetermined parameter. The total $\lambda-$integral value of $\tilde{A}$ is defined as*

$$I_\lambda(\tilde{A}) = \lambda I_R(\tilde{A}) + (1 - \lambda)I_L(\tilde{A}),$$

where $I_L(\tilde{A})$ and $I_R(\tilde{A})$ are the left and right integral values of $\tilde{A}$ defined as the following, respectively:

$$I_L(\tilde{A}) = \int_0^1 \mu_L^{-1}(\alpha)\, d\alpha$$

and

$$I_R(\tilde{A}) = \int_0^1 \mu_R^{-1}(\alpha)\, d\alpha,$$

where $\mu_L^{-1}(\alpha)$ and $\mu_R^{-1}(\alpha)$ are the inverse function of $I_L(\tilde{A})$ and $I_R(\tilde{A})$, respectively. The total $\lambda-$Integral value of fuzzy number can be used to rank fuzzy numbers.

Definition 2.9 *Let $\lambda \in [0,1]$ be predetermined. For any two fuzzy numbers $\tilde{A}$ and $\tilde{B}$, we define $\tilde{A} <, = or> \tilde{B}$ if and only if $I_\lambda(\tilde{A}) <, = or> I_\lambda(\tilde{B})$.*

3. Problem Formulation

We are considering single order inventory problem for the entire demand period where demand is uncertain and occurs only once. The seller has to procure certain number of items at the beginning of period and at the end of certain period. It is either of no use or to be sold at a lower price.

Let

$p-$ Unit price of an item at which it is purchased(or produced);

$s-$ Unit selling price of the item($s > p$);

$h-$ holding cost per each item remaining at the end of the period, or it can be considered as unit selling price of the item after the end of the period; Note that h is negative ($h < s$);

$r-$ Unit shortage cost if there is a shortage or lost revenue due to the inability to supply the demand($r > p$);
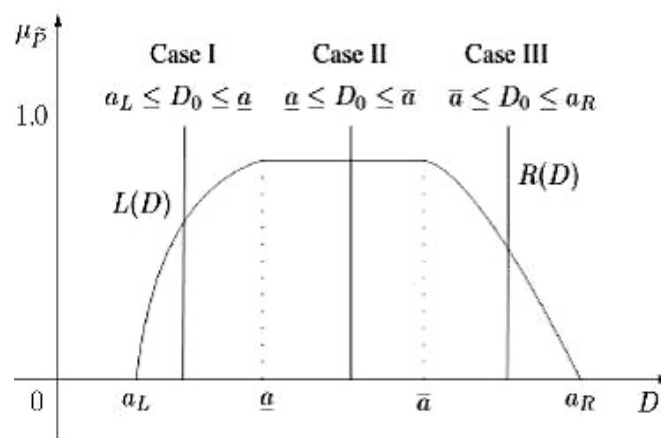
Figure 1: The membership function $\tilde{a}$

Let us assume that there is no initial inventory on hand; Denote by D_0 the order quantity at the beginning of the period and the actual demand D_i as a bifuzzy variable with the given set of variables $\{\tilde{x}_1, \tilde{x}_2, \ldots, \tilde{x}_n\}$. If the demand D_i is smaller than the order quantity D_0, then an amount of $(D_0 - D_i)$ will be left at the end of the period, and the total cost is $pD_0 + h(D_0 - D_i)$. On the contrary, if the demand D_i is greater than D_0, then the inventory is insufficient by an amount of $(D_i - D_0)$, and the total cost becomes $pD_0 + r(D_i - D_0)$. To summarize, for a prespecified order quantity D_0. Hence, the revenue $\tilde{R}(D)$ received and the total cost $\tilde{C}(D)$ incurred are given as follows:

$$
\tilde{R}(D) = \begin{cases} s\,D_i, & D_i \le D_0 \\ s\,D_0, & D_i > D_0 \end{cases}
$$

$$
\tilde{C}(D) = \begin{cases} pD_0 + h(D_0 - D_i), & D_i \le D_0 \\ pD_0 + r(D_i - D_0), & D_i > D_0 \end{cases}
$$

and the total profit $\tilde{P}(D) = \tilde{R}(D) - \tilde{C}(D)$ achieved is given by

$$\tilde{P}(D) = \begin{cases} (s+h)D_i - (p+h)D_0, & D_i \leq D_0 \\ (s-p+r)D_0 - rD_i, & D_i \geq D_0 \end{cases}$$

Let $P(\alpha)$ denote the $\alpha-$cut set of $\tilde{P}$. There are three cases to be considered for the value of D_0 in discussing the membership function of $\tilde{P}(D)$: $a_L \leq D_0 \leq \underline{a}, \underline{a} \leq D_0 \leq \overline{a}$ and $\overline{a} \leq D_0 \leq a_R$, See Fig. 1.

Case 1. $a_L \leq D_0 \leq \underline{a}$. For D_0 lying in the range of a_L and a. $\mu_{\tilde{p}}$ is the same as $L(\cdot)$, viz., the left shape function of $\mu_{\tilde{D}_i}$. It is clear from Fig.1 that for $\alpha \leq L(D)$, the lower bound of the $\alpha-$ cut $P(\alpha)$ is $(s+h)L^{-1}(\alpha) - (p+h)D_0$ because the supply is greater than the demand by an amount of $(D_0 - L^{-1}(\alpha))$, and the upper bound of $p(\alpha)$ is $(s-p+r)D_0 - rR^{-1}(\alpha)$ because the supply is insufficient by an amount of $(R^{-1}(\alpha) - D_0)$. When $\alpha \geq L(D)$, the supply is always insufficient for any value of the demand defined in the $\alpha-$ cut. Thus we have

$$P(\alpha) = \begin{cases} \left[(s+h)L^{-1}(\alpha) - (p+h)D_0 \quad (s-p+r)D_0 - rR^{-1}(\alpha) \right], & 0 \leq \alpha \leq L(D_0) \\ \left[(s-p+r)D_0 - rL^{-1}(\alpha) \quad (s-p+r)D_0 - rR^{-1}(\alpha) \right], & L(D_0) \leq \alpha \leq 1 \end{cases}$$

Case 2. $\underline{a} \leq D_0 \leq \overline{a}$. For D_0 lying in the range of $\underline{a}$ and $\overline{a}$ the lower bound and upper bound of the $\alpha-$ cut of $\tilde{P}$ are $(s+h)L^{-1}(\alpha) - (p+h)D_0$ and $(s-p+r)D_0 - rR^{-1}(\alpha)$, respectively, for any value of α. Therefore, the $\alpha-$ cut of $\tilde{P}$ is

$$P(\alpha) = \left[(s+h)L^{-1}(\alpha) - (p+h)D_0, \ (s-p+r)D_0 - rR^{-1}(\alpha) \right], \quad 0 \leq \alpha \leq 1.$$

Case 3. $\overline{a} \leq D_0 \leq a_R$. For D_0 lying in the range of $\overline{a}$ and a_R, $\mu_{\tilde{p}}$ is the same as $R(\cdot)$, viz., the right-shape function of $\mu_{\tilde{D}_i}$. Similar to the discussion in Case 1, the $\alpha-$cut of $\tilde{P}$ is

$$P(\alpha) = \begin{cases} \left[(s+h)L^{-1}(\alpha) - (p+h)D_0 \quad (s-p+r)D_0 - rR^{-1}(\alpha) \right], & 0 \leq \alpha \leq R(D_0) \\ \left[(s+h)L^{-1}(\alpha) - (p+h)D_0 \quad (s+h)R^{-1}(\alpha) - (p+h)D_0 \right], & R(D_0) \leq \alpha \leq 1. \end{cases}$$

4. Bifuzzy Model Transformation

Let $\xi = (a_L, \tilde{\rho}, a_R)$, where $\tilde{\rho} = (\rho_L, \rho_0, \rho_R)$ is a triangular fuzzy variable with membership function $\mu_{\tilde{p}}(x)$; Then ξ is a bifuzzy variable. Here, $\tilde{\rho} = (\rho_L, \rho_0, \rho_R)$ is a

fuzzy variable with membership function $\mu_{\tilde{p}}(x)$. See Fig.2.By the concept of $\alpha-$ cuts, denote the α_1- cuts (or α_1- level sets) of $\tilde{\rho}$ as follows

$$\tilde{\rho}_{\alpha_1} = [\rho_{\alpha_1}^L, \rho_{\alpha_1}^R] = \{x \in X | \mu_{\tilde{p}}(x) \geq \alpha_1\}$$

Here $\alpha_{\alpha_1}^L = \rho_L + \alpha_1(\rho_0 - \rho_L)$ and $\alpha_{\alpha_1}^R = \rho_R + \alpha_1(\rho_R - \rho_0)$.The parameter $\alpha_1 \in [0, 1]$ here reflects decision-maker's degree of optimism. These intervals indicate where the group arrival rate and service rate lie at possibility level α Note that $\tilde{\rho}_{\alpha_1}$ are crisp sets than fuzzy sets.
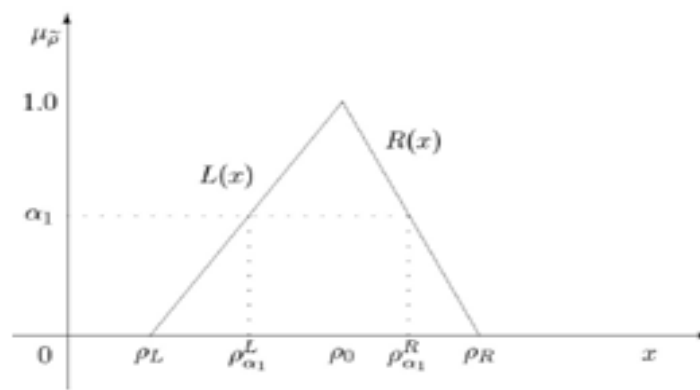
Fig. 2. The membership function of $\tilde{\rho}$

Let $X = \{x_i \in X | \mu(x_i) \geq \alpha_1, i = 1, 2 \ldots, n\}$, so the bifuzzy variable $x = (a_L \tilde{\rho}_{\alpha_1}, a_R)$ can be denoted as $\xi = (a_L, X, a_R)$ or denoted as follows:

$$\xi = \begin{cases} \tilde{\xi}_1(a_L, X_1, a_R) \\ \tilde{\xi}_2(a_L, X_1, a_R) \\ \vdots \\ \tilde{\xi}_n(a_L, X_n, a_R) \end{cases}$$

where $x_1 \leq x_2 \leq \ldots \leq x_n, X = [x_1, x_n] = [\rho_{\alpha_1}^L, \rho_{\alpha_1}^R], i = 1, 2 \ldots, n$ and $\tilde{\xi}_i$ is fuzzy variable. It is easy to reach that $x_1 = \rho_{\alpha_1}^L, x_n = \rho_{\alpha_1}^R$. In other words, $\rho_{\alpha_1}^L$ is the minimum value that $\tilde{\rho}$ achieves with possibility α_1; $\rho_{\alpha_1}^R$ is the maximum value that $\tilde{\rho}$ achieves with possibility α_1. The variable ξ can be expressed in another form as $\xi = \tilde{\xi}_1 U \tilde{\xi}_2 U \ldots U \tilde{\xi}_n$. Here $\tilde{\xi}_i$ is fuzzy variable so the bifuzzy variable ξ is transformed into a fuzzy variable with membership function $\mu_{\tilde{\xi}}(D)$. On the basis of the concept of $\alpha-$cuts (or α level sets),denote the α_2- cuts (or α_2-level sets)of ξ as follows:

$$\tilde{\xi}_{\alpha_2}(D) = \left[\tilde{\xi}_{\alpha_2}^L, \tilde{\xi}_{\alpha_2}^R\right] = \{D \in X | \mu_{\tilde{\xi}}(D) \geq \alpha_2\},$$

or

$$
\tilde{\xi}_{\alpha_2}(D) = \begin{cases} \tilde{\xi}_1(a_L, \rho^L_{\alpha_1}, a_R) \geq \alpha_2, \\[2mm] \tilde{\xi}_2(a_L, X_2, a_R) \geq \alpha_2, \\[2mm] \vdots \\[2mm] \tilde{\xi}_{n-1}(a_L, X_{n-1}, a_R) \geq \alpha_2, \\[2mm] \tilde{\xi}_n(a_L, \rho^R_{\alpha_1}, a_R) \geq \alpha_2 \end{cases}
$$

By the convexity of a fuzzy number, the bounds of these intervals are function of

$$
\alpha_2 \left(0 \leq \alpha_2 \leq \frac{a_R - a_L}{a_R - a_L + \rho^R_{alpha_1} - \rho^L_{alpha_1}} \right)
$$

and can be obtained as

$$
\tilde{\xi}_{\alpha_2} = \left[\tilde{\xi}^L_{\alpha_2}, \tilde{\xi}^R_{\alpha_2} \right].
$$

$$
\xi^L_{\alpha_2} = \max \tilde{\xi}^L_{i\alpha_2}, \tilde{\xi}^R_{i\alpha_2} = \min \tilde{\xi}^R_{i\alpha_2};
$$

and

$$
\tilde{\xi}^L_{i\alpha_2} = \min \mu^{-1}_{\tilde{\xi}_i}(\alpha_2) \tilde{\xi}^R_{i\alpha_2} = \max \mu^{-1}_{\tilde{\xi}_i}(\alpha_2), i = 1, 2, \ldots, n,
$$

respectively. Obviously,

$$
\xi^L_{\alpha_2} = \max \min \mu^{-1}_{\tilde{\xi}_i}(\alpha_2) = \min \mu^{-1}_{\tilde{\xi}_n}(\alpha_2),
$$

and

$$
\xi^R_{\alpha_2} = \max \min \mu^{-1}_{\tilde{\xi}_i}(\alpha_2) = \min \mu^{-1}_{\tilde{\xi}_i}(\alpha_2).
$$

Consequently, we can use its α_2- cuts to construct the corresponding membership function. $\xi^L_{\alpha_2} = \underline{a}, \xi^L_{\alpha_2} = \overline{a}$, viz.$\tilde{\xi} = (a_L, \underline{a}, \overline{a}, a_R)$ is a similar trapezoidal fuzzy number with the membership function $\mu_\xi(D)$ at $D \in [\underline{a}, \overline{a}]$ is considered subjectively to be 1 approximately.

5. Solution methodology

We consider the above single -period inventory problem where the demand is considered as a bifuzzy variable. $D_i = (a_L, \tilde{\rho}, a_R)$ is a bifuzzy variable, so its $\overline{P}(D)$ is also a bifuzzy variable. Here $\tilde{\rho} = (\rho_L, \rho_0, \rho_R)$ is fuzzy variable with membership function $\mu_{\tilde{(p)}}(x)$ denote the α_1 level set of $\tilde{\rho}$. It follows from (9) and (10) that $\tilde{(D)}_i = (a_L, \underline{a}, \overline{a}, a_R)$ where $\underline{a} = P^L_{\alpha_2}$ is a fuzzy variable. For each α_1 and α_2 is given by

decision-maker. Depending on the demand D_i. Obviously, the demand D_i and the profit $\tilde{P}(D)$ have the same membership grade. In the other words, the demand D_i and $\tilde{P}(D)$ have the same shape of the membership function. In the rest of this section, we will exploit the exact expression of the total integral value of the fuzzy profit $\tilde{P}(D)$ for each given order quantity D_0 when the imprecise demand D_i is characterized by a trapezoidal fuzzy number $D_i = (a_L, \underline{a}, \overline{a}, a_R)$.

From the definition 9, we can know that the parameter $\lambda \in [0, 1]$ reflects decision-maker's degree of optimism. A large λ indicates a higher degree of optimism. More specifically,

$$I_0(\tilde{A}) = I_L(\tilde{A})(\lambda = 0)$$

and

$$I_1((\tilde{A})) = I_R((\tilde{A}))(\lambda = 1)$$

represent pessimistic and optimistic decision view points, respectively, while

$$I_{\frac{1}{2}}(\tilde{A}) = \frac{1}{2}(I_L((\tilde{A})) + I_R((\tilde{A})) \left(\lambda = \frac{1}{2} \right)$$

provides the moderately optimistic decision -maker a comparison criterion for fuzzy numbers. Moreover, when

$$\lambda = \frac{1}{2} I_{\frac{1}{2}}(\tilde{A}) = I_1((\tilde{A})) = I_R((\tilde{A}))(\lambda = 1)$$

is well qualified for a crisp representative(Defuzzification)of the fuzzy number $\tilde{A}$ Though we do this for the case when the parameter $\lambda = \frac{1}{2}$, it can be done for all $\lambda \in (0, 1)$ if so desired. The Yager's ranking method is based on an area measurement index defined as following:

$$I(\tilde{P}) = \frac{I_L(\tilde{P}) + I_R(\tilde{P})}{2}$$

Where $I_L(\tilde{P})$ represents the area bounded by the left-shape function of $\tilde{P}(D)$, the x-axis ,the y-axis, and the horizontal line $\mu_{\tilde{p}} = 1.I_R(\tilde{P})$ represents the area bounded by the right -shape function of $\tilde{P}(D)$, the x-axis, y- axis, and the horizontal line $\mu_{\tilde{p}} = 1$. The optimal order quantity D^* can be discussed from the three cases categorized in the preceding sections.

Case 1. $a_L \leq D_0 \leq a$.For D_0 lying in the range of a_L and $\underline{a}$, the corresponding area measurement index can be calculated as follows based on equations (6) and (11):

$$I(\tilde{P}) \;=\; (s - b + r)D_0 - 0.5(s + h + r)D_0 L(D_0) + 0.5 \int_0^{L(D0)} (s + h)L^{-1}(\alpha)d\alpha$$

$$-0.5 \int_{L(D0)}^1 \gamma L^{-1}(\alpha)d\alpha, 0.5 \int_1^0 \gamma R^{-1}(\alpha)d\alpha,$$

The first and second derivatives of $I(\tilde{P})$ with respect to D_0 are

$$\frac{\partial I(\tilde{P})}{\partial D_0} \;=\; (s - p + r) - 0.5(s + h + r)L(D_0),$$

$$\frac{\partial^2 I(\tilde{P})}{\partial D_0^2} \;=\; -0.5(s + h + r)L'(D_0).$$

The first derivative vanishes when $L(D_0) = \dfrac{2(s - p + r)}{(s + h + r)}$. Since $s + h + r > 0$ and $L(\cdot)$ is an increasing function with $L'(D_0) > 0$. Therefore $\dfrac{\partial^2 I(\tilde{P})}{\partial D_0^2}$ is negative, implying that $\tilde{P}(D)$ attains the maximum at the

$$D^* = L^{-1}\left[\frac{2(s - p + r)}{(s + h + r)}\right].$$

However, $2\dfrac{(s - p + r)}{(s + h + r)}$ must lie in the range of 0 and 1 so that D^{ast} will lie between a_L and $\underline{a}$. Since $a > b$, $2\dfrac{(s - p + r)}{(s + h + r)}$ is always positive. The requirement of

$$\frac{(s - p + r)}{(s + h + r)} \leq 1$$

implies $s + r \leq 2p + h$. Hence, we have derived that

$$D^* = L^{-1}\left[\frac{(2(s - p + r))}{((s + h + s))}\right], \qquad \text{for} \quad s + r \leq 2p + h.$$

Case 2. $\underline{a} \leq D_0 \leq \overline{a}$. For D_0 lying in the range of $\underline{a}$ and $\overline{a}$, the corresponding area measurement index, based on equation (7) and (11),is

$$I(\tilde{P}) = 0.5(\frac{s}{r - 2p - h})D_0 + 0.5(s + h)\int_0^1 ?L^{-1}(\alpha)d\alpha - 0.5r \int_0^1 R^{-1}(\alpha)d\alpha$$

Which is a linear function in D_0. If $0.5(s + r - 2p - h)$ is positive, then $\tilde{P}(D)$ attains its maximum when D_0 is set to its upper bound $\overline{a}$. On the contrary. If $0.5(s + r - 2p - h)$

is negative, then $\tilde{P}(D)$ is maximized by setting D_0 to its lower bound $\underline{a}$. When $0.5(s + r - 2p - h) = 0$, any $D_0 \in [\underline{a}, \overline{a}]$ has the same maximum cost $\tilde{P}(D_0)$ Now $0.5(s + r - 2p - h). > 0$ implies $s + r > 2p + h, 0.5(s + r - 2P - h) < 0$ implies $s + r < 2p + h$ and $0.5(s + r - 2p - h) = 0$ implies $s + r = 2p + h$, and we have concluded that

$$D^* = \begin{cases} \overline{a}, & s + r \geq 2p + h \\ \underline{a}, \overline{a}, & s + r = 2p + h \\ \underline{a}, & s + r \leq 2p + h \end{cases}$$

Case 3. $\overline{a} \leq D_0 \leq \underline{a_R}$ When D_0 lies in the range of $\overline{a}$ and a_R, the area measurement index can be calculated from equations (8) and (11) as follows:

$$I(\tilde{P}) = 0.5(s + r + h)D_0 R(D_0) - (p + h)D_0 - 0.5 \int_0^{R(D_0)} (s + r + h)R^{-1}(\alpha)d\alpha$$

$$+ 0.5 \int_0^1 (s + h)L^{-1}(\alpha)d\alpha + 0.5 \int_0^1 (s + r + h)R^{-1}(\alpha)d\alpha,$$

The first and second derivatives of $I(\tilde{P})$ are

$$\frac{\partial I(\tilde{P})}{\partial D_0} = 0.5(s + h + r)R(D_0) - (p + h),$$

$$\frac{\partial^2 I(\tilde{P})}{\partial D_0^2} = 0.5(s + h + r)R'(D_0).$$

By setting $\frac{\partial I(P)}{\partial D_0}$ to 0, one derives

$$R(D_0) = \frac{2(p + h)}{(s + r + h)}.$$

Since $s + r + h$ and $R(\cdot)$ is decreasing function with $R'(D_0) < 0$, therefore $\frac{\partial^2 I(\tilde{P})}{\partial D_0^2}$ is negative, which implies that $\tilde{P}(D)$ is maximized for

$$D^* = R - 1\left[\frac{2(p + h)}{(s + r + h)}\right],$$

provided $\frac{2(p + h)}{(s + h + r)} \leq 1$. It is obvious that $\frac{2(p + h)}{(s + h + r)} > 0$. The upper bound constraint of

$$\frac{2(p + h)}{(s + h + r)} \leq 1$$

implies $s + r \geq 2p + h$. Thus, we have derived that

$$D^* = R^{-1} \left[\frac{2(p + h)}{s + h + r}, \right] \quad \text{for} \quad s + r \geq 2p + h.$$

Combining the three cases, i.e., equations (12), (13) and (14), the optimal order quantity is calculated as

$$D^* = \begin{cases} L^{-1} \dfrac{2(s - p + r)}{(s + h + r)}, & s + r \leq 2p + h \\[2mm] \underline{a}, \overline{a}, & s + r = 2p + h \\[2mm] R^{-1} \dfrac{2(s - p + r)}{(s + h + r)}, & s + r \geq 2p + h \end{cases}$$

In an imprecise and uncertain environment, we sometimes do not know the explicit form of membership function, so following (15) we can't derive the optimal order quantity. We know that the $\alpha-$ cut of this fuzzy number is

$$\tilde{A}(\alpha) = [L^{-1}(\alpha), R^{-1}(\alpha)] = [a_L + \alpha(\underline{a} - a_L), a_R - \alpha(a_R - \overline{a})],$$

and

$$\rho_{\alpha_1}^1 = \rho_L + \alpha(\rho_0 - \rho_L), \rho_{\alpha_1}^R = \rho_R - \alpha_1(\rho_R - \rho_0).$$

When

$$0 \leq \frac{(\alpha R - \alpha L)}{(\alpha R - \alpha L) + (\rho R \alpha 1 - \rho L \alpha 1)}$$

based on (9) and (10) we reach that

$$\underline{a} = a_L + \alpha_2[\rho_R - \alpha_1(\rho_R - \rho_0) - a_L]$$

and

$$\overline{a} = a_R + \alpha_2[a_R - \rho_L - \alpha_1(\rho_0 - \rho_L)]$$

respectively. Then, based on equation (15), the optimal quantity D^* to order is

$$D^* = \begin{cases} a_L + \alpha_2 \left[\rho_R - \rho_1(\rho_R - \rho_0) - a_L \right] \left[\dfrac{2(s - p + r)}{(s + h + r)} \right], & s + r \leq 2p + h \\[3mm] \{a_L + \alpha_2 \left[\rho_R - \alpha_1(\rho_R - \rho_0) - a_L \right], a_R - \alpha_2 \left[a_R - \rho_L - \alpha_1(\rho_0 - \rho_L) \right] \}, & s + r = 2p + h \\[3mm] a_R - \alpha_2 \left[a_R - \rho_L - \alpha_1 \right] (\rho_0 - \rho_L) \left[\dfrac{2(p + h)}{(s + h + r)} \right], & s + r \geq 2p + h \end{cases}$$

which is very simple to calculate.

Now, we consider the above single-period inventory problem in two-fold imprecise and uncertain environment where the demand is considered as a bifuzzy variable

Following (16), we can derive the optimal quantity. From the definition of s, p, h and r, $s - p$ represents the profit gained from selling one unit of the item; $p + h$ represents the loss incurred for each item not sold. If the profit gained from selling one unit is less than the loss incurred for each item left unsold, then the inventory policy should be conservative to reduce the leftover. On the contrary, if the profit gained is greater than the loss incurred, then the inventory policy should be aggressive to satisfy the possible demand. When the profit gained is equal to the loss incurred, the order quantity should be equal to the most likely demand, i.e., the quantity with membership grade I.

6.   Numerical Example

We consider a single - period inventory problem with a bifuzzy demand $D_i = (100, \tilde{\rho}, 200), \tilde{\rho} = (p_L, p_0, \rho_R)$. Denote $\alpha_1 = 0.5$, so $\tilde{\rho_0}.5 = [135, 165[150 - 120]$. Thus, we derive a set of triangular fuzzy numbers $D_i = \{100, x, 200 | x \in [135, 165]\}$. Based on equations (9) and (10), denote $\alpha_2 = 0.615 (\alpha_2 \leq 0.769)$, we can derive a similar trapezoidal fuzzy number $\tilde{D}_i = (100, 140, 160, 200)$. Suppose the unit cost, selling price, holding cost and unit shortage cost of the item are, respectively , $p = 100, s = 140, h = 80$ and $r = 120$. Because $s + r = 260$ is less than $2p + h = 280$, the first formula of equation (16) is applied to find the optimal order quantity $D^* = 137.647$. It is the most superior quantity corresponding to discrete value of α_1 and α_2 when $s + r \leq 2p + h$; If the unit cost dropped to $p = 90$, then the value of $s + r = 260$ is equal to that of $2p + h = 260$. In that case, any amount defined for the plateau of the membership function. viz.., the amount between 140 and 160, is optimal . If the unit cost is further dropped to $p = 80$, then value of $s + r = 260$ is greater than that of $2p + h = 240$. Third formula of equation (16) is applied to find the optimal order quantity as $D^* = 162.353$, It is the most superior quantity corresponding to discrete value of α_1 and α_2 when $s + r \geq 2p + h$.

7.   Conclusion

In this paper, we transform a bifuzzy into a similar trapezoidal fuzzy variable and by applying the Yager's method for ranking fuzzy numbers, a quantity with largest profit is calculated. Since most single-period inventory problems do not have historical data to construct the probability distribution function for calculating the optimal quantity, or one - fold fuzzy variable can't intactly describe the uncertain environment, the bifuzzy model constructed in this paper has dealt with this problem well. The future scope of research using bifuzzy modelling is very wide and vast as it is highly helpful for solving real world problems providing more avenues towards simplified analysis and problem solving capacities leading to easier methods of finding apt and appropriate solutions.

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On Intuitionistic Fuzzy Volterra Spaces

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Abstract

In this paper, the concept of intuitionistic fuzzy Volterra spaces and intitionistic fuzzy weakly Volterra spaces are introduced and characterizations of intuitionistic fuzzy Volterra spaces and intuitionistic fuzzy weakly Volterra spaces are studied. Several examples are given to illustrate the concepts introduced in this paper.

1.   Introduction

The fuzzy concept has invaded almost all branches of mathematics ever since the introduction of fuzzy set by L.A. Zadeh [15]. The theory of fuzzy topological spaces was introduced and developed by Chang [6]. The idea of *Intitionistic fuzzy set* was first published by Atanassov [1]. Later, this concept was generalised to *Intitionistic L-fuzzy set* by Atanassov and Stoneva. The concept of volterra spaces have been studied extensively in classical topology in [8], [9], [11] and [12]. The concept of fuzzy Volterra space is introduces and studied by Thangaraj and Soundararajan [14]. In this paper, we introduce the concept of Intitionistic fuzzy Volterra spaces and Intitionistic fuzzy weakly Volterra spaces. We discuss several characterizations of those spaces and several examples are given to illustrate the concepts introduced in this paper.

2.   Preliminaries

Definition 2.1 [3] *Let X be a non-empty set. An Intuitionistic Fuzzy Set (IFS) A in X is defined as an object of the form $A = \{\langle x, \mu_A(x), \nu_A(x)\rangle : x \in X\}$, where*

$\mu_A(x) : X \to [0,1]$ *and* $\nu_A(x) : X \to [0,1]$ *denote the membership and non-membership functions of A respectively, and* $0 \le \mu_A(x) + \nu_A(x) \le 1$, *for each* $x \in X$.

Definition 2.2 [3] *Let A and B be two IFSs of the non-empty set X such that*

$$
\begin{aligned}
A &= \{\langle x, \mu_A(x), \nu_A(x)\rangle : x \in X\}, \\
B &= \{\langle x, \mu_B(x), \nu_B(x)\rangle : x \in X\}.
\end{aligned}
$$

We define the following basic operations on A and B.

(i) $A \subseteq B$ *iff* $\mu_A(x) \le \mu_B(x)$ *and* $\nu_A(x) \ge \nu_B(x)$, $\forall x \in X$

(ii) $A \supseteq B$ *iff* $\mu_A(x) \ge \mu_B(x)$ *and* $\nu_A(x) \le \nu_B(x)$, $\forall x \in X$

(iii) $A = B$ *iff* $\mu_A(x) = \mu_B(x)$ *and* $\nu_A(x) = \nu_B(x)$, $\forall x \in X$

(iv) $A \cup B = \{\langle x, \mu_A(x) \vee \mu_B(x), \ \nu_A(x) \wedge \nu_B(x)\rangle : x \in X\}$

(v) $A \cap B = \{\langle x, \mu_A(x) \wedge \mu_B(x), \ \nu_A(x) \vee \nu_B(x)\rangle : x \in X\}$

(vi) $A^c = \{\langle x, \nu_A(x), \mu_A(x)\rangle : x \in X\}$.

Definition 2.3 [7] *An Intuitionistic fuzzy topology (IFT) on X is a family T of IFSs in X satisfying the following axioms.*

(i) $0, 1 \in T$

(ii) $G_1 \cap G_2 \in T$, for any $G_1, G_2 \in T$

(iii) $\cup G_i \in T$ for any family $\{G_i / i \in J\} \subseteq T$.

In this case, the pair (X, T) *is called an Intuitionistic fuzzy topological space (IFTS) and any IFS in T is known as Intuitionistic fuzzy open set (IFOS) in* X.
The complement A^c *of an IFOS A in an IFTS* (X, T) *is called an Intuitionistic fuzzy colsed set (IFCS) in* X.

Definition 2.4 [7] *Let* (X, T) *be an IFTS and* $A = \langle X, \mu_A, \nu_A \rangle$ *be an IFS in X. Then the Intuitionistic fuzzy interior and an Intuitionistic fuzzy closure are defined by*

$$int(A) \ = \cup \{G/G \text{ is an IFOS in } X \text{ and } G \subseteq A\},$$

$$cl(A) \ = \cap \{K/K \text{ is an IFCS in } X \text{ and } A \subseteq K\},$$

Proposition 2.5 [7] *Let (X, T) be any Intuitionistic fuzzy topological space. Let A be an IFS in (X, T). Then*

$$(i) \quad 1 - IFcl(A) \quad = IFint(1 - A),$$
$$(ii) \quad 1 - IFint(A) \quad = IFcl(1 - A).$$

Definition 2.6 [10] *An Intuitionistic Fuzzy set A in an Intuitionistic fuzzy topological space(X, T) is called Intuitionistic fuzzy dense if there exists no Intuitionistic fuzzy closed set B in (X, T) such that $A \subset B \subset 1$.*

3. Intuitionistic Fuzzy Volterra Spaces

Definition 3.1 *An Intuitionistic fuzzy set A in an Intuitionistic fuzzy topological space (X, T) is called an Intuitionistic fuzzy G_δ set in (X, T) if $A = \cap_{i=1}^{\infty} A_i$ where $A_i \in T, \forall i$*

Definition 3.2 *An Intuitionistic fuzzy set A in an Intuitionistic fuzzy topological spaces (X, T) is called an Intuitionistic fuzzy F_σ set in (X, T)) if $A = \cup_{i=1}^{\infty}$ where $1 - A_i \in T, \forall i$.*

Lemma 3.3 *A is an Intuitionistic fuzzy G_δ set in an Intuitionistic fuzzy topological spaces (X, T) if and only if $1 - A$ an Intuitionistic fuzzy F_σ set in (X, T).*

Definition 3.4 *Let (X, T) be an Intuitionistic fuzzy topological space. Then (X, T) is called an Intuitionistic fuzzy Volterra space if, $IFcl(\cap_{i=1}^{N} A_i) = 1$, where A_i's are Intuitionistic fuzzy dense and Intuitionistic fuzzy G_δ sets in (X, T).*

Example 3.1 *Let $X = \{z, b, c\}$. Define the Intuitionistic fuzzy sets A, B $A \cap B$ and $A \cup B$ as follows*

$$A = \left\{ x, \left\langle \frac{a}{0.8}, \frac{b}{0.6}, \frac{c}{0.7} \right\rangle, \left\langle \frac{a}{0.2}, \frac{b}{0.4}, \frac{c}{0.3} \right\rangle \right\}$$

$$B = \left\{ x, \left\langle \frac{a}{0.6}, \frac{b}{0.9}, \frac{c}{0.8} \right\rangle, \left\langle \frac{a}{0.4}, \frac{b}{0.1}, \frac{c}{0.2} \right\rangle \right\}$$

$$A \cap B = \left\{ x, \left\langle \frac{a}{0.6}, \frac{b}{0.6}, \frac{c}{0.7} \right\rangle, \left\langle \frac{a}{0.4}, \frac{b}{0.4}, \frac{c}{0.3} \right\rangle \right\}$$

$$A \cup B = \left\{ x, \left\langle \frac{a}{0.8}, \frac{b}{0.9}, \frac{c}{0.8} \right\rangle, \left\langle \frac{a}{0.2}, \frac{b}{0.1}, \frac{c}{0.2} \right\rangle \right\}$$

Clearly, $T = \{0, 1, A, B, A \cup B, A \cap B\}$ is an Intuitionistic fuzzy topology on X. Thus (X, T) is an Intuitionistic fuzzy topological space.

$$\begin{aligned}
\text{Let} \quad G &= \{A \cap B \cap (A \cup B)\}, \\
H &= \{A \cap B \cap (A \cap B)\}, \\
I &= \{A \cap B \cap (A \cap B) \cap (A \cup B)\},
\end{aligned}$$

where, G, H and I are Intuitionistic fuzzy G_δ sets in (X, T). Also, we have $IFcl(G) = 1, IFcl(H) = 1, IFcl(I) = 1$. Also we have $IFcl(G \cap H \cap I) = 1$.
Therefore, (X, T) is an Intuitionistic fuzzy Volterra space.

Example 3.2 Let $X = \{a, b, c\}$ let the Intuitionistic fuzzy sets are defined by

$$\begin{aligned}
A &= \left\{ x, \left\langle \frac{a}{0.4}, \frac{b}{0.5}, \frac{c}{0.5} \right\rangle, \left\langle \frac{a}{0.6}, \frac{b}{0.5}, \frac{c}{0.5} \right\rangle \right\} \\
B &= \left\{ x, \left\langle \frac{a}{0.6}, \frac{b}{0.4}, \frac{c}{0.5} \right\rangle, \left\langle \frac{a}{0.4}, \frac{b}{0.6}, \frac{c}{0.5} \right\rangle \right\} \\
A \cap B &= \left\{ x, \left\langle \frac{a}{0.4}, \frac{b}{0.4}, \frac{c}{0.5} \right\rangle, \left\langle \frac{a}{0.6}, \frac{b}{0.6}, \frac{c}{0.5} \right\rangle \right\} \\
A \cup B &= \left\{ x, \left\langle \frac{a}{0.6}, \frac{b}{0.5}, \frac{c}{0.5} \right\rangle, \left\langle \frac{a}{0.4}, \frac{b}{0.5}, \frac{c}{0.5} \right\rangle \right\}
\end{aligned}$$

Clearly, $T = \{A, B, A \cup B, A \cap B\}$ is an Intuitionistic fuzzy topological on X. Therefore (X, T) is an Intuitionistic fuzzy topological space. But there is no Intuitionistic fuzzy dense G_δ set in (X, T) therefore (X, T) is not an Intuitionistic fuzzy Volterra space.

Proposition 3.5 *Let (X, T) be an Intuitionistic fuzzy topological space. If $IFint\left(\cup_{i=1}^{N} A_1\right) = 0$, A_i's are Intuitionistic fuzzy nowhere dense and Intuitionistic fuzzy F_σ sets in (X, T), then (X, T) is an Intuitionistic fuzzy Volterra space.*

Proof. Let $IFint\left(\cup_{i=1}^{N} A_1\right) = 0$, then this implies that,

$$1 - int(\cup_{i=1}^{N} A_i) = 1$$

that is, $\qquad cl(\cap_{i=1}^{N}(1 - A_i)) = 1$

A_i's are Intuitionistic fuzzy nowhere dense and Intuitionistic fuzzy F_σ sets implies that $(1 - A_i)$'s are Intuitionistic fuzzy dense and Intuitionistic G_δ sets (X, T).

Hence $cl(\cap_{i=1}^{N}(1 - A_i)) = 1$ where $(1 - A_i)^s$ are Intuitionistic fuzzy dense and Intuitionistic fuzzy G_δ sets in (X, T) implies that (X, T) is an Intuitionistic fuzzy Volterra space. ∎

Definition 3.6 *An Intuitionistic fuzzy topological spaces (X,T) is called an Intuitionistic fuzzy p-space if countable intersection of Intuitionistic fuzzy open sets in (X,T) is Intuitionistic fuzzy open in (X,T).*

Definition 3.7 [13] *An Intuitionistic fuzzy topological space (X,T) is called an Intuitionistic fuzzy hyperconnected space if every Intuitionistic fuzzy open set A is an Intuitionistic fuzzy dense set in (X,T) that is $IFcl(A) = 1 \, \forall \, 0 \neq A \in T$.*

Proposition 3.8 *If the Intuitionistic fuzzy topological space (X,T) is an Intuitionistic fuzzy p-space and Intuitionistic fuzzy hyperconnected space then (X,T) is an Intuitionistic fuzzy volterra space.*

Proof. Let A_i's ($i = 1 \, to \, N$) be Intuitionistic fuzzy dense and Intuitionistic fuzzy G_δ sets in a Intuitionistic fuzzy topological space (X,T). Since (X,T) is an Intuitionistic fuzzy p-space, A_i's are Intuitionistic fuzzy G_δ sets, implies that A_i's are Intuitionistic fuzzy open sets in (X,T). Then $\cap_{i=1}^{N} A_i \in T$. Since (X,T) is an Intuitionistic fuzzy hyperconnected space $\cap_{i=1}^{N} A_i \in T$ implies that $\cap_{i=1}^{N} A_i$ Intuitionistic fuzzy dense set in (X,T). Therefore $cl(\cap_{i=1}^{N} A_i = 1)$. Hence, (X,T) is an Intuitionistic fuzzy Volterra space. ∎

Definition 3.9 [10] *An Intuitionistic fuzzy topological space (X,T) is called Intuitionistic fuzzy submaximal space if for each Intuitionistic fuzzy set A in (X,T) such that $IFcl(A) = 1$, then $A \in T$.*

Proposition 3.10 *If the Intuitionistic fuzzy topological space (X,T) is an Intuitionistic fuzzy submaximal and Intuitionistic fuzzy hyper connected space then (X,T) is an Intuitionistic fuzzy Volterra space.*

Proof. Let A_i's ($i = 1 \cdots N$) be Intuitionistic fuzzy dense and Intuitionistic fuzzy G_δ sets in (X,T). Since (X,T) is an Intuitionistic fuzzy submaximal space $IFcl(A_i) = 1$, implies that $A_i \in T \quad \forall i = 1, \cdots, N$ this implies that $\cap_{i=1}^{N} A_i \in T$ Since (X,T) is an Intuitionistic fuzzy hyper connected space, $\cap_{i=1} A_i \in T$ implies that $IFcl(\cap_{i=1} A_i) = 1$ Therefore (X,T) is an Intuitionistic fuzzy Volterra space. ∎

Definition 3.11 *Let (X,T) be an Intuitionistic fuzzy topological space. An Intuitionistic fuzzy set A in (X,T) is called an Intuitionistic fuzzy σ-nowhere dense set if A is an Intuitionistic fuzzy F_σ set such that $IFint(A) = 0$.*

Definition 3.12 *Let (X,T) be an Intuitionistic fuzzy topological space Then (X,T) is called an Intuitionistic fuzzy $\sigma-$Baire Space if $IFint(\cup_{i=1}^{\infty} A_i) = 0$ where A_i's are Intuitionistic fuzzy σ nowhere dense sets in (X,T).*

Proposition 3.13 *In an IFST* (X, T)*, an IFS* A *is an Intuitionistic fuzzy* σ*-nowhere dense sets in* (X, T)*. if and only if* $1 - A$ *is an Intuitionistic fuzzy dense and Intuitionistic fuzzy* G_δ *set in* (X, T)*.*

Proof.   Let A be an Intuitionistic fuzzy σ-nowhere dense set in (X, T). Then A is an intuitionistic fuzzy $F_\sigma-$set such that $IFint A = 0$. A is an intuitionistic fuzzy $F_\sigma-$set if and only if $1 - A$ is an Intuitionistic fuzzy G_δ set. Now

$$
\begin{aligned}
IFint A = 0 &\iff 1 - IFint A = 1 \\
&\iff IFcl(1 - A) = 1 \\
&\iff (1 - A) \text{ is Intuitionistic fuzzy dense set.}
\end{aligned}
$$

Therefore, A is an Intuitionistic fuzzy σ nowhere dense if and only if $(1 - A)$ is Intuitionistic fuzzy dense and Intuitionistic fuzzy G_δ set in (X, T). ∎

Proposition 3.14 *If the Intuitionistic fuzzy topological space* (X, T) *is an Intuitionistic fuzzy* $\sigma-$*Baire Space, then* (X, T) *is an Intuitionistic fuzzy Volterra space.*

Proof.   Let A_i's ($i = 1 \cdots N$) be Intuitionistic fuzzy dense and Intuitionistic fuzzy G_δ sets in (X, T). Consider the Intuitionistic fuzzy set $IFcl\left(\cap_{i=1}^N A_i\right)$. Now

$$
1 - IFcl\left(\cap_{i=1}^N A_i\right) = IFint\left(\cup_{i=1}^N (1 - A_i)\right).
$$

But

$$
IFint\left(\cup_{i=1}^N (1 - A_i)\right) \subseteq IFint\left(\cup_{i=1}^\infty (1 - A_i)\right). \tag{1}
$$

Since IF sets A_i's IF dense and fuzzy G_δ sets, $(1 - A_i)$'s are Intuitionistic fuzzy σ nowhere dense sets in (X, T). Since, (X, T) is an Intuitionistic fuzzy $\sigma-$Baire Space

$$
IFint\left(\cup_{i=1}^\infty (1 - A_i)\right) = 0 \tag{2}
$$

From (1) and (2),

$$
IFint\left(\cup_{i=1}^N (1 - A_i)\right) = 0
$$

This implies that, $IFint\left(1 - \cap_{i=1}^N (1 - A_i)\right) = 0$, that is, $1 - IFcl\left(\cap_{i=1}^N (1 - A_i)\right) = 0$. This implies that $IFcl\left(\cap_{i=1}^N (1 - A_i)\right) = 1$. Hence, (X, T) is an Intuitionistic fuzzy Volterra space. ∎

4.   Intuitionistic Fuzzy Weakly Volterra Space

Definition 4.1 *Let* (X, T) *be an IFTS. Then* (X, T) *is called an Intuitionistic fuzzy weakly volterra space if*

$$
IF\,Cl\left(\bigcap_{i=1}^N A_i\right) \neq 0
$$

where A_i^s *are an intuitionistic fuzzy dense and intuitionistic fuzzy* G_δ *- sets in* (X, T)*.*

It is clear from the definition that every Intuitionistic fuzzy volterra space is Intuitionistic fuzzy weakly volterra space.

The following example shows that the reverse implication need not be true.
Let $X = \{a, b, c\}$. The IF sets are defined as

$$A = \left\{ x, \left(\frac{a}{0.9}, \frac{b}{0.2}, \frac{c}{0.7} \right), \left(\frac{a}{0.1}, \frac{b}{0.8}, \frac{c}{0.3} \right) \right\}$$

$$B = \left\{ x, \left(\frac{a}{0.3}, \frac{b}{0.9}, \frac{c}{0.2} \right), \left(\frac{a}{0.7}, \frac{b}{0.1}, \frac{c}{0.8} \right) \right\}$$

$$A \cap B = \left\{ x, \left(\frac{a}{0.3}, \frac{b}{0.2}, \frac{c}{0.2} \right), \left(\frac{a}{0.7}, \frac{b}{0.8}, \frac{c}{0.8} \right) \right\}$$

$$A \cup B = \left\{ x, \left(\frac{a}{0.9}, \frac{b}{0.9}, \frac{c}{0.7} \right), \left(\frac{a}{0.1}, \frac{b}{0.1}, \frac{c}{0.3} \right) \right\}$$

Clearly, $T = \{0, 1, A, B, A \cap B, A \cup B\}$ is an IFT on X. Thus (X, T) is an IFTS.

$$IF \; cl \; A = 1, IF \; cl \; B = 1, IF \; cl \; (A \cup B) = 1$$

Now
$$\begin{aligned} IF \; Cl \; (A \cap B \cap (A \cup B)) &= 1 - (A \cap B) \\ &\neq 0. \end{aligned}$$

Therefore (X, T) is an intuitionistic fuzzy weakly volterra space but it is not an Intuitionistic fuzzy volterra space.

Proposition 4.2

(1) Let (X, T) be an intuitionistic fuzzy weakly volterra space and if $\bigcup\limits_{i=1}^{N} (A_i) = 1$, where A_i^s are intuitionistic fuzzy F_σ - sets in (X, T) then there exists atleast one A_i in (X, T) with $IF \; int(\lambda_i) \neq 0$

(2) If $\bigcup\limits_{i=1}^{N} A_i = 1$ where A_i^s are intuitionistic fuzzy F_σ - sets in (X, T) and if, $IF \; int(A_i) \neq 0$ for atleast one $(i = 1, \cdots, N)$ then (X, T) is an intuitionistic fuzzy weakly volterra space.

Proof. $\boxed{(1) \Rightarrow (2)}$

Suppose that $IF \; int(A_i) = 0$; for all $i = 1, 2, \cdots, N$. Then

$$
\begin{aligned}
1 - IF\ int(A_i) &= 1 \\
IF\ cl[1 - A_i] &= 1.
\end{aligned}
$$

Therefore $(1 - A_i)'s$ are intuitionistic fuzzy dense sets in X.

A_i^s are intuitionistic fuzzy F_δ - sets in (X, T) implies that $(1 - A_i)'s$ are intuitionistic fuzzy G_δ - sets. Now,

$$
\begin{aligned}
IFCL\left(\bigcap_{i=1}^{N}(1 - A_i)\right) &= IFcl\left(1 - \bigcup_{i=1}^{N} A_i\right) \\
&= IFcl(1 - 1) \\
&= 0.
\end{aligned}
$$

Therefore, $IFcl\left(\cap_{i=1}^{N}(1 - A_i)\right) = 0$. where $(1 - A_i)$ are intuitionistic fuzzy dense and intuitionistic fuzzy G_δ - sets.

This implies (X, T) is not an IF weakly volterra space, which is a contradiction.

Therefore $IF\ int(A_i) \neq 0$ for atleast one $i(i = 1, \cdots, N)\ in(X, T)$.

$\boxed{(2) \Rightarrow (1)}$ Suppose that (X, T) is not an intuitionistic fuzzy weakly volterra space.
$IFcl\left(\cap_{i=1}^{N} A_i\right) = 0$ where $A_i's$ are intuitionistic fuzzy dense and intuitionistic fuzzy G_δ sets in (X, T).

This implies $IF\ int\left(\cup_{i=1}^{N}(1 - A_i)\right) = 1$.

$$\Rightarrow \bigcup_{i=1}^{N}(1 - A_i) = 1,\ where(1 - A_i)'s \text{ are intuitionistic fuzzy } F_\delta \text{ - sets in } (X, T) \text{ and}$$

$IF\ int[1 - A_i] = 0$ (because $IFcl[A_1] = 1\ \forall\ i = 1, \cdots, N$) which is a contradiction to the hypothesis.

Hence, (X, T) must be an intuitionistic fuzzy weakly volterra space.

Definition 4.3 [10] *Let (X, T) be an IFTS. Then (X, T) is called an Intuitionistic fuzzy open heriditarily irresolvable space if,*

$$IF\ int\left(IF\ cl(A)\right) \neq 0,$$

then $IFint(A) \neq 0$ for any intuitionistic fuzzy set A in (X, T).

Theorem 4.4 [10] *Let (X, T) be an IFTS. If (X, T) is called an Intuitionistic fuzzy open heriditarily irresolvable space, then $IF\ int(A) = 0$ for any non-zero intuitionistic fuzzy set A in (X, T) implies*

$$IF\ int\left(IF\ cl(A)\right) = 0.$$

Definition 4.5 *An IFS A in an IFTS (X, T) is called Intuitionistic fuzzy first category if $A = \cup_{i=1}^{\infty} A_i$, where $A_i's$ are intuitionistic fuzzy nowhere dense sets in (X, T). Any other intuitionistic fuzzy set in (X, T) said to be of second category.*

Definition 4.6 *An IFTS (X,T) is called an Intuitionistic fuzzy first category space if $1 = \cup_{i=1}^{\infty} A_i$, where $A_i's$ are intuitionistic fuzzy nowhere dense sets in (X,T). (X,T) is called Intuitionistic fuzzy second category space if it is not an Intuitionistic fuzzy first category space.*

Proposition 4.7 *If the $IFTS(X,T)$ is an intuitionistic fuzzy open hereditarily irresolvable and intuitionistic fuzzy second category space, then (X,T) is an intuitionistic fuzzy weakly volterra space.*

Proof. Assume that (X,T) is not an intuitionistic fuzzy weakly volterra space. Therefore, $IFcl\left(\bigcap_{i=1}^{N} A_i\right) = 0$, where A_i^s are intuitionistic fuzzy dense and intuitionistic fuzzy G_δ - sets in (X,T). Then

$$IFcl\left(\bigcap_{i=1}^{N} A_i\right) = 0$$

$$\Rightarrow IF\ int\left(\bigcup_{i=1}^{N}(1 - A_i)\right) = 1.$$

$$\Rightarrow \bigcup_{i=1}^{N}(1 - A_i) = 1.$$

$$Now,$$

$$\bigcup_{i=1}^{N}(1 - A_i) \subseteq \bigcup_{i=1}^{\infty}(1 - A_i).$$

$$\Rightarrow \bigcup_{i=1}^{\infty}(1 - A_i) = 1.$$

since $IF\ cl(A_i) = 1$, we have $IF\ int(1 - A_i) = 0$. Since (X,T) is an IF open heriditarily irresolvable, $IF\ int(1 - A_i) = 0$.

$\Rightarrow IF\ int\ Ifcl(1 - A_i) = 0$.

$\Rightarrow (1 - A_i)'s$ are intuitionistic fuzzy nowhere dense sets.

Therefore $\bigcup_{i=1}^{\infty}(1 - A_i) = 1$, where A_i^s intuitionistic fuzzy nowhere dense sets. This implies that (X,T) is an intuitionistic fuzzy first category space, which is a contradiction to (X,T) being an intuitionistic fuzzy second category space. Hence (X,T) is an intuitionistic fuzzy weakly volterra space. ■

Definition 4.8 *A non-zero intuitionistic fuzzy set A in a $IFTS(X,T)$ called an intuitionistic fuzzy somewhere dense set, if*

$$IF \ int \ IF \ cl(\lambda) \neq 0 \in \ [X,T].$$

Proposition 4.9 *If $\cap_{i=1}^{N} A_i$ is an IF somewhere dense set in an $IFTS(X,T)$ where A_i^s are intuitionistic fuzzy dense and intuitionistic fuzzy G_δ−sets in $[X,T]$, then (X,T) is an intuitionistic fuzzy weakly volterra space.*

Proof. Assume that (X,T) is not an IF weakly volterra space. Then

$$IF \ cl\left(\bigcap_{i=1}^{N} A_i\right) = 0,$$

where A_i^s are intuitionistic fuzzy dense and intuitionistic fuzzy G_δ in seta in (X,T). Now

$$IF \ int \ cl\left(\bigcap_{i=1}^{N} A_i\right) \ \subseteq \ IFcl\left(\bigcap_{i=1}^{N} A_i\right)$$

$$\Rightarrow IF \ int \ cl\left(\bigcap_{i=1}^{N} A_i\right) \ \subseteq \ 0$$

$$\Rightarrow IF \ int \ cl\left(\bigcap_{i=1}^{N} A_i\right) \ = \ 0$$

$\Rightarrow \bigcap_{i=1}^{N} A_i$ is not an intuitionistic fuzzy somewhere dense set which is a contradiction to the hypothesis. Therefore

$$IF \ cl\left(\bigcap_{i=1}^{N} A_i\right) \neq 0.$$

and hence (X,T) is an intuitionistic fuzzy weakly volterra space.   ∎

5.   Conclusion

The concept of intuitionistic fuzzy Volterra spaces and intitionistic fuzzy weakly Volterra spaces are introduced and characterizations of intuitionistic fuzzy Volterra spaces and intuitionistic fuzzy weakly Volterra spaces are studied. Several examples are given to illustrate the concepts introduced.

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A New Class of Life Distribution based on Characteristic Function Ordering

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Abstract

In this paper, a new class of life distribution is established based on characteristic function ordering.

AMS Subject Classification: 60K10

Keywords: Ageing classes, Characteristic Functions, Moment Inequality.

1. Introduction

Let X and Y be two non-negative random variables, representing the life of a system with distribution functions $F(x)$ and $G(y)$, respectively and their survival functions $\overline{F}(x) = 1 - F(x)$ and $\overline{G}(y) = 1 - G(y)$. Their corresponding characteristic functions are given by

$$
\psi_X(t) = \int_0^\infty e^{itx}\, dF(x)
$$

$$
\psi_Y(t) = \int_0^\infty e^{ity}\, dG(y) \ \text{ for all } t \geq 0.
$$

Definition 1.1 *Let X and Y be two non-negative random variables. Then Y is Larger than X in characteristic function order (written as, $X \leq_{chf} Y$), if $\psi_X(t) \leq \psi_Y(t)$ for all $t \geq 0$. That is,*

$$
\int_0^\infty e^{itx}\, \overline{F}(x)dx \leq \int_0^\infty e^{ity}\, \overline{G}(y)dy, \ \text{ for all } t \geq 0.
$$

Definition 1.2 (Elbatal (2002)) *A non-negative random variable X with distribution function F is said to be exponential better than used (EBU) ordering (written as, $X \in$ EBU or $F \in$ EBU) if and only if* $\overline{F}_t(u) \leq e^{-\frac{u}{\mu}}$, where μ denotes the mean of F. *Equivalently,* $\overline{F}(u+t) \leq \overline{F}(t)\, e^{-\frac{u}{\mu}}$

Remark. The corresponding negative ageing class, exponential worse than used (EWU), is obtained by reversing the inequality in the above definition.

2.   The New Class of EBU$_{chf}$ (EWU$_{chf}$) of Life Distribution

In this section we introduce the new class of life distribution namely, EBU$_{chf}$ and EWU$_{chf}$.

Definition 2.1 *A life distribution F or its survival function $\overline{F}$ is said to have the exponential better than used in characteristic function ordering (written as, EBU$_{chf}$), if*

$$\overline{F}(t) \int_0^\infty e^{i\lambda x}\, e^{-\frac{x}{\mu}}\, dx \geq \int_0^\infty e^{i\lambda x}\, \overline{F}(x+t)\, dx, \ \text{ for all } x, t, \lambda \geq 0. \tag{2.1}$$

That is, $\dfrac{\mu}{1 - i\lambda\mu}\, \overline{F}(t) \geq \displaystyle\int_0^\infty e^{i\lambda x}\, \overline{F}(x + t)\, dx, \ \text{ for all } x, t, \lambda \geq 0.$

Definition 2.2 *A life distribution F or its survival function $\overline{F}$ is said to have the exponential worse than used in characteristic function ordering (written as, EWU$_{chf}$), if*

$$\overline{F}(t) \int_0^\infty e^{i\lambda x}\, e^{-\frac{x}{\mu}}\, dx \leq \int_0^\infty e^{i\lambda x}\, \overline{F}(x + t)\, dx, \ \text{ for all } x, t, \lambda \geq 0.$$

That is, $\qquad\quad \dfrac{\mu}{1 - i\lambda\mu}\, \overline{F}(t) \leq \displaystyle\int_0^\infty e^{i\lambda x}\, \overline{F}(x + t)\, dx, \ \text{ for all } x, t, \lambda \geq 0.$

3.   Moment Inequality

In this section, we derive the moment inequality for the new class of life distribution.

Theorem 3.1 *If F is EBU$_{chf}$ (EWU$_{chf}$) then for $r \geq 0$, we have*

$$\frac{\mu_{r+1}}{(i\lambda)(r+1)(1 - i\lambda\mu)} \geq (\leq) \frac{r!}{(i\lambda)^{r+2}}\, E\left[e^{i\lambda x} - \sum_{j=0}^r \frac{(i\lambda x)^j}{j!}\right],$$

where $\mu_r = E(\mathbf{X}^r) = r \int_0^\infty t^{r-1} \overline{F}(t) \, dt$.

Proof. F is EBU_{chf}, if

$$\frac{\mu}{1 - i\lambda\mu} \, \overline{F}(t) \geq \int_0^\infty e^{i\lambda x} \, \overline{F}(x + t) \, dx, \quad \text{for all } x, t, \lambda \geq 0.$$

Multiplying both sides by t^r and integrating with respect to t, we obtain

$$\frac{\mu}{1 - i\lambda\mu} \int_0^\infty t^r \, \overline{F}(t) \, dt \;\geq\; \int_0^\infty \int_0^\infty e^{i\lambda x} \, t^r \, \overline{F}(x + t) \, dx \, dt$$

$$\frac{\mu}{1 - i\lambda\mu} \cdot \frac{\mu_{r+1}}{r + 1} \;\geq\; \text{I}_1 \tag{2.2}$$

where I_1 is the integral on the right side of the proceeding inequality. Now

$$\begin{aligned}
I_1 &= \int_0^\infty \int_0^\infty e^{i\lambda x} \, t^r \, \overline{F}(x + t) \, dx \, dt \\[2mm]
&= E\left[\int_0^X \int_0^{X-t} t^r \, e^{i\lambda x} \, dx \, dt \right] \\[2mm]
&= E\left[\frac{1}{i\lambda} \int_0^X t^r \left\{ e^{i\lambda(x-t)} - 1 \right\} dt \right] \\[2mm]
&= \frac{1}{i\lambda} E\left[\frac{e^{i\lambda x}}{(i\lambda)^{r+1}} \int_0^X (i\lambda t)^r \, e^{-i\lambda t} \, d(i\lambda t) - \int_0^X t^r \, dt \right] \\[2mm]
&= \frac{r!}{(i\lambda)^{r+2}} E\left[e^{i\lambda x} \int_0^X \frac{(i\lambda t)^r}{r!} e^{-i\lambda t} \, d(i\lambda t) \right] - \frac{1}{i\lambda} E\left[\int_0^X t^r \, dt \right] \\[2mm]
&= \frac{r!}{(i\lambda)^{r+2}} E\left[e^{i\lambda x} \int_0^X \frac{(i\lambda t)^r}{r!} e^{-i\lambda t} \, d(i\lambda t) \right] - \frac{1}{i\lambda} \left[\frac{\mu_{r+1}}{r + 1} \right].
\end{aligned}$$

Therefore, from inequality (2.1), we have

$$\frac{\mu}{1 - i\lambda\mu} \cdot \frac{\mu_{r+1}}{r + 1} \;\geq\; \frac{r!}{(i\lambda)^{r+2}} E\left[e^{i\lambda x} \int_0^X \frac{(i\lambda t)^r}{r!} e^{-i\lambda t} \, d(i\lambda t) \right] - \frac{1}{i\lambda} \left[\frac{\mu_{r+1}}{r + 1} \right]$$

$$\frac{\mu_{r+1}}{r + 1} \left[\frac{\mu}{1 - i\lambda\mu} + \frac{1}{i\lambda} \right] \;\geq\; \frac{r!}{(i\lambda)^{r+2}} E\left[e^{i\lambda x} - \sum_{j=0}^r \frac{(i\lambda x)^j}{j!} \right]$$

Hence

$$\mu_{r+1}(i\lambda)(r + 1)(1 - i\lambda\mu) \geq \frac{r!}{(i\lambda)^{r+2}} E\left[e^{i\lambda x} - \sum_{j=0}^r \frac{(i\lambda x)^j}{j!} \right].$$

For the EWU_{chf} class, we obtained the desired result by reversing the inequality. This completes the proof. ∎

Corollary 3.1 *When $r = 0$, then the above inequality reduces to*

$$\frac{\lambda^2 \mu^2}{\lambda^2 \mu^2 + 1} \geq E\left[1 - \cos \lambda x\right].$$

Proof. Let $r = 0$. Then

$$\frac{\mu}{(i\lambda)(1 - i\lambda\mu)} \geq \frac{1}{(i\lambda)^2} E\left[e^{i\lambda x} - 1\right]$$

$$= -\frac{1}{\lambda^2} E\left[\frac{i\lambda x}{1!} + \frac{(i\lambda x)^2}{2!} + \frac{(i\lambda x)^3}{3!} + \cdots\right]$$

$$\frac{\mu}{i(1 - i\lambda\mu)} \cdot \frac{\lambda\mu - i}{\lambda\mu - i} \geq -\frac{1}{\lambda} E\left[\frac{i\lambda x}{1!} + \frac{(i\lambda x)^2}{2!} + \frac{(i\lambda x)^3}{3!} + \cdots\right]$$

$$\frac{\lambda\mu^2 - i\mu}{\lambda^2\mu^2 + 1} \geq -\frac{1}{\lambda} E\left[\frac{i\lambda x}{1!} + \frac{(i\lambda x)^2}{2!} + \frac{(i\lambda x)^3}{3!} + \cdots\right]$$

Equating the real part both sides, we get

$$\frac{\lambda\mu^2}{\lambda^2\mu^2 + 1} \geq -\frac{1}{\lambda} E\left[-\frac{(\lambda x)^2}{2!} + \frac{(\lambda x)^4}{4!} - \cdots\right]$$

$$\frac{\lambda^2\mu^2}{\lambda^2\mu^2 + 1} \geq E\left[\frac{(\lambda x)^2}{2!} - \frac{(\lambda x)^4}{4!} + \cdots\right]$$

$$\frac{\lambda^2 \mu^2}{\lambda^2 \mu^2 + 1} \geq E\left[1 - \cos \lambda x\right].$$

This completes the proof. ∎

4. Testing Exponential Against EBU_{chf} Alternatives

Suppose that $X_1, X_2, \ldots, X_n$ be the sample derived from a population with distribution $F(\cdot)$. We test the null hypothesis $H_0 : F$ is exponential against the alternative hypothesis $H_1 : F$ is EBU_{chf} and not exponential.

Using the moment inequality in theorem 3.1 and corollary 3.1, a measure of departure from H_0 may be defined as follows.

$$\Delta = \frac{\mu_{r+1}}{(i\lambda)(r+1)(1-i\lambda\mu)} - \frac{r!}{(i\lambda)^{r+2}} E\left[e^{i\lambda x} - \sum_{j=0}^{r} \frac{(i\lambda x)^j}{j!}\right]$$

The test can be written as

$$H_0 : \Delta = 0 \text{ against}$$
$$H_1 : \Delta > 0.$$

The measure Δ above can be estimated by

$$\widehat{\Delta} = \frac{1}{n^2} \sum_{l-0}^{n} \left\{\sum_{k=0}^{n} \frac{X_k^{r+1}}{(i\lambda)(r+1)(1-i\lambda\overline{X})} - \frac{r!}{(i\lambda)^{r+2}} \left[e^{i\lambda X_l} - \sum_{j=0}^{r} \frac{(i\lambda X_l)^j}{j!}\right]\right\}.$$

Let

$$\varphi(X_1, X_2) = \frac{X_2^{r+1}}{(i\lambda)(r+1)(1-i\lambda\mu)} - \frac{r!}{(\lambda)^{r+2}} \left[e^{i\lambda X_1} - \sum_{j=0}^{r} \frac{(i\lambda X_1)^j}{j!}\right]$$

and define the symmetric kernel

$$\psi(X_1, X_2) = \frac{1}{2!} \sum \varphi(X_l, X_k),$$

where the sum is over all the arrangements of X_l and X_k, the $\widehat{\Delta}$ is equivalent to the U$-$statistic given by

$$U_n = \frac{1}{\binom{n}{2}} \sum \varphi(X_l, X_k).$$

Theorem 4.1 *As $n \longrightarrow \infty$, $\sqrt{n}\left(\widehat{\Delta} - \Delta\right)$ is asymptotically normal with mean 0 and variance σ^2 and under H_0, the variance is σ_0^2, where*

$$\sigma_0^2 = \frac{(r!)^2}{\lambda^{2r+4}} \left[\frac{1}{1-2\lambda} + \sum_{i=0}^{r}\sum_{j=0}^{r} \frac{\lambda^{i+j}}{i!j!}(i+j)! - 2\sum_{j=0}^{r} \frac{\lambda^j}{(1-\lambda)^{j+1}}\right]$$

$$+ \frac{(2r+2)!}{\lambda^2(1-\lambda)^2(r+1)^2} - 2\frac{r!}{\lambda^{r+3}(1-\lambda)(r+1)} \left[\frac{(r+1)!}{(1-\lambda)^{r+2}} - \sum_{j=0}^{r} \frac{\lambda^j}{j!}(r+j+1)!\right]$$

The proof follows from the standard theory of U$-$statistic Lee (1990) and direct calculations.

5. Pitman Asymptotic Efficiency (PAE)

The pitman asymptotic efficiency of the class EBU_{chf} was calculated using the Linear Failure Rate (LFR) and Makeham (MAK) distributions. The pitman efficiency is defined by

$$PAE = \frac{1}{\sigma_0}\left(\frac{\partial\Delta}{\partial\theta}\bigg|_{\theta=\theta_0}\right)$$

$$= \frac{1}{\sigma_0}\left|\frac{1}{\lambda(r+1)}\left[\frac{\mu'_{\theta(r+1)}}{1-\lambda\mu_\theta} + \mu_{\theta(r+1)}\frac{\lambda\mu'_\theta}{(1-\lambda\mu_\theta)^2}\right] + \frac{r!}{\lambda^{r+2}}\sum_{j=0}^{r}\frac{\lambda^j}{j!}\mu'_{\theta(j)}\right|$$

where μ' denote the partial derivative with respective to θ.
The following two families of alternatives are often used for efficiency calculation

- Linear Failure Rate (LFR) : $\overline{F_\theta}(x) = \exp(-x - \frac{1}{2}\theta x^2)$

- Makeham (MAK) : $\overline{F_\theta}(x) = \exp(-x - \theta(x + \exp(-x) - 1))$

The null exponential is attained when θ is 0 in both the cases. The efficiency calculation for the above two alternatives at $r = 0$ are

$$PAE\,(\Delta)|_{LFR} = \frac{1}{\sigma_0}\frac{1}{\lambda(\lambda^2+1)} \tag{5.1}$$

$$PAE\,(\Delta)|_{MAK} = \frac{1}{\sigma_0}\frac{\sqrt{16\lambda^4 + 49\lambda^2 + 16}}{2\lambda^2(1+\lambda^2)} \tag{5.2}$$

The relation between efficiency and mean λ at $r = 0$ of these distributions described in equations (5.1) and (5.2) are plotted in figure 1 and figure 2.

6. Conclusion

In this paper, the new class of life time distributions based on characteristic function ordering, called EBU_{chf} is introduced. A moment inequality for this class is derived. A test statistic for testing exponential against EBU_{chf} is proposed based on this inequality. The pitman's asymptotic efficiency for the linear failure rate and makeham distributions are calculated.
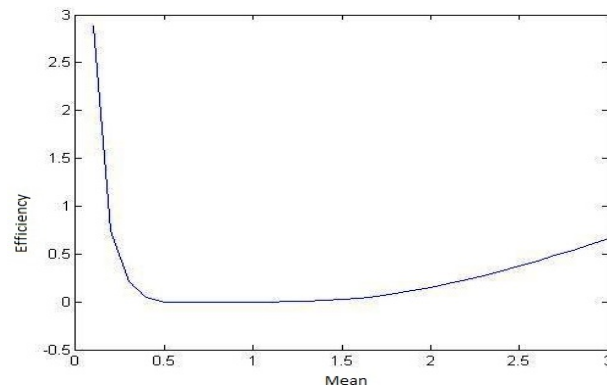
Figure 1: Linear Failure Rate
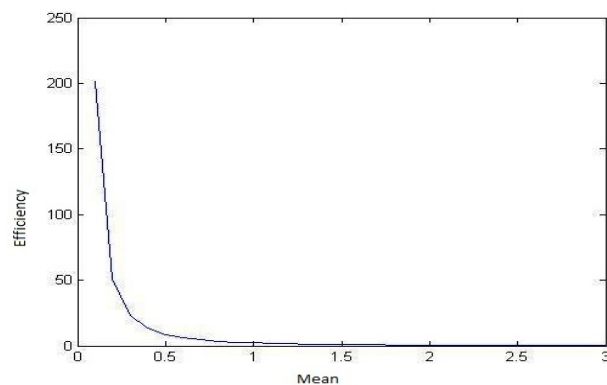
Figure 2: Makeham

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Geometric Processes in Two Dimensions: Basic Results and Applications

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Abstract

In this paper, a two dimensional version of the geometric process is introduced. The joint distribution, joint probability generating function, the bivariate Laplace Transform of the bivariate probability generating function, the moments of the first and second orders are obtained for the geometric process in two variates. The distribution function, probability generating function, the renewal function and its associated renewal density and an integral equation for the geometric process in two dimensions have also been derived. As an application of the geometric process in two dimensions, the optimal replacement policy for a two component system is obtained.

1.   Introduction

Let $\{(X_n, Y_n)\}, n = 1, 2, \ldots$ be a sequence of non-negative and independent random variables with joint distribution function of (X_n, Y_n) given by

$$F(a^{n-1}x, b^{n-1}y) = P(X \le a^{n-1}x, Y \le b^{n-1}y),$$

for $n = 1, 2, \ldots$, where a and b are positive constants. Let

$$U_n = \left(U_n^{(1)}, U_n^{(2)}\right) = \left(\sum_{i=1}^{n} X_i, \sum_{i=1}^{n} Y_i\right).$$

We shall call the sequence of bivariate random variables $\{(X_n, Y_n)\}$, $n = 1, 2, \ldots$, a bivariate geometric process and observe that the marginal sequences, $\{X_n\}$ and $\{Y_n\}$ are each univariate geometric process. For further details regarding univariate geometric process one may refer to Lam Yeh [1988].

For distinction between different geometric processes, we say that an X-renewal occurs at the point x on the X axis, if $U_n^{(1)} = x$, a Y-renewal occurs at the point y on the Y axis, if $U_n^{(2)} = y$, and an (X, Y)-renewal occurs at the point (x, y) in the (X, Y) plane, if $U_n^{(1)} = x$ and $U_n^{(2)} = y$, for some n.

Define

$$
\begin{aligned}
N_x^{(1)} &= \max\{n : U_n^{(1)} \leq x\} \\
N_y^{(2)} &= \max\{n : U_n^{(2)} \leq y\} \\
N_{x,y} &= \max\{n : U_n^{(1)} \leq x, U_n^{(2)} \leq y\}.
\end{aligned}
\tag{1.1}
$$

Thus associated with a geometric process in two variates, there are various counting processes. More precisely, $N_x^{(1)}$ and $N_y^{(2)}$ are the univariate geometric counting processes for the X-renewals and the Y-renewals, respectively, and $N_{x,y}$ is the number of (X, Y)-renewals that occur in the closed region of the positive quadrant of the (X, Y) plane bounded by the coordinate axes and the lines $X = x$ and $Y = y$. We call the random pair $\left(N_x^{(1)}, N_y^{(2)}\right)$, the *geometric counting process in two variates* and $N_{x,y}$ as the *geometric process in two dimensions*.

The rest of the paper is organized as follows: In section 2, an outline of the basic tools needed in the ensuing sections are presented. Results pertaining to bivariate geometric process are discussed in section 3. Section 4 deals with two dimensional geometric process and related properties. Finally, in section 5, application to maintenance model of a two component system is given. Finally conclusion is given in section 6.

2. Basic Tools

In this section, we present an outline of the properties of bivariate convolutions, bivariate probability generating functions and bivariate Laplace transforms (L.T.) which are necessary in the ensuing sections.

Let $F(x, y)$ and $G(x, y)$ be any two Stieltjes integrable functions of two non-negative random variables. For $x, y \geq 0$, their double convolution is defined as

$$
F * *G(x, y) = \int_0^x \int_0^y F(x - u, y - v) \, dG(u, v).
$$

This operation is commutative with respect to F and G and the order of integration is immaterial.

Suppose that for each $n = 1, 2, \ldots, (X_n, Y_n)$ has a joint distribution function given by $F\left(a^{n-1}x, b^{n-1}y\right)$. For each $x, y \geq 0$, define

$$
\begin{aligned}
F_0(x, y) &= 1 \\
F_1(x, y) &= F(x, y) \\
F_{n+1}(x, y) &= F * *F_n(ax, by). \quad (n = 1, 2, \ldots)
\end{aligned}
$$

Thus $F_n(\cdot, \cdot)$ is the joint distribution of the random pair $\left(U_n^{(1)}, U_n^{(2)}\right)$ and more precisely, $F_n(x, y)$ is the double convolution of $F(x, y)$ and $F_{n-1}\left(ax, by\right)$, for all $n = 1, 2, \ldots$. For the joint distribution function $F(x, y)$, we shall write $F^1(x)$ and $F^2(y)$ for the marginal distributions.

We now develop the relationships between the probability generating function of a bivariate, non-negative, integer valued random variables (X, Y) and the generating function of their *tail probabilities*. We shall first prove the following result.

Lemma 2.1 *Let*

$$
P(\alpha, \beta) = \sum_{i=0}^{\infty} \sum_{j=0}^{\infty} p_{i,j} \alpha^i \beta^j \qquad and \qquad Q(\alpha, \beta) = \sum_{i=0}^{\infty} \sum_{j=0}^{\infty} q_{i,j} \alpha^i \beta^j,
$$

where $p_{i,j} = P(X = i, Y = j)$ and $q_{i,j} = P(X \geq i, Y \geq j)$. Then for $|\alpha|, |\beta| < 1$,

$$
(1 - \alpha)\,(1 - \beta)Q(\alpha, \beta) = 1 - \alpha P(\alpha, 1) - \beta P(1, \beta) + \alpha\beta P(\alpha, \beta) \qquad (2.1)
$$

and

$$
\alpha\beta P(\alpha, \beta) = 1 - (1 - \alpha)Q(\alpha, 0) - (1 - \beta)Q(0, \beta) + (1 - \alpha)\,(1 - \beta)Q(\alpha, \beta) \quad (2.2)
$$

Proof. In the following steps, changing the order of summation is justified whenever it

is necessary.

$$Q(\alpha, \beta)$$
$$= \sum_{j=0}^{\infty} \sum_{i=0}^{\infty} q_{i,j} \, \alpha^i \beta^j$$
$$= \sum_{i=0}^{\infty} \sum_{j=0}^{\infty} \left[\sum_{k=i}^{\infty} \sum_{l=j}^{\infty} p_{k,l} \alpha^i \beta^j \right]$$
$$= \sum_{k=0}^{\infty} \sum_{i=0}^{k} \sum_{l=0}^{\infty} \sum_{j=0}^{l} p_{k,l} \alpha^i \beta^j$$
$$= \sum_{k=0}^{\infty} \sum_{l=0}^{\infty} p_{k,l} \frac{(1 - \alpha^{k+1})}{(1 - \alpha)} \frac{(1 - \beta^{l+1})}{(1 - \beta)}$$
$$= \frac{1}{(1 - \alpha)(1 - \beta)} \sum_{k=0}^{\infty} \sum_{l=0}^{\infty} p_{k,l} \left(1 - \alpha^{k+1} - \beta^{l+1} + \alpha^{k+1} \beta^{l+1} \right)$$
$$= \frac{1}{(1 - \alpha)(1 - \beta)} \left[1 - \sum_{k=0}^{\infty} \sum_{l=0}^{\infty} p_{k,l} \, \alpha^{k+1} - \sum_{k=0}^{\infty} \sum_{l=0}^{\infty} p_{k,l} \, \beta^{l+1} + \sum_{k=0}^{\infty} \sum_{l=0}^{\infty} p_{k,l} \, \alpha^{k+1} \beta^{l+1} \right]$$
$$= \frac{1}{(1 - \alpha)(1 - \beta)} \left[1 - \alpha \sum_{k=0}^{\infty} \sum_{l=0}^{\infty} p_{k,l} \, \alpha^k - \beta \sum_{k=0}^{\infty} \sum_{l=0}^{\infty} p_{k,l} \, \beta^l - \alpha\beta \sum_{k=0}^{\infty} \sum_{l=0}^{\infty} p_{k,l} \, \alpha^k \beta^l \right]$$
$$= \frac{1}{(1 - \alpha)(1 - \beta)} \left[1 - \alpha P(\alpha, 1) - \beta P(1, \beta) + \alpha\beta P(\alpha, \beta) \right],$$

from which we obtain (2.1). Next,

$$P(X = i, Y = j)$$
$$= \sum_{i=0}^{\infty} \sum_{j=0}^{\infty} p_{i,j} \, \alpha^i \beta^j$$
$$= \sum_{i=0}^{\infty} \sum_{j=0}^{\infty} P(X = i, Y = j) \, \alpha^i \beta^j$$
$$= \sum_{i=0}^{\infty} \sum_{j=0}^{\infty} \left[P(X \geq i, Y \geq j) - P(X \geq i+1, Y \geq j) \right.$$
$$\left. - P(X \geq i, Y \geq j+1) + P(X \geq i+1, Y \geq j+1) \right] \alpha^i \beta^j$$

$$= \sum_{i=0}^{\infty}\sum_{j=0}^{\infty} q_{i,j}\, \alpha^i\, \beta^j - \sum_{i=0}^{\infty}\sum_{j=0}^{\infty} q_{i+1,j}\, \alpha^i\, \beta^j - \sum_{i=0}^{\infty}\sum_{j=0}^{\infty} q_{i,j+1}\, \alpha^i\, \beta^j$$

$$+ \sum_{i=0}^{\infty}\sum_{j=0}^{\infty} q_{i+1,j+1}\, \alpha^i\, \beta^j$$

$$= \frac{1}{\alpha\beta}\left[\alpha\beta Q(\alpha\beta) - \beta\sum_{i=0}^{\infty}\sum_{j=0}^{\infty} q_{i+1,j}\, \alpha^{i+1}\, \beta^j - \alpha\sum_{i=0}^{\infty}\sum_{j=0}^{\infty} q_{i,j+1}\, \alpha^i\, \beta^{j+1} \right.$$

$$\left. + \sum_{i=0}^{\infty}\sum_{j=0}^{\infty} q_{i+1,j}\, \alpha^{i+1}\, \beta^{j+1} \right]$$

$$= \frac{1}{\alpha\beta}\left[\alpha\beta Q(\alpha\beta) - \beta[Q(\alpha,\beta) - Q(0,\beta)] - \alpha[Q(\alpha,\beta) - Q(\alpha,0)] \right.$$

$$\left. + [Q(\alpha,\beta) - Q(\alpha,0) - Q(0,\beta) + 1] \right]$$

$$= \frac{1}{\alpha\beta}\left[Q(\alpha\beta)[1 - \alpha - \beta + \alpha\beta] - Q(\alpha,0)[1 - \alpha] - Q(0,\beta)[1 - \beta] + 1 \right]$$

$$= \frac{1}{\alpha\beta}\left[1 - (1-\alpha)Q(\alpha,0) - (1-\beta)Q(0,\beta) + (1-\alpha)(1-\beta)Q(\alpha\beta) \right],$$

from which (2.2) follows and this completes the proof. ∎

From the equations (2.1) and (2.2) we obtain on simplification that

$$(1 - \beta)Q(0,\beta) \;=\; 1 - \beta P(1,\beta) \tag{2.3}$$

$$(1 - \alpha)Q(\alpha,0) \;=\; 1 - \alpha P(\alpha,1) \tag{2.4}$$

The marginal probability generating functions of X and Y are

$$P(\alpha,1) \;=\; \sum_{i=0}^{\infty} P(X=i)\alpha^i \tag{2.5}$$

and
$$P(1,\beta) \;=\; \sum_{j=0}^{\infty} P(Y=j)\beta^j \tag{2.6}$$

Similarly, the generating functions of the tail probabilities of the marginal distributions of X and Y are given by

$$Q(\alpha,0) \;=\; \sum_{i=0}^{\infty} P(X \geq i)\alpha^i \tag{2.7}$$

$$Q(0,\beta) \;=\; \sum_{j=0}^{\infty} P(Y \geq j)\beta^j \tag{2.8}$$

In order to determine the independence of the random variables X and Y, we need the following result.

Lemma 2.2 *The following conditions are equivalent.*

(i) X *and* Y *are independent.* $(p_{i,j} = p_i \, p_j, \ \text{for all } i, j = 1, 2, \ldots)$

(ii) $P(\alpha, \beta) = P(\alpha, 1) \, P(1, \beta); \quad |\alpha|, |\beta| \leq 1$

(iii) $Q(\alpha, \beta) = Q(\alpha, 0) \, Q(0, \beta); \quad |\alpha|, |\beta| < 1$

Proof. $\boxed{\text{(i)} \ \Leftrightarrow \ \text{(ii)}}$

Assume that X and Y are independent. Then

$$
\begin{aligned}
P(\alpha, \beta) &= \sum_{j,k=0}^{\infty} p_{j,k} \, \alpha^j \beta^k \\
&= \sum_{j,k=0}^{\infty} P(X = j, Y = k) \, \alpha^j \beta^k \\
&= \sum_{j=0}^{\infty} \sum_{k=0}^{\infty} P(X = j) P(Y = k) \, \alpha^j \beta^k \\
&= \sum_{j=0}^{\infty} P(X = j) \, \alpha^j \sum_{k=0}^{\infty} P(Y = k) \, \beta^k \\
&= P(\alpha, 1) \, P(1, \beta)
\end{aligned}
$$

$\boxed{\text{(ii)} \ \Leftrightarrow \ \text{(iii)}}$

Consider

$$(1 - \alpha)(1 - \beta)[Q(\alpha, \beta) - Q(\alpha, 0)Q(0, \beta)]$$

$$= 1 - \alpha P(\alpha, 1) - \beta P(1, \beta) + \alpha \beta P(\alpha, \beta) - (1 - \beta P(1, \beta))(1 - \alpha P(\alpha, 1))$$

$$= 1 - \alpha P(\alpha, 1) - \beta P(1, \beta) + \alpha \beta P(\alpha, \beta) - 1 + \alpha P(\alpha, 1) + \beta P(1, \beta)$$

$$- \alpha \beta P(\alpha, 1) P(1, \beta)$$

$$= \alpha \beta [P(\alpha, \beta) - P(\alpha, 1) P(1, \beta)],$$

where the first equality is because of equation (2.1) and the second equality is obtained by using the equations (2.3) and (2.4) and this completes the proof. ∎

The moments of X and Y, for low orders, may be easily obtained from $q_{i,j}$ or from $Q(\alpha, \beta)$ and in particular, we have the following result.

Lemma 2.3

$$E(X) \;=\; \sum_{i=1}^{\infty} q_{i,0} = Q(1,0) - 1 \tag{2.9}$$

$$E(Y) \;=\; \sum_{j=1}^{\infty} q_{0,j} = Q(0,1) - 1 \tag{2.10}$$

$$E(XY) \;=\; \sum_{i=1}^{\infty}\sum_{j=1}^{\infty} q_{i,j} = Q(1,1) - Q(1,0) - Q(0,1) + 1 \tag{2.11}$$

$$and \qquad \text{Cov}(X,Y) \;=\; Q(1,1) - Q(1,0)\,Q(0,1). \tag{2.12}$$

Proof. Consider

$$E(X) \;=\; \sum_{i=1}^{\infty} P(X \geq i, Y \geq 0)$$

$$=\; \sum_{i=1}^{\infty} q_{i,0}$$

$$=\; Q(1,0) - 1$$

$$E(Y) \;=\; \sum_{j=1}^{\infty} P(X \geq 0, Y \geq j)$$

$$=\; \sum_{j=1}^{\infty} q_{0,j}$$

$$=\; Q(0,1) - 1$$

$$E(XY) \;=\; \sum_{i=1}^{\infty}\sum_{j=1}^{\infty} q_{i,j}$$

$$=\; q_{0,0} + q_{0,1} + q_{0,2} + q_{0,3} + \cdots$$
$$q_{1,0} + q_{1,1} + q_{1,2} + q_{1,3} + \cdots$$
$$q_{2,0} + q_{2,1} + q_{2,2} + q_{2,3} + \cdots$$
$$+ \cdots \quad \cdots$$
$$-(q_{0,0} + q_{0,1} + q_{0,2} + q_{0,3} + \cdots)$$
$$-(q_{0,0} + q_{1,0} + q_{2,0} + q_{3,0} + \cdots - q_{0,0})$$

$$=\; Q(1,1) - (q_{0,0} + q_{0,1} + q_{0,2} + q_{0,3} + \cdots) - $$
$$\qquad (q_{0,0} + q_{1,0} + q_{2,0} + q_{3,0} + \cdots) + q_{0,0}$$

$$=\; Q(1,1) - Q(1,0) - Q(0,1) + 1$$

and

$$
\begin{aligned}
\mathrm{Cov}(X, Y) &= E(XY) - E(X)\,E(Y) \\
&= Q(1,1) - Q(1,0) - Q(0,1) + 1 - [Q(1,0) - 1][Q(0,1) - 1] \\
&= Q(1,1) - Q(1,0)\,Q(0,1).
\end{aligned}
$$

This completes the proof of the lemma. ∎

We use the following notations for life distributions, that is bivariate life distribution functions which vanish identically for negative values of their arguments.

(i) If $F(x, y)$ is any function of bounded variation in every finite rectangle then we shall write

$$
F^*(p, q) = \int_0^\infty \int_0^\infty \exp(-(px + qy))dF(x, y) \tag{2.13}
$$

for the bivariate Laplace Stieltjes Transform (L.S.T.) of $F(x, y)$.

(ii) If $F(x, y)$ is any function which is integrable in every finite rectangle then we shall write

$$
\begin{aligned}
F^0(p, q) &\equiv \mathcal{L}^2\{F(x, y)\} \\
&= \int_0^\infty \int_0^\infty \exp(-(px + qy))F(x, y)dxdy, \tag{2.14}
\end{aligned}
$$

for the bivariate Laplace Transform (L.T.) of $F(x, y)$.

(iii) For the univariate transforms, we write

$$
F^*(p) = \int_0^\infty \exp(-px)dF(x) \tag{2.15}
$$

$$
F^0(p) \equiv \mathcal{L}\{F(x)\} = \int_0^\infty \exp(-px)F(x)dx \tag{2.16}
$$

for L.S.T. and L.T. (when they exist) of the function $F(x)$.

Assume that $F(x, y)$ is an absolutely continuous distribution function with joint *probability density function* (pdf) $f(x, y)$, whose marginal pdf's are given by $f^1(x)$ and $f^2(y)$. Then the bivariate L.T. of $f(x, y)$, (denoted by $f^0(x, y)$) exists for all p, q such that $\Re(p), \Re(q) \geq 0$. For such a distribution, the L.S.T. and L.T. are given by

$$
F^*(p, q) = f^0(p, q) \tag{2.17}
$$

$$
F^0(p, q) = \frac{f^0(p, q)}{pq} \tag{2.18}
$$

The L.T.'s of the marginal distribution functions and pdf's are given by

$$\mathcal{L}^2\{F^1(x)\} = \frac{f^0(p,0)}{pq} \tag{2.19}$$

$$\mathcal{L}^2\{F^2(y)\} = \frac{f^0(0,q)}{pq} \tag{2.20}$$

$$\mathcal{L}\{f^1(x)\} = f^0(p,0) = f^{10}(p) \tag{2.21}$$

$$\mathcal{L}\{f^2(y)\} = f^0(0,q) = f^{20}(q) \tag{2.22}$$

The bivariate L.S.T. and L.T.'s of convolution of joint distribution functions are given below:

(i) If F and G are joint distribution functions then

$$(F**G)^*(p,q) = F^*(p,q)\, G^*(p,q). \tag{2.23}$$

(i) If G is absolutely continuous with joint pdf g, then

$$(F**G)^0(p,q) = F^0(p,q)\, g^0(p,q). \tag{2.24}$$

We conclude this section with the following result, which will be used in the proof of Theorem 3.5.

Lemma 2.4 *If $F(x,y)$ is absolutely continuous, then for all $r \geq 0, k \geq 0$ and $\Re(p), \Re(q) > 0$*

$$(F_k**F_r)^0(p,q) = \frac{[f^0(p,q)]^{k+r}}{pq} \tag{2.25}$$

$$(F_k^1**F_r)^0(p,q) = \frac{[f^0(p,0)]^k[f^0(p,q)]^r}{pq} \tag{2.26}$$

$$(F_k^2**F_r)^0(p,q) = \frac{[f^0(0,q)]^k[f^0(p,q)]^r}{pq} \tag{2.27}$$

Proof. Denoting the bivariate L.T. of $f_r(x,y)$, the joint pdf of $\left(U_r^{(1)}, U_r^{(2)}\right)$ by $f_r^0(p,q)$ and using (2.24), we obtain

$$\begin{aligned}
(F_k**F_r)^0(p,q) &= F_k^0(p,q)f_r^0(p,q) \\
&= \frac{f_k^0(p,q)}{pq}f_r^0(p,q) \qquad \text{using (2.18)} \\
&= \frac{[f^0(p,q)]^{k+r}}{pq},
\end{aligned}$$

upon using the fact that $f_i^0(p,q) = [f^0(p,q)]^i$ for $i = 1,2,\dots$. Since $F_0 = F_0^1 = F_0^2$ with bivariate L.T. $1/pq$, the equation (2.25) holds for $k = r = 0$. The proof of (2.26) and (2.27) are similar and hence omitted. ∎

3. Geometric Counting Process in Two Variates

In this section, the properties of geometric counting process in two variates are studied. The joint distribution and the joint probability generating function of $\left(N_x^{(1)}, N_y^{(2)}\right)$ and the bivariate L.T. of this bivariate probability generating function are obtained. The joint moments of $\left(N_x^{(1)}, N_y^{(2)}\right)$ and the independence of $N_x^{(1)}$ and $N_y^{(2)}$ are also discussed. The following theorem gives the joint distribution of $\left(N_x^{(1)}, N_y^{(2)}\right)$.

Theorem 3.1 *If for $m, n = 0, 1, 2, \ldots$, and $x, y \geq 0$,*

$$q_{m,n}(x,y) \equiv P\left(N_x^{(1)} \geq m, N_y^{(2)} \geq n\right), \tag{3.1}$$

then for $m, r = 0, 1, 2, \ldots$, and $x, y \geq 0$,

$$q_{m+r,m}(x,y) = F_r^1 * *F_m(ax, by) \tag{3.2}$$

$$q_{m,m+r}(x,y) = F_r^2 * *F_m(ax, by), \tag{3.3}$$

and, in particular,

$$q_{m,m}(x,y) = F_m(ax, by).$$

Proof. Using equation (1.1), we have

$$\{N_x^{(1)} \geq m, N_y^{(2)} \geq n\} = \{U_m^{(1)} \leq x, U_n^{(2)} \leq y\}.$$

Thus

$$q_{m,n}(x,y) = P\{U_m^{(1)} \leq x, U_n^{(2)} \leq y\}$$

and hence

$$q_{m,m}(x,y) = F_m(ax, by).$$

Further, consider $q_{m+r,m}(x,y)$ and suppose that the m-th (X, Y)-renewal occurs at the point (u, v). Then, we require that

   (i) $v \leq y$ and

   (ii) r further X-renewals should occur between u and x.

That is,

$$\begin{aligned} q_{m+r,m}(x,y) &= \int_0^x \int_0^y F_r(a(x-u), \infty) dF_m(au, bv) \\ &= F_r^1 * *F_m(ax, by), \end{aligned}$$

as desired.

Proceeding on similar lines as above, we obtain

$$q_{m,m+r}(x,y) = \int_0^x \int_0^y F_r(\infty, b(y-v))dF_m(au, bv)$$
$$= F_r^2 * *F_m(ax, by),$$

and this completes the proof of the theorem. ∎

Remark. When $a = 1$ and $b = 1$ this constitutes a renewal process.

Theorem 3.2 *If for $m, n = 0, 1, 2, \ldots$, and $x, y \geq 0$,*

$$p_{m,n}(x,y) = P\{N_x^{(1)} = m, N_y^{(2)} = n\} \tag{3.4}$$

then

$$p_{m,m}(x,y) = (F_0 - F^1 - F^2 + F) * *F_m(ax, by) \tag{3.5}$$

and for $r \geq 1$,

$$p_{m+r,m}(x,y) = (F_r^1 - F_{r+1}^1 - F_{r-1}^1 * *F + F_r^1 * *F) * *F_m(ax, by), \tag{3.6}$$

$$p_{m,m+r}(x,y) = (F_r^2 - F_{r+1}^2 - F_{r-1}^2 * *F + F_r^2 * *F) * *F_m(ax, by). \tag{3.7}$$

Proof. Using equation (3.1), the equation (3.4) may be written as

$$p_{m,n}(x,y) = q_{m+1,n+1}(x,y) - q_{m,n+1}(x,y) - q_{m+1,n}(x,y) + q_{m,n}(x,y)$$

Then

$$p_{m,m}(x,y)$$
$$= q_{m+1,m+1}(x,y) - q_{m,m+1}(x,y) - q_{m+1,m}(x,y) + q_{m,m}(x,y)$$
$$= F_{m+1}(ax, by) - F_1^2 * *F_m(ax, by) - F_1^1 * *F_m(ax, by) + F_m(ax, by)$$
$$= (F - F^2 - F^1 + F_0) * *F_m(ax, by)$$
$$= (F_0 - F^1 - F^2 + F) * *F_m(ax, by).$$

The identity (5.3.7) may be proved similarly. ∎

The marginal distributions of $N_x^{(1)}$ and $N_y^{(2)}$ can be obtained from the above theorem.

Corollary 3.1 *For $m, n = 0, 1, 2, \ldots$ and $x, y \geq 0$,*

$$P\{N_x^{(1)} = m\} = F_m^1(ax) - F_{m+1}^1(ax) \tag{3.8}$$
$$P\{N_y^{(2)} = n\} = F_n^2(by) - F_{n+1}^2(by) \tag{3.9}$$

The following theorems give the joint probability generating function of $\left(N_x^{(1)}, N_y^{(2)}\right)$.

Theorem 3.3 *If*

$$Q(x, y; \alpha, \beta) = \sum_{m=0}^{\infty} \sum_{n=0}^{\infty} q_{m,n}(x, y)\, \alpha^m \beta^n,$$

then for $|\alpha| < 1, |\beta| < 1$ and $x, y \geq 0$

$$Q(x, y; \alpha, \beta) = \left(F_0 + \sum_{i=1}^{\infty} \alpha^i F_i^1 + \sum_{j=1}^{\infty} \beta^j F_j^2 \right) ** \left(\sum_{r=0}^{\infty} (\alpha\beta)^r F_r(ax, by) \right). \quad (3.10)$$

Proof. Consider

$$
\begin{aligned}
Q(x, y; \alpha, \beta) &= \sum_{m=0}^{\infty} \sum_{n=0}^{\infty} q_{m,n}(x, y)\alpha^m \beta^n \\
&= q_{0,0}(x, y) + q_{0,1}(x, y)\beta + q_{0,2}(x, y)\beta^2 + \cdots \\
&\quad + q_{1,0}(x, y)\alpha + q_{1,1}(x, y)\alpha\beta + q_{1,2}(x, y)\alpha\beta^2 + \cdots \\
&\quad + q_{2,0}(x, y)\alpha^2 + q_{2,1}(x, y)\alpha^2\beta + q_{2,2}(x, y)\alpha^2\beta^2 + \cdots \\
&= \sum_{r=0}^{\infty} (\alpha\beta)^r F_r(ax, by) + \left(\sum_{i=1}^{\infty} \alpha^i F_i^1 \right) ** \left(\sum_{r=0}^{\infty} (\alpha\beta)^r F_r(ax, by) \right) \\
&\quad + \left(\sum_{j=1}^{\infty} \beta^j F_j^2 \right) ** \left(\sum_{r=0}^{\infty} (\alpha\beta)^r F_r(ax, by) \right) \\
\\
&= \left(F_0 + \sum_{i=1}^{\infty} \alpha^i F_i^1 + \sum_{j=1}^{\infty} \beta^j F_j^2 \right) ** \left(\sum_{r=0}^{\infty} (\alpha\beta)^r F_r(ax, by) \right)
\end{aligned}
$$

and the proof is complete.　　　　　　　　　　　　　　　　　　■

Theorem 3.4 *If*

$$P(x, y; \alpha, \beta) = \sum_{m=0}^{\infty} \sum_{n=0}^{\infty} p_{m,n}(x, y)\alpha^m \beta^n$$

then for $|\alpha|, |\beta| \leq 1$ and $x, y \geq 0$,

$$
\begin{aligned}
&\alpha\beta P(x, y; \alpha, \beta) \\
&= (1-\alpha)(1-\beta)\left(F_0 + \sum_{i=1}^{\infty} \alpha^i F_i^1 + \sum_{j=1}^{\infty} \beta^j F_j^2 \right) ** \left(\sum_{r=0}^{\infty} (\alpha\beta)^r F_r(ax, by) \right) \\
&\quad - \beta(1-\alpha) \sum_{i=1}^{\infty} \alpha^i F_i^1(ax) - \alpha(1-\beta) \sum_{j=1}^{\infty} \beta^j F_j^2(by) + \alpha\beta \quad\quad\quad (3.11)
\end{aligned}
$$

Proof. From equation (2.2), we have

$$\alpha\beta P(x,y;\alpha,\beta) \;=\; 1 - (1-\alpha)Q(x,y;\alpha,0) - (1-\beta)Q(x,y;0,\beta)$$
$$+(1-\alpha)(1-\beta)Q(x,y;\alpha,\beta).$$

Using the results for $Q(x,y;\alpha,0)$ and $Q(x,y;0,\beta)$ and simplifying we obtain (3.11). This completes the proof of the theorem. ∎

The marginal probability generating functions of $N_x^{(1)}$ and $N_y^{(2)}$ are given by

$$P_1(x;\alpha) \;=\; P(x,y;\alpha,1)$$

and
$$P_2(y;\beta) \;=\; P(x,y;1,\beta),$$

respectively, which can also be derived from (5.3.11).

Corollary 3.2 *For $|\alpha|,|\beta| \leq 1$ and $x,y \geq 0$,*

$$P_1(x;\alpha) \;=\; 1 + (\alpha-1)\sum_{i=1}^{\infty} F_i^1(ax)\alpha^{i-1}$$

and
$$P_2(y;\beta) \;=\; 1 + (\beta-1)\sum_{j=1}^{\infty} F_j^2(by)\beta^{j-1}$$

We now derive an expression for the bivariate Laplace Transform of the joint probability generating function of $\left(N_x^{(1)}, N_y^{(2)}\right)$

Theorem 3.5 *If $Q^0(p,q;\alpha,\beta) \;=\; \mathcal{L}^2\{Q(x,y;\alpha,\beta)\}$ then, for $|\alpha|,|\beta| < 1$ and $\Re(p),\Re(q) > 0$,*

$$Q^0(p,q;\alpha,\beta) = \frac{1 - \alpha\beta f^0(p,0)f^0(0,q)}{pq\beta(1-\alpha\beta f^0(p,q))(1-\alpha f^0(p,0))(1-\beta f^0(0,q))} \qquad (3.12)$$

Proof. Consider

$$Q^0(p,q;\alpha,\beta)$$
$$= \mathcal{L}^2[Q(x,y;\alpha,\beta)$$
$$= \mathcal{L}^2\left[\left(F_0 + \sum_{i=1}^{\infty}\alpha^i F_i^1 + \sum_{j=1}^{\infty}\beta^j F_j^2\right) * * \left(\sum_{r=0}^{\infty}(\alpha\beta)^r F_r(ax,by)\right)\right]$$
$$= \sum_{r=0}^{\infty}(\alpha\beta)^r (F_0 * *F_r)^0(p,q) + \sum_{i=1}^{\infty}\alpha^i \sum_{r=0}^{\infty}(\alpha\beta)^r (F_i^1 * *F_r)^0(p,q)$$
$$+ \sum_{j=1}^{\infty}\beta^j \sum_{r=0}^{\infty}(\alpha\beta)^r (F_j^2 * *F_r)^0(p,q)$$

$$= \sum_{r=0}^{\infty}(\alpha\beta)^r \frac{[f^0(p,q)]^r}{pq} + \sum_{i=1}^{\infty}\alpha^i \sum_{r=0}^{\infty}(\alpha\beta)^r \frac{[f^0(p,0)]^i[f^0(p,q)]^r}{pq}$$

$$+ \sum_{j=1}^{\infty}\beta^j \sum_{r=0}^{\infty}(\alpha\beta)^r \frac{[f^0(0,q)]^j[f^0(p,q)]^r}{pq}$$

$$= \sum_{r=0}^{\infty}(\alpha\beta)^r \frac{[f^0(p,q)]^r}{pq} \left[1 + \sum_{i=0}^{\infty}\alpha^i[f^0(p,0)]^i + \sum_{j=0}^{\infty}\beta^j[f^0(o,q)]^i\right]$$

$$= \sum_{r=0}^{\infty}(\alpha\beta)^r \frac{[f^0(p,q)]^r}{pq} \left[1 + \left(\frac{1}{1-\alpha f^0(p,0)} - 1\right) + \left(\frac{1}{1-\beta f^0(0,q)} - 1\right)\right]$$

$$= \sum_{r=0}^{\infty}(\alpha\beta)^r \frac{[f^0(p,q)]^r}{pq}$$

$$\times \left[\frac{1 - \beta f^0(0,q) + 1 - \alpha f^0(p,0) - (1-\alpha f^0(p,0))(1-\beta f^0(0,q))}{(1-\alpha f^0(p,0))(1-\beta f^0(0,q))}\right]$$

$$= \frac{1 - \alpha\beta f^0(p,0)f^0(0,q)}{pq\,(1-\alpha\beta f^0(p,q))(1-\alpha f^0(p,0))(1-\beta f^0(0,q))}.$$

This completes the proof of the theorem ∎

Theorem 3.6 *If* $P^0(p,q;\alpha,\beta) = \mathcal{L}^2\{P(x,y;\alpha,\beta)\}$ *then, for* $|\alpha|,|\beta| \leq 1$ *and* $\Re(p),\Re(q) \geq 0$, *we have*

$$P^0(p,q;\alpha,\beta) = \frac{(1-\alpha)(1-\beta)[f^0(p,q) - f^0(p,0)f^0(0,q)]}{pq(1-\alpha\beta f^0(p,q))(1-\alpha f^0(p,0))(1-\beta f^0(0,q))}$$
$$+ \frac{(1-f^0(p,0))(1-f^0(0,q))}{pq(1-\alpha f^0(p,0))(1-\beta f^0(0,q))}. \tag{3.13}$$

Proof. Using equation (2.2), we may write

$$\alpha\beta P^0(p,q;\alpha,\beta)$$
$$= (1-\alpha)(1-\beta)Q^0(p,q;\alpha,\beta)$$
$$\quad -(1-\alpha)Q^0(p,q;\alpha,0)(1-\beta)Q^0(p,q;0,\beta) + \frac{1}{pq}$$
$$= (1-\alpha)(1-\beta)\frac{1 - \alpha\beta f^0(p,0)f^0(0,q)}{pq[1-\alpha\beta f^0(p,q)][1-\alpha f^0(p,0)][1-\beta f^0(p,q)]}$$
$$\quad -(1-\alpha)\frac{1}{pq[1-\alpha f^0(p,0)]} - (1-\beta)\frac{1}{pq[1-\beta f^0(0,q)]} + \frac{1}{pq},$$

upon using (3.12). Simplifying the above equation, we obtain (3.13) and the proof is complete. ∎

Corollary 3.3

$$P_1^0(x; \alpha) = \frac{1 - f^{10}(p)}{p\left[1 - \alpha f^{10}(p)\right]} = \frac{1 - f^0(p, 0)}{p[1 - \alpha f^0(p, 0)]} \qquad (3.14)$$

$$P_2^0(y; \beta) = \frac{1 - f^{20}(q)}{q\left[1 - \beta f^{20}(q)\right]} = \frac{1 - f^0(0, q)}{q[1 - \beta f^0(0, q)]}. \qquad (3.15)$$

The moments of $\left(N_x^{(1)}, N_y^{(2)}\right)$, for low orders, are given below.

Theorem 3.7 *For $x, y \geq 0$*

$$\Lambda_1(x) \equiv E[N_x^{(1)}] = \sum_{i=1}^{\infty} F_i^1(ax) \qquad (3.16)$$

$$\Lambda_2(y) \equiv E[N_y^{(2)}] = \sum_{j=1}^{\infty} F_j^2(by) \qquad (3.17)$$

and

$$
\begin{aligned}
K(x, y) &\equiv \mathrm{Cov}\left(N_x^{(1)}, N_y^{(2)}\right) \\
&= \left(F^0 + \sum_{i=1}^{\infty} F_i^1 + \sum_{j=1}^{\infty} F_j^2\right) ** \left(\sum_{r=1}^{\infty} F_r(ax, by)\right) \\
&\quad - \left(\sum_{i=1}^{\infty} F_i^1(x)\right)\left(\sum_{j=1}^{\infty} F_j^2(y)\right) \qquad (3.18)
\end{aligned}
$$

Proof. Consider

$$
\begin{aligned}
\Lambda_1(x) \equiv E[N_x^{(1)}] &= \sum_{i=1}^{\infty} i\, P[N_x^{(1)} = i] \\
&= \sum_{i=1}^{\infty} i\, \left(F_i^1(ax) - F_{i+1}^1(ax)\right) \\
&= \sum_{i=1}^{\infty} F_i^1(ax).
\end{aligned}
$$

Consider
$$
\begin{aligned}
\Lambda_2(y) \equiv E[N_y^{(2)}] &= \sum_{j=1}^{\infty} j\, P[N_y^{(2)} = j] \\
&= \sum_{j=1}^{\infty} j\, \left(F_j^2(by) - F_{i+1}^2(by)\right) \\
&= \sum_{j=1}^{\infty} F_j^2(by).
\end{aligned}
$$

Using Lemma (2.4) and Theorem (3.4), we obtain on simplification that

$$E\left(N_x^{(1)} N_y^{(2)}\right) = \left(F_0 + \sum_{i=1}^{\infty} F_i^1 + \sum_{j=1}^{\infty} F_j^2\right) * * \left(\sum_{r=0}^{\infty} F_r(ax, by)\right).$$

Thus (3.18) follows from the identity

$$\mathrm{Cov}\left(N_x^{(1)}, N_y^{(2)}\right) = E\left(N_x^{(1)} N_y^{(2)}\right) - E\left(N_x^{(1)}\right) E\left(N_y^{(2)}\right),$$

and the proof is complete.   ∎

The functions $\Lambda_1(x) \equiv E\left[N_x^{(1)}\right]$ and $\Lambda_2(y) \equiv E\left[N_y^{(2)}\right]$ are both one dimensional *geometric renewal functions*. We next investigate $\mathrm{Cov}\left(N_x^{(1)}, N_y^{(2)}\right)$ as this gives a measure of dependence between $N_x^{(1)}$ and $N_y^{(2)}$.

Theorem 3.8 *If $K(x, y) = Cov\left(N_x^{(1)}, N_y^{(2)}\right)$, then*

$$K^0(p, q) = \frac{f^0(p, q) - f^0(p, 0)f^0(0, q)}{pq(1 - f^0(p, q))(1 - f^0(p, 0))(1 - f^0(0, q))} \tag{3.19}$$

Proof. Consider

$$
\begin{aligned}
K(x, y) &= E\left(N_x^{(1)} N_y^{(2)}\right) - E\left[N_x^{(1)}\right] E\left[N_y^{(2)}\right] \\[6pt]
&= Q(x, y; 1, 1) - Q(x, y; 1, 0)Q(x, y; 0, 1) \\[6pt]
\Rightarrow K^0(p, q) &= Q^0(p, q; 1, 1) - pq\, Q^0(p, q; 1, 0)Q^0(p, q; 0, 1) \\[6pt]
&= \frac{1 - f^0(p, 0)\, f^0(0, q)}{pq\left(1 - f^0(p, q)\right)\left(1 - f^0(p, 0)\right)\left(1 - f^0(0, q)\right)} \\[6pt]
&\qquad - pq\, \frac{1}{pq\left(1 - f^0(p, 0)\right)}\, \frac{1}{pq\left(1 - f^0(0, q)\right)} \\[6pt]
&= \frac{1 - f^0(p, 0)f^0(0, q) - 1 + f^0(p, q)}{pq\left(1 - f^0(p, q)\right)\left(1 - f^0(p, 0)\right)\left(1 - f^0(0, q)\right)} \\[6pt]
&= \frac{f^0(p, q) - f^0(p, 0)f^0(0, q)}{pq\left(1 - f^0(p, q)\right)\left(1 - f^0(p, 0)\right)\left(1 - f^0(0, q)\right)}
\end{aligned}
$$

and the proof is complete.   ∎

We conclude this section with a result concerning the independence of the random variables $N_x^{(1)}$ and $N_y^{(2)}$.

Theorem 3.9 *The following are equivalent*

(i) X and Y are independent

(ii) $Cov\left(N_x^{(1)}, N_y^{(2)}\right) = 0$

(iii) $N_x^{(1)}$ and $N_y^{(2)}$ are independent, for all $x, y \geq 0$.

Proof.

X and Y are independent

$$\Leftrightarrow \quad F(x,y) = F^1(x)\, F^2(y) \quad \text{for all } x, y$$
$$\Leftrightarrow \quad f(x,y) = f^1(x)\, f^2(y) \quad \text{for all } x, y \text{ (a.e.)}$$
$$\Leftrightarrow \quad f^0(p,q) = f^{10}(p)\, f^{20}(q)$$
$$\Leftrightarrow \quad f^0(p,q) = f^1(p,0)\, f^2(q,0).$$

$Cov\left(N_x^{(1)}, N_y^{(2)}\right) = 0$ for all $x, y \geq 0$

$$\Leftrightarrow \quad K^0(p,q) = 0$$
$$\Leftrightarrow \quad f^0(p,q) = f^1(p,0)\, f^2(q,0). \quad (\text{using}(3.19))$$

$N_x^{(1)}$ and $N_y^{(2)}$ are independent

$$\Leftrightarrow \quad P(x,y;\alpha,\beta) = P_1(x;\alpha)\, P_2(y;\beta) \ \text{ for } |\alpha|, |\beta| \leq 1$$
$$\Leftrightarrow \quad P^0(p,q;\alpha,\beta) = P_1^0(p;\alpha)\, P_2^0(q;\beta)$$
$$\Leftrightarrow \quad \frac{(1-\alpha)(1-\beta)[f^0(p,q) - f^0(p,0)f^0(0,q)]}{\alpha\beta(1-\alpha\beta f^0(p,q))(1-\alpha f^0(p,0))(1-\beta f^0(0,q))} = 0$$
$$(\text{using}(3.13), (3.14)\text{and}(3.15))$$
$$\Leftrightarrow \quad f^0(p,q) = f^1(p,0)\, f^2(q,0).$$

and the result follows. ∎

4. Geometric Counting Process in Two Dimensions

We study the characteristics of the two dimensional geometric counting process in this section. The distribution of $N_{x,y}$, its probability generating function and the L.T. of this probability generating function are discussed. The renewal function in two dimensions for the geometric process and its associated renewal density are also presented. Finally, the integral equation of the geometric process in two dimensions is derived.

We shall first derive the distribution of $N_{x,y}$.

Theorem 4.1 *For $x, y \geq 0$ and $n \geq 0$*

$$P(N_{x,y} = n) = F_n(x, y) - F_{n+1}(x, y) \tag{4.1}$$

Proof. Since $N_{x,y} = \min\left(N_x^{(1)}, N_y^{(2)}\right)$, we have

$$
\begin{aligned}
\{N_{x,y} \geq n\} &= \{N_x^{(1)} \geq n\} \cap \{N_y^{(2)} \geq n\} \\
&= \{U_n^{(1)} \leq x, V_n^{(2)} \leq y\}
\end{aligned}
$$

Thus

$$P\{N_{x,y} \geq n\} = F_n(x, y)$$

and

$$
\begin{aligned}
P\{N_{x,y} = n\} &= P\{N_{x,y} \geq n\} - P\{N_{x,y} \geq n + 1\} \\
&= F_n(x, y) - F_{n+1}(x, y),
\end{aligned}
$$

and the proof is complete. ∎

An expression for the probability generating function of $N_{x,y}$ can be easily derived from (4.1).

Theorem 4.2 *If*

$$\prod(x, y; \alpha) = \sum_{n=0}^{\infty} P\{N_{x,y} = n\}\alpha^n, \tag{4.2}$$

then for $|\alpha| \leq 1$ and $x, y \geq 0$

$$\prod(x, y; \alpha) = 1 + (\alpha - 1) \sum_{n=1}^{\infty} \alpha^{n-1} F_n(x, y)$$

Proof. Consider

$$
\begin{aligned}
\prod(x, y; \alpha) &= \sum_{n=0}^{\infty} P\{N_{x,y} = n\}\alpha^n \\
&= \sum_{n=o}^{\infty} \alpha^n \{F_n(x, y) - F_{n+1}(x, y)\} \\
&= 1 - F_1(x, y) + \alpha(F_1(x, y) - F_2(x, y)) \\
&\qquad\qquad + \alpha^2(F_2(x, y) - F_3(x, y)) + \cdots \\
&= 1 + (\alpha - 1)F_1(x, y) + (\alpha - 1)\alpha F_2(x, y) \\
&\qquad\qquad + (\alpha - 1)\alpha^2 F_3(x, y) + \cdots \\
&= 1 + (\alpha - 1)\sum_{n=1}^{\infty} \alpha^{n-1} F_n(x, y)
\end{aligned}
$$

and the proof is complete. ∎

Remark. The probability generating functions of $N_x^{(1)}$ and $N_y^{(2)}$ can be obtained directly from $\prod(x, y; \alpha)$, viz

$$P_1(x, s) = \prod(x, \infty; s)$$

and
$$P_2(y, s) = \prod(\infty, y; s)$$

We now find an expression for the bivariate L.T. of the probability generating function of $N_{x,y}$

Theorem 4.3 *If* $\prod^0(x, y; \alpha) = \mathcal{L}^2\left\{\prod(x, y; \alpha)\right\}$, *then for* $|\alpha| \leq 1$, *and* $\Re(p), \Re(q) > 0$,

$$\prod^0(p, q; \alpha) = \frac{1 - f^0(p, q)}{pq(1 - \alpha f^0(p, q))} \tag{4.3}$$

Proof. Consider

$$
\begin{aligned}
\prod^0(p, q; \alpha) &= \mathcal{L}^2\left\{\prod(x, y; \alpha)\right\} \\
&= \mathcal{L}^2\left[1 + (\alpha - 1)\sum_{n=0}^{\infty} \alpha^{n-1} F_n(ax, ay)\right] \\
&= \frac{1}{pq} + (\alpha - 1)\sum_{n=0}^{\infty} \alpha^{n-1} F_n^0(ax, ay) \\
&= \frac{1}{pq} + (\alpha - 1)\sum_{n=0}^{\infty} \alpha^{n-1} \frac{[f^0(p, q)]^n}{pq} \\
&= \frac{1}{pq} + \frac{(\alpha - 1)}{pq}\frac{1}{\alpha}\left[\frac{1}{(1 - \alpha f^0(p, q))} - 1\right] \\
&= \frac{(1 - \alpha f^0(p, q)) + (\alpha - 1)f^0(p, q)}{pq\,(1 - \alpha f^0(p, q))} \\
&= \frac{1 - f^0(p, q)}{pq\,(1 - \alpha f^0(p, q))}.
\end{aligned}
$$

This completes the proof of the theorem. ∎

As in the two dimensional renewal funciton in a two dimensional process, we define the renewal function for the geometric process in two dimensions as

$$H(x, y) = E[N_{x,y}].$$

Theorem 4.4 *For all* $x, y \geq 0$,

$$H(x, y) = \sum_{n=1}^{\infty} F_n(x, y).$$

Proof. Consider

$$
\begin{aligned}
H(x, y) &= E[N_{x,y}] \\
&= \sum_{n=1}^{\infty} P(N_{x,y} \geq n) \\
&= \sum_{n=1}^{\infty} F_n(x, y)
\end{aligned}
$$

Here $F_n(x, y)$ is the convolution of $F(x, y)$ and $F_{n-1}(ax, by)$ and completes the proof of the theorem. ∎

We now derive the integral equation of the two dimensional geometric process.

Theorem 4.5 *For all* $x, y \geq 0$,

$$H(x, y) = F(x, y) + \int_0^x \int_0^y H(a(x - u), b(y - v))dF(u, v) \qquad (4.5)$$

Proof. For $n = 2, 3, \ldots$, consider

$$F_n(x, y) = \int_0^x \int_0^y F_{n-1}(a(x - u), b(y - v))dF(u, v)$$

Here $F_n(x, y)$ is the convolution of $F(x, y)$ and $F_{n-1}(x, y)$. When $n = 2$,

$$F_2(x, y) = \int_0^x \int_0^y F_1(a(x - u), b(y - v))dF(u, v),$$

then (4.5) holds. Assume that (4.5) is true for an integer n and consider $(n + 1)$.

$$F_{n+1}(x, y)$$

$$= \int_0^x \int_0^y F_n(x - u, y - v)dF(a^n u, b^n v)$$

$$= \int_0^x \int_0^y \left(\int_0^{x-u} \int_0^{y-v} F_{n-1}(a(x - u - l), b(y - v - m))dF(l, m) \right) dF(a^n u, b^n v)$$

$$= \int_0^x \int_0^y \left(\int_0^{x-l} \int_0^{y-m} F_{n-1}(a(x - u - l), b(y - v - m))dF(a^n u, b^n v) \right) dF(l, m)$$

$$= \int_0^x \int_0^y \left(\int_0^{x-l} \int_0^{y-m} F_{n-1}(a(x-l)-s, a(y-m)-t) dF(a^{n-1}s, b^{n-1}t) \right) dF(l, m)$$

$$= \int_0^x \int_0^y F_n(a(x-l), b(y-m)) \, dF(l, m),$$

the second and the last equality are by induction assumption, the third equality is by changing the order of integration and the fourth equality is by substituting $au = s$ and $bv = t$. This completes the proof. ∎

The equation (4.5) is analogous to the integral equation of one dimensional geometric process (Lam [1988]).

The L.S.T. of $H(x, y)$ is given by

$$
\begin{aligned}
H^*(p, q) &\equiv \frac{F^*(p, q)}{1 - F^*(p, q)} \\
&= \frac{f^0(p, q)}{1 - f^0(p, q)}
\end{aligned}
$$

Further if $F(x, y)$ is absolutely continuous, then the density function of the geometric process in two dimensions is given by

$$h(x, y) = \frac{\partial^2}{\partial x \partial y} H(x, y) = \sum_{n=1}^{\infty} f_n(x, y)$$

and from (4.5), we have

$$h(x, y) = f(x, y) + a^2 \int_0^x \int_0^y h(a(x-u), b(y-v)) f(u, v) du dv$$

Taking bivariate Laplace Transforms, we have

$$h^0(p, q) = \frac{f^0(p, q)}{1 - f^0(p, q)}.$$

5. Two dimensional $\mathbb{T}$ Policy

As an application of the two dimensional geometric process, we consider a maintenance and replacement model and make the following assumptions:

A5.1 At the beginning a system consisting of two components is used.

A5.2 At the moment the component i ($i = 1, 2$) fails, it is repaired. Let X_{in} be the survival time after $(n - 1)$st repair, for $i = 1, 2$, respectively. The distribution function of X_{in} is $F^i(a_i^{n-1}x)$, where each $a_i > 1$ is constant. $F(a_1^{n-1}x_1, a_2^{n-1}x_2)$ is the joint distribution function of (X_{1n}, X_{2n}). The two dimensional successive survival times $\{(X_{1n}, X_{2n}); n = 1, 2, \ldots\}$ form a decreasing geometric process or a renewal process.

A5.3 Let Y_{in} be the repair time after the $n-$th failure of component i for $i = 1, 2$ respectively. For convenience, it is assumed that $b_1 = b_2 = b$, where $0 < b < 1$. The marginal distribution function of Y_{in} is $G^i(b^{n-1}y)$, where $0 < b < 1$ is constant. $G(b^{n-1}y_1, b^{n-1}y_2)$ is the joint distribution function of (Y_{1n}, Y_{2n}). The two dimensional successive repair times $\{(Y_{1n}, Y_{2n}); n = 1, 2, \ldots\}$ constitute an increasing geometric process or a renewal process.

A5.4 The survival times $\{(X_{1n}, X_{2n}); n = 1, 2, \ldots\}$ and the repair times $\{(Y_{1n}, Y_{2n}); n = 1, 2, \ldots\}$ are independent and each is independent of the repair process.

A5.5 The repair cost rate for each component is c_1 and the reward rate, whenever the system is working is r_i and without loss of generality, we can assume $r_i = 1$, for $i = 1, 2$.

A5.6 The replacement cost is c_2.

Let T_{i1} be the first replacement time; in general, for $n \geq 2$, let T_{in} be the time between $(n - 1)$-st replacement and the n-th replacement of component i, $(i = 1, 2)$. Thus $\{(T_{1n}, T_{2n})\}$ form a geometric renewal process in two dimensions. We now explore two distinct cases.

Case (i) The system works if both the components work.

Let

$$\gamma_k = \sum_{j=1}^{k} \min(X_{1j}, X_{2j})$$

$$\delta_k = \sum_{j=1}^{k} \max(Y_{1j}, Y_{2j}),$$

where vacuous sums are taken to be zero. Since the repair times are non-negligible we need to consider the working age of the system. The *working age* of a system at time t is the cumulative survival time by time t. The working age $T(t)$ of a system at time t is

given by

$$T(t) = \begin{cases} t - \delta_n & \gamma_n + \delta_n \le t < \gamma_{n+1} + \delta_n \\ \gamma_{n+1} & \gamma_{n+1} + \delta_n \le t < \gamma_{n+1} + \delta_{n+1} \end{cases}$$

A two dimensional replacement policy is a policy under which the system will be replaced, whenever the working age of the system reaches T.

The length of a cycle is

$$W = T + \delta_{N_{x,y}}, \quad \gamma_{N_{x,y}} < T \le \gamma_{N_{x,y}}, \quad N_{x,y} = 0, 1, 2, \ldots$$

where $N_{x,y}$ is a random variable. We now determine the expectation of $\delta_{N_{x,y}}$. Since

$$
\begin{aligned}
E[\delta_{N_{x,y}}] &= E\left[\sum_{j=1}^{N_{x,y}} \max(Y_{1j}, Y_{2j})\right] \\
&= E\left[E\left(\sum_{j=1}^{N_{x,y}} \max(Y_{1j}, Y_{2j})|N_{x,y}\right)\right] \\
&= \sum_{n=1}^{\infty}\left[\sum_{j=1}^{n} E(\max(Y_{1j}, Y_{2j}))\right] P(N_{x,y} = n) \quad (5.1)
\end{aligned}
$$

Now

$$P(\max(Y_{1j}, Y_{2j}) > t) = P(Y_{1j} > t) + P(Y_{2j} > t) - P(Y_{1j} > t, Y_{2j} > t),$$

so that

$$
\begin{aligned}
E[\max(Y_{1j}, Y_{2j})] &= E(Y_{1j}) + E(Y_{2j}) - E(Y_{1j} Y_{1j}) \\
&= \frac{\mu_1}{b^{j-1}} + \frac{\mu_2}{b^{j-1}} - \frac{\mu_1 \mu_2}{b^{j-1}}.
\end{aligned}
$$

Thus (5.1) becomes

$$
\begin{aligned}
E[\delta_{N_{x,y}}] &= \sum_{n=1}^{\infty}\sum_{j=1}^{n}\left[\frac{\mu_1}{b^{j-1}} + \frac{\mu_2}{b^{j-1}} - \frac{\mu_1 \mu_2}{b^{j-1}}\right](F_n(T, T) - F_{n+1}(T, T)) \\
&= (\mu_1 + \mu_2 - \mu_1 \mu_2)\sum_{n=1}^{\infty} \frac{F_n(T, T)}{b^{n-1}}
\end{aligned}
$$

so that the expected length of a cycle is

$$E(W) = T + \sum_{k=1}^{\infty} \frac{F_k(T, T)}{b^k}(\mu_1 + \mu_2 - \mu_1\mu_2).$$

Then the long-run average cost per unit time under two dimensional replacement policy is given by

$$C_1(T) = \frac{c_1\left(\mu_1 + \mu_2 - \mu_1\mu_2\right)\sum\limits_{k=1}^{\infty}\dfrac{F_k(T,T)}{b^k} + c_2 - T}{T + \left(\mu_1 + \mu_2 - \mu_1\mu_2\right)\sum\limits_{k=1}^{\infty}\dfrac{F_k(T,T)}{b^k}}$$

Case (ii) The system works if atleast one component works.

Let

$$\nu_k = \sum_{j=1}^{k} \max(X_{1j}, X_{2j})$$

$$\omega_k = \sum_{j=1}^{k} \min(Y_{1j}, Y_{2j}),$$

where vacuous sums are taken to be zero. The working age $T(t)$ of a system at time t is given by

$$T(t) = \begin{cases} t - \omega_n & \nu_n + \omega_n \le t < \nu_{n+1} + \omega_n \\ \\ \nu_{n+1} & \nu_{n+1} + \omega_n \le t < \nu_{n+1} + \omega_{n+1} \end{cases}$$

A two dimensional replacement policy is a policy under which the system will be replaced, whenever the working age of the system reaches T.

The length of a cycle is

$$W = T + \omega_{N_{x,y}} \qquad \nu_{N_{x,y}} < T \le \nu_{N_{x,y}}, \quad N_{x,y} = 0, 1, 2, \ldots$$

where $N_{x,y}$ is a random variable. We now determine the expectation of $\omega_{N_{x,y}}$. Since

$$
\begin{aligned}
E[\omega_{N_{x,y}}] &= E\left[\sum_{j=1}^{N_{x,y}} \min(Y_{1j}, Y_{2j})\right] \\
&= E\left[E\left(\sum_{j=1}^{N_{x,y}} \min(Y_{1j}, Y_{2j}) | N_{x,y}\right)\right] \\
&= \sum_{n=1}^{\infty}\left[\sum_{j=1}^{n} E(\min(Y_{1j}, Y_{2j}))\right] P(N_{x,y} = n) \qquad (5.2)
\end{aligned}
$$

Now

$$P(\min(Y_{1j}, Y_{2j}) > t) = P(Y_{1j} > t, Y_{2j} > t),$$

so that

$$E[\min(Y_{1j}, Y_{2j})] = E(Y_{1j})\, E(Y_{2j})$$
$$= \frac{\mu_1}{b^{j-1}} \frac{\mu_2}{b^{j-1}}.$$

Thus (5.2) becomes

$$E[\omega_{N_{x,y}}] = \sum_{n=1}^{\infty} \left[\frac{\mu_1}{b^{j-1}} \frac{\mu_2}{b^{j-1}} \right] (F_n(T,T) - F_{n+1}(T,T))$$
$$= \mu_1\, \mu_2 \sum_{n=1}^{\infty} \frac{F_n(T,T)}{b^{n-1}}$$

so that the expected length of a cycle is

$$E(W) = T + \sum_{k=1}^{\infty} \frac{F_k(T,T)}{b^k} \mu_1\, \mu_2.$$

Then the long-run average cost per unit time under two dimensional replacement policy is given by

$$C_2(T) = \frac{c_1\, \mu_1\, \mu_2 \sum_{k=1}^{\infty} \dfrac{F_k(T,T)}{b^k} + c_2 - T}{T + \mu_1\, \mu_2 \sum_{k=1}^{\infty} \dfrac{F_k(T,T)}{b^k}}$$

Lemma 5.1 *If* $F(\zeta_1, \zeta_2) \geq b$ *and* $\zeta_i = \dfrac{(a_i - 1)T}{a_i}, for\ i = 1, 2\ then$

$$\sum_{k=1}^{\infty} \frac{F_k(T,T)}{b^k} = \infty.$$

Proof. Let $\omega_i = \dfrac{(a_i - 1)T}{a_i}$ for $i = 1, 2$. Then

$$F_k(T,T) = \lim_{t_n \to T} F_k(t_n, t_n)$$
$$= \lim_{t_n \to T} \int_0^{t_n} \int_0^{t_n} F_{k-1}\left(a_1(t_n - u), a_2(t_n - v)\right) dF(u,v)$$
$$\geq \lim_{t_n \to T} \int_0^{\omega_1} \int_0^{\omega_2} F_{k-1}\left(a_1(t_n - u), a_2(t_n - v)\right) dF(u,v)$$
$$\geq \lim_{t_n \to T} F_{k-1}\left(a_1(t_n - \omega_1), a_2(t_n - \omega_2)\right) F(\omega_1, \omega_2)$$
$$\geq F_{k-1}(T,T)\, F(\omega_1, \omega_2)$$
$$\geq [F(\omega_1, \omega_2)]^k$$

Thus

$$\frac{F_k(T,T)}{b^k} \;\geq\; \left[\frac{F(\omega_1,\omega_2)}{b}\right]^k \geq 1,$$

so that $\displaystyle\sum_{k=1}^{\infty} \frac{F_k(t,T)}{b^k}$ diverges. ∎

In view of Lemma 5.1, let $F\left(\dfrac{(a_1-1)\zeta_0}{a_1}, \dfrac{(a_2-1)\zeta_0}{a_2}\right) \;=\; b$. Then the optimal replacement policy T^* can be found by minimizing $\mathcal{C}_i(T)$, for $i \;=\; 1,2$. Clearly, T^* can be found analytically or numerically.

6.   Conclusion

A two dimensional version of the geometric process is introduced. The joint distribution, joint probability generating function, the bivariate Laplace Transform of the bivariate probability generating function, the moments of the first and second orders are obtained for the geometric process in two variates. The distribution function, probability generating function, the renewal function and its associated renewal density and an integral equation for the geometric process in two dimensions have also been derived. As an application of the geometric process in two dimensions, the optimal replacement policy for a two component system is obtained.

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Bivariate Optimal Replacement Policies for a Multistate Degenerative System with Varying Cost Structures

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Abstract

In this paper some Bivariate Optimal Replacement Policies (U, N), (T^+, N), (U^-, N) With Varying Cost Structure where T is the working age of the system, N is the number of failures of the system, U is the cumulative repair time of the system, T^+ is the system replaced at the first failure point after the cumulative operating time exceeds T and U^- is the failure point just before the total repair time exceed U are studied. Explicit expressions for the long run average cost for the models are derived. Optimality conditions are deduced.

AMS Subject Classification: 60K10

Keywords: Geometric Process, Optimal Replacement Policy.

1.   Introduction

The maintenance problem of a multistate degenerative system with k-working states having k-distinct rewards and l-failure states with l-different repair costs, is considered in this paper. The long-run average cost for a multistate degenerative system under the bivariate optimal replacement policies (U, N), (T^+, N), (U^-, N) With varying cost structure where T is the working age of the system, N is the number of failures of the system, U is the cumulative repair time of the system, T^+ is the system replaced at the first failure point after the cumulative operating time exceeds T and U^- is the failure point just before the cumulative repair time exceed U are derived. Existence of optimality under the bivariate optimal replacement policies with varying cost structure are deduced.

The rest of the paper is structured as follows: In Section 2, we give a general description of the model. We also present the monotone process model of a one-component multistate system and the relevant results regarding their probability

structure. Existence of optimality under the bivariate replacement policy is also deduced in this Section. In Section 3, we derive an expression for the long-run average cost per unit time for this model under a bivariate replacement policy (U, N). Existence of optimality under the bivariate replacement policy is also deduced in this Section. In Section 4, we derive an expression for the long-run average cost per unit time for this model under a bivariate replacement policy (T^+, N). In Section 5, we derive an expression for the long-run average cost per unit time for this model under a bivariate replacement policy (U^-, N). Existence of optimality under the bivariate replacement policy is also deduced in this Section. Finally, conclusion is given in Section 6.

2. Description of the Model

In this section, we first give some definitions. Next, we consider the model of a one-component under a bivariate replacement policies.

Definition 2.1 *A life distribution $F(\cdot)$ is said to be* new better than used in expectation *(NBUE), if*

$$\int_0^\infty \overline{F}(t+x)dx \le \overline{F}(t) \int_0^\infty \overline{F}(x)dx, \qquad for\ all\ t \ge 0.$$

To say that the life distribution of an item is $NBUE$ is equivalent to saying that the mean life length of a new item is greater than the mean residual life length of a non-failed item of age $t > 0$.

Definition 2.2 *At every failure point, a decision is taken whether it can be sent for repair. If the cumulative repair time after this repair is expected to exceed a threshold value U, the repair need not be initiated at that failure time. Such a fictitious repair time is called a* virtual repair time.

We now describe the probability structure of the model.

Assume that the transition probability from working state $i, \ i = 1, 2, \ldots, k$, to failure state $k + j, \ j = 1, 2, \ldots, l$, is

$$P(S(s_{n+1}) = k + j | S(t_n) = i) = q_j,$$

with $\sum_{j=1}^{l} q_j = 1$. Moreover, the transition probability from failure state $k + j, \ j = 1, 2, \ldots, l$, to working state $i, \ i = 1, 2, \ldots, k$ is given by

$$P(S(t_n) = i | S(s_n) = k + j) = p_i,$$

with $\displaystyle\sum_{i=1}^{k} p_i = 1$.

Assume that there exist a life-time distribution $U(t)$ and $a_i > 0$, $i = 1, \ldots, k$ such that

$$P(X_1 \leq t) \quad = \quad U(t) \tag{2.1}$$

and

$$P(X_2 \leq t | S(t_1) = i) \quad = \quad U(a_i t), \quad i = 1, 2, \ldots, k \tag{2.2}$$

where $1 \leq a_1 \leq a_2 \leq \cdots \leq a_k$. In general, for $i_j \in \{1, 2, \ldots, k\}$,

$$P\left(X_n \leq t | S(t_1) = i_1, \ldots, S(t_{n-1}) = i_{n-1}\right) \quad = \quad U(a_{i_1} \cdots a_{i_{n-1}} t). \tag{2.3}$$

Similarly, assume that there exist a life-time distribution $V(t)$ and $b_i > 0$, $i = 1, 2, \ldots, l$ such that

$$P(Y_1 \leq t | S(s_1) = k + i) \quad = \quad V(b_i t), \tag{2.4}$$

where $1 \geq b_1 \geq b_2 \geq \cdots \geq b_l > 0$ and in general, for $i_j \in \{1, 2, \ldots, l\}$,

$$P(Y_n \leq t | S(s_1) = k + i_1, \ldots, S(s_n) = k + i_n) \quad = \quad V(b_{i_1} \cdots b_{i_n} t) \tag{2.5}$$

Consider a monotone process model for a multistate one-component system and make the following package of assumptions.

2.1 At the beginning, a new system is installed. The system has $(k+l)$ possible states, where the states $1, 2, \ldots, k$ denote, respectively, the first-type working state, the second-type working state ,..., k-th-type working state and the states $(k + 1)$, $(k + 2), \ldots, (k + l)$ denote, respectively, the first-type failure state, the second-type failure state, ... and the l-th type failure state of the system. The occurrences of these types of failures are stochastic and mutually exclusive.

2.2 Whenever the system fails in any of the failure states,it will be repaired. The system will be replaced by an identical one some times later.

2.3 Let X_n be the survival time of the system after $(n - 1)$-st repair.Then $\{X_n, n = 1, 2, \ldots\}$ forms a non-increasing geometric process with parameter $a > 1$ and $E(X_1) = \lambda > 0$.

2.4 Let Y_n be the repair time after n-th failure.Then $\{Y_n, n = 1, 2, \ldots\}$ forms a non-decreasing geometric process with parameter b, $0 < b < 1$ and $E(Y_1) = \mu \geq 0$. Here $\mu = 0$ means that repair time is negligible.

2.5 If the system in working state i is operating, then let the reward rate be r_i. If the system in failure state $(k + i)$ is under repair, the repair cost is c_i. The replacement cost comprises two parts: one part is the basic replacement cost R and the other proportional to the replacement time Z at rate c_p. In other words, the replacement cost is given by $R + c_p Z$.

2.6 Assume that $1 \leq a_1 \leq a_2 \leq \cdots \leq a_k$ and $1 \geq b_1 \geq b_2 \geq \cdots \geq b_l > 0$.

2.7 Assume that $F_n(t)$ is the cumulative distribution of $L_n = \sum_{i=1}^{n} X_i$ and $G_n(t)$ be the cumulative distribution of $M_n = \sum_{i=1}^{n} Y_i$.

2.8 The survival time X_n, the repair time Y_n and the replacement time Z, $(n = 1, 2, \ldots)$ are independent random variables.

2.9 The policies (U, N), (T^+, N) and (U^-, N) are used.

3. The Policy (U, N)

In this section, we introduce and study a bivariate replacement policy (U, N) for the multistate degenerative system, under which the system is replaced at the time of N-th failure or the total repair time exceeds U, whichever occurs earlier. The problem is to choose an optimal replacement policy $(U, N)^*$ such that the long-run average cost per unit time is minimized.

Following Lam [2005], the distribution of the survival time X_n in assumption **2.3** and the distribution of the repair time Y_n in assumption **2.4** are given by

$$P(X_n \leq t) \;=\; \sum_{\sum_{i=1}^{k} j_i = n-1} \frac{(n-1)!}{j_1! \cdots j_k!} \; p_1^{j_1} \cdots p_k^{j_k} \, U(a_1^{j_1} \cdots a_k^{j_k} t), \qquad (3.1)$$

where $j_1, j_2, \ldots, j_k \in \mathbb{Z}^+$ and

$$P(Y_n \leq t) \;=\; \sum_{\sum_{i=1}^{l} j_i = n} \frac{n!}{j_1! \cdots j_l!} \; q_1^{j_1} \cdots q_l^{j_l} \, V(b_1^{j_1} \cdots b_l^{j_l} t), \qquad (3.2)$$

where $j_1, j_2, \ldots, j_l \in \mathbb{Z}^+$. If $E(X_1) = \lambda$, then the mean survival time is $E(X_n) = \frac{\lambda}{a^{n-1}}$, for $n > 1$, where $a = \left(\sum_{i=1}^{k} \frac{p_i}{a_i} \right)^{-1}$ and if $E(Y_1) = \mu$, then the mean repair time

is $E(Y_n) = \dfrac{\mu}{b^n}$ for $n > 1$, where $b = \left(\sum\limits_{j=1}^{l} \dfrac{q_j}{b_j} \right)^{-1}$.

Further if $R_n = r_i$ denotes the reward earned after the n-th repair, where $S(s_{n-1}) = i$, $i = 1, 2, \ldots, k$ then mean reward earned after $(n-1)$-st repair is $E(R_1 X_1) = r\lambda$ and for $n \geq 2$ then expected reward after installation is given by

$$E(R_n X_n) = \frac{r\lambda}{a^{n-1}}, \tag{3.3}$$

where $r = \sum\limits_{i=1}^{k} \dfrac{r_i p_i}{a_i}$, and if $C_n = c_i$ denotes the repair cost after the n-th failure, where $S(s_n) = k + i$, $i = 1, 2, \ldots, l$ then mean repair cost after n-th failure is

$$E(C_n Y_n) = \frac{c\mu}{b^{n-1}}, \tag{3.4}$$

where $c = \sum\limits_{i=1}^{l} \dfrac{c_i q_i}{b_i}$.

The length of a cycle W under the bivariate replacement policy (U, N) is

$$W = \left(\sum_{i=1}^{N} X_i + \sum_{i=1}^{N-1} Y_i \right) \chi_{(M_N \leq U)} + \left(\sum_{i=1}^{\eta} X_i + U \right) \chi_{(M_N > U)} + Z,$$

where $\eta = 0, 1, 2, \ldots, N-1$ is the number of failures before the total repair time exceeds U and $\chi_{(\cdot)}$ denotes the indicator function.

From Leung [2006], we have

$$\begin{aligned} E\left[\chi_{(M_n \leq U < M_N)} \right] &= P(M_n \leq U < M_N) \\ &= G_n(U) - G_N(U). \end{aligned}$$

Lemma 3.1 *The mean length of the cycle under the policy (U, N) is*

$$E(W) = \sum_{n=1}^{N-1} \frac{\lambda}{a^{n-1}} G_{n-1}(U) + \frac{\lambda}{a^{N-1}} G_N(U) + \int_0^U \overline{G}_N(u) du + \tau . \tag{3.5}$$

Proof. Consider

$E(W)$

$$= E\left[\left(\sum_{n=1}^{N} X_n + \sum_{n=1}^{N-1} Y_n\right)\chi_{(M_N \leq U)}\right] + \left[\left(\sum_{n=1}^{\eta} X_n + U\right)\chi_{(M_N > U)}\right] + E(Z)$$

$$= E\left\{E\left[\left(\sum_{n=1}^{N} X_n + \sum_{n=1}^{N-1} Y_n\right)\chi_{(M_N \leq U)}|M_N = u\right]\right\}$$

$$+ E\left[\sum_{n=1}^{\eta} X_n \chi_{(M_N > U)}\right] + E\left[U\,\chi_{(M_N > U)}\right] + E(Z)$$

$$= E\left(\sum_{n=1}^{N} X_n\right)E\left(\chi_{(M_N \leq U)}\right) + \int_0^U u\mathrm{d}G_N(u)$$

$$+ \sum_{n=1}^{N-1} E(X_n)E[\chi_{(M_{n-1} \leq U < M_N)}] + UE\left[\chi_{(M_N > U)}\right] + \tau$$

$$= \sum_{n=1}^{N} \frac{\lambda}{a^{n-1}}G_N(U) + \int_0^U u\,\mathrm{d}G_N(u)$$

$$+ \sum_{n=1}^{N-1} E(X_n)P(M_{n-1} \leq U < M_N) + U\overline{G}_N(U) + \tau$$

$$= \sum_{n=1}^{N} \frac{\lambda}{a^{n-1}}G_N(U) + \int_0^U u\,\mathrm{d}G_N(u)$$

$$+ \sum_{n=1}^{N-1} \frac{\lambda}{a^{n-1}}[G_{n-1}(U) - G_N(U)] + U\overline{G}_N(U) + \tau$$

which on simplification yields (3.5).   ∎

Lemma 3.2 *If $M_N \leq U$ and $n \geq 2$, then the expected reward earned is*

$$E\left[\left(\sum_{n=2}^{N} R_n X_n\right)\chi_{(M_N \leq U)}\right] = \sum_{n=2}^{N} \frac{r\lambda}{a^{n-2}}\int_0^U udG_N(u). \qquad (3.6)$$

Proof.   Consider

$$E\left[\left(\sum_{n=2}^{N} R_n X_n\right)\chi_{(M_N \leq U)}\right] = E\left\{E\left[\left(\sum_{n=2}^{N} R_n X_n\right)\chi_{(M_N \leq U)}|M_N\right]\right\}$$

$$= \int_0^U E\left(\sum_{n=2}^{N} R_n X_n \,\bigg|\, G_N = u\right)dG_N(u)$$

$$= \sum_{n=2}^{N} \frac{r\lambda}{a^{n-2}}\int_0^U udG_N(u).$$

which is (3.6). ∎

Lemma 3.3 *If $M_N > U$ and $n \geq 2$ then the expected reward earned is*

$$E\left[\left(\sum_{n=2}^{N} R_n X_n\right) \chi_{(M_N > U)}\right] = \sum_{n=2}^{N} \frac{r\,\lambda}{a^{n-2}} \left[G_{n-1}(U) - G_N(U)\right] . \qquad (3.7)$$

Proof. Consider

$$E\left[\left(\sum_{n=2}^{N} R_n X_n\right) \chi_{(M_N > U)}\right] = E\left[\left(\sum_{n=2}^{N} R_n X_n\right) \chi_{(M_{n-1} < U < M_N)}\right]$$

$$= \sum_{n=2}^{N} E(R_n X_n) E\left[\chi_{(M_{n-1} < U < M_N)}\right]$$

$$= \sum_{n=2}^{N} \frac{r\,\lambda}{a^{n-2}} P[M_{n-1} < U < M_N]$$

$$= \sum_{n=2}^{N} \frac{r\,\lambda}{a^{n-2}} \left[G_{n-1}(U) - G_N(U)\right] .$$

which is (3.7). ∎

Lemma 3.4 *If $M_N \leq U$, then the expected repair cost is*

$$E\left[\left(\sum_{n=1}^{N-1} C_n Y_n\right) \chi_{(M_N \leq U)}\right] = \sum_{n=1}^{N-1} \frac{c\mu}{b^{n-1}} G_N(U) . \qquad (3.8)$$

Proof. Consider

$$E\left[\left(\sum_{n=1}^{N-1} C_n Y_n\right) \chi_{(M_N \leq U)}\right] = E\left[E\left(\sum_{n=1}^{N-1} C_n Y_n \Big| M_N\right) \chi_{(M_N \leq U)}\right]$$

$$= \int_0^U E\left(\sum_{n=1}^{N-1} C_n Y_n \,\Big|\, M_N\right) dG_n(u)$$

$$= \int_0^U \sum_{n=1}^{N-1} E(C_n Y_n) dG_N(u)$$

$$= \sum_{n=1}^{N-1} E(C_n Y_n) \int_0^U dG_N(u)$$

which on simplification yields (3.8). ∎

Lemma 3.5 *If $M_N > U$, then the expected repair cost is*

$$E\left[\left(\sum_{n=1}^{\eta-1} C_n Y_n\right)\chi_{(M_N>U)}\right] = \sum_{n=1}^{N-1}\frac{c\,\mu}{b^{n-1}}\left[G_{n-1}(U) - G_N(U)\right].\qquad(3.9)$$

Proof. Consider

$$
\begin{aligned}
E\left[\left(\sum_{n=1}^{\eta-1} C_n Y_n\right)\chi_{(M_N>U)}\right] &= E\left[\left(\sum_{n=1}^{N-1} C_n Y_n\right)\chi_{(M_{n-1}<U<M_N)}\right] \\
&= \sum_{n=1}^{N-1}E(C_n Y_n)E\left[\chi_{(M_{n-1}<U<M_N)}\right] \\
&= \sum_{n=1}^{N-1}\frac{c\,\mu}{b^{n-1}}P[M_{n-1}<U<M_N] \\
&= \sum_{n=1}^{N-1}\frac{c\,\mu}{b^{n-1}}\left[G_{n-1}(U) - G_N(U)\right].
\end{aligned}
$$

which is (3.9). ∎

We now calculate the cost structure of the model under the bivariate replacement policy (U, N). Let U_1 be the first replacement time and let U_n $(n \geq 2)$ be the time between the $(n-1)$-st replacement and the n-th replacement. Then the sequence U_n, $n = 1, 2, \ldots$, forms a renewal process. The interarrival time between two consecutive replacement is a renewal cycle. By the renewal reward theorem, the long-run average cost per unit time under the bivariate replacement policy-(U, N) for a multistate degenerative system is given by

$$
\begin{aligned}
\mathcal{C}(U, N) &= \frac{\text{the expected cost incurred in a cycle}}{\text{the expected length of a cycle}} \\
&= \frac{\left[\begin{array}{l} E\left\{\left(\sum_{n=1}^{N-1} C_n Y_n - \sum_{n=1}^{N} R_n X_n\right)\chi_{(M_N\leq U)}\right\} + R \\[2ex] +E\left\{\left(\sum_{n=1}^{\eta} C_n Y_n - T\sum_{n=1}^{\eta} R_n\right)\chi_{(M_N>U)}\right\} + c_p E(Z)\end{array}\right]}{E(W)}.
\end{aligned}
$$

Using Lemmas 3.1 to 3.5, we obtain

$\mathcal{C}(U, N)$

$$= \frac{\left[\begin{array}{l} \sum_{n=1}^{N-1} \dfrac{c\mu}{b^{n-1}} G_N(U) - \sum_{n=2}^{N} \dfrac{r\lambda}{a^{n-2}} \int_0^U u dG_N(u) + c_p \, \tau + R - r_1 \lambda \\[3mm] + \sum_{n=1}^{N-1} \dfrac{c\,\mu}{b^{n-1}} \left[G_{n-1}(U) - G_N(U) \right] - \sum_{n=2}^{N} \dfrac{r\,\lambda}{a^{n-2}} \left[G_{n-1}(U) - G_N(U) \right] - r_1 U \end{array} \right]}{\displaystyle \sum_{n=1}^{N-1} \dfrac{\lambda}{a^{n-1}} G_{n-1}(U) + \dfrac{\lambda}{a^{N-1}} G_N(U) + \int_0^U \overline{G}_N(u)\mathrm{d}u + \tau}.$$

On summarizing the above facts, we obtain the following result.

Theorem 3.1 *For the model described in Section 2, under the assumptions* **2.1** *to* **2.8***, the long-run average cost per unit time under the bivariate replacement policy* (U, N) *for a multistate degenerative system is given by*

$$\mathcal{C}(U, N) = \frac{\left[\begin{array}{l} \sum_{n=1}^{N-1} \dfrac{c\mu}{b^{n-1}} G_{n-1}(U) - \sum_{n=2}^{N} \dfrac{r\lambda}{a^{n-2}} \int_0^U u dG_N(u) - r_1(\lambda + U) \\[3mm] + \sum_{n=2}^{N} \dfrac{r\,\lambda}{a^{n-2}} \left[G_{n-1}(U) - G_N(U) \right] + c_p \, \tau + R \end{array} \right]}{\displaystyle \sum_{n=1}^{N-1} \dfrac{\lambda}{a^{n-1}} G_{n-1}(U) + \dfrac{\lambda}{a^{N-1}} G_N(U) + \int_0^U \overline{G}_N(u)du + \tau}.$$

$$(3.10)$$

Deductions

Here $\mathcal{C}(U, N)$ is a bivariate function. Obviously, when N is fixed, $\mathcal{C}(U, N)$ is a function of U. For fixed $N = m$, it can be written as

$$\mathcal{C}(U, N) = C_m(U), \quad m = 1, 2, \ldots.$$

Thus, for a fixed m, we can find U_m^* by analytical or numerical methods such that $C_m(U_m^*)$ is minimized. That is, when $N = 1, 2, \ldots, m, \ldots$, we can find $U_1^*, U_2^*, U_3^*, \ldots, U_m^*, \ldots$, respectively, such that the corresponding $C_1(U_1^*), C_2(U_2^*), \ldots, C_m(U_m^*), \ldots$ are minimized. Because the total lifetime of a multistate degenerative system is limited, the minimum of the long-run average cost per unit time exists. So we can determine the minimum of the long-run average cost per unit time based on $C_1(U_1^*), C_2(U_2^*), \ldots, C_m(U_m^*), \ldots$. For example, if the minimum is denoted by $C_n(U_n^*)$, we obtain the bivariate optimal replacement policy $(U, N)^*$ such that

$$\mathcal{C}((U, N)^*) = \min_n C_n(U_n^*).$$

4. The Policy (T^+, N)

It is a policy for which the multistate degenerative system, under which the system replaced at the first failure point after the cumulative operating time exceeds T or at the occurrence of the N-th failure, whichever occurs earlier. The technique of replacing *at the first failure point after the cumulative operating time exceeds a predetermined value* is used in Muth [1977].

The Length of a Cycle and its Mean

The length of the cycle under the bivariate replacement policy (T^+, N) is

$$W = \left(\sum_{n=1}^{N} X_n + \sum_{n=1}^{N-1} Y_n \right) \chi_{(L_N \leq T)} + \left(\sum_{n=1}^{\eta} X_n + \sum_{n=1}^{\eta} Y_{n-1} \right) \chi_{(L_N > T)} + Z,$$

where $\eta = 1, 2, \ldots, N - 1$ is the number of failures before the total operating time exceeds T. The random variable η has a geometric distribution given by

$$
\begin{aligned}
P(\eta = j) &= P(X_1 \leq T, X_2 \leq T, \ldots, X_{\eta-1} \leq T, X_\eta > T); \quad j = 1, 2, \ldots \\
&= F^{j-1}(T)\overline{F}(T).
\end{aligned}
$$

Since η is a random variable,

$$
\begin{aligned}
E(\eta - 1) &= \sum_{j=1}^{\infty} (j-1)P(\eta = j) \\
&= \overline{F}(T)\sum_{j=1}^{\infty}(j-1)F^{j-1}(T) \\
&= \frac{F(T)}{\overline{F}(T)}.
\end{aligned}
$$

Lemma 4.1 *The mean length of the cycle under the policy (T^+, N) is*

$$
\begin{aligned}
E(W) &= \int_0^T u\, dF_N(u) + \frac{F(T)}{\overline{F}(T)} \sum_{n=1}^{N-1} \frac{\lambda}{a^{n-1}} \left[F_n(T) - F_N(T) \right] \qquad (4.1) \\
&\quad + \sum_{n=1}^{N-1} \frac{\mu}{b^{n-1}} \left[(1-b)F_N(T) + bF_n(T) \right] + \tau.
\end{aligned}
$$

Proof. Consider

$E(W)$

$$= E\left[\left(\sum_{n=1}^{N} X_n + \sum_{n=1}^{N-1} Y_n \right) \chi_{(L_N \leq T)} \right] + E\left[\left(\sum_{n=1}^{\eta} X_n + \sum_{n=1}^{\eta} Y_{n-1} \right) \chi_{(L_N > T)} \right] + E(Z)$$

$$
\begin{aligned}
=\ & E\left\{E\left[\left(\sum_{n=1}^{N} X_n + \sum_{n=1}^{N-1} Y_n\right) \chi_{(L_N \le T)}|L_N\right]\right\} \\
& + E\left[\sum_{n=1}^{\eta} X_n \chi_{(L_N > T)}\right] + E\left[\left(\sum_{n=1}^{\eta} Y_{n-1}\right) \chi_{(L_N > T)}\right] + E(Z) \\
=\ & \int_0^T u \, dF_N(u) + \int_0^T \sum_{n=1}^{N-1} E(Y_n) \, dF_N(u) + \sum_{n=1}^{N-1} E(X_n|\eta = N-1) \\
& \times P(L_n \le T < L_N) + \sum_{n=1}^{N-1} E(Y_{n-1}) E\left[\chi\left(L_n \le T < L_N\right)\right] + \tau \\
=\ & \int_0^T u \, dF_N(u) + \sum_{n=1}^{N-1} \frac{\mu}{b^{n-1}} \, F_N(T) \\
& + \frac{F(T)}{\overline{F}(T)} \sum_{n=1}^{N-1} \frac{\lambda}{a^{n-1}} \left[F_n(T) - F_N(T)\right] + \sum_{n=1}^{N-1} \frac{\mu}{b^{n-2}} \left[F_n(T) - F_N(T)\right] + \tau
\end{aligned}
$$

which on simplification yields (4.1). ∎

Lemma 4.2 *If $L_N \le T$ and $n \ge 2$, then the expected reward earned is*

$$
E\left[\left(\sum_{n=2}^{N} R_n X_n\right) \chi_{(L_N \le T)}\right] = \sum_{n=2}^{N} \frac{r\lambda}{a^{n-2}} \int_0^T u \, dF_N(u) . \tag{4.2}
$$

Proof. Consider

$$
\begin{aligned}
E\left[\left(\sum_{n=2}^{N} R_n X_n\right) \chi_{(L_N \le T)}\right] =\ & E\left\{E\left[\left(\sum_{n=2}^{N} R_n X_n\right) \chi_{(L_N \le T)}|L_N\right]\right\} \\
=\ & \int_0^T E\left(\sum_{n=2}^{N} R_n X_n \,\middle|\, F_N = u\right) dF_N(u) \\
=\ & \sum_{n=2}^{N} \frac{r\lambda}{a^{n-2}} \int_0^T u \, dF_N(u) .
\end{aligned}
$$

which is (4.2). ∎

Lemma 4.3 *If $L_N > T$ and $n \ge 2$, then the expected reward earned is*

$$
E\left[\left(\sum_{n=2}^{\eta} R_n X_n\right) \chi_{(L_N > T)}\right] = \sum_{n=2}^{N} \frac{r\lambda}{a^{n-2}} \left[F_{n-1}(T) - F_N(T)\right] . \tag{4.3}
$$

Proof. Consider

$$
E\left[\left(\sum_{n=2}^{\eta} R_n X_n\right)\chi_{(L_N>T)}\right] = E\left[\left(\sum_{n=2}^{N} R_n X_n\right)\chi_{(L_{n-1}<T<L_N)}\right]
$$

$$
= \sum_{n=2}^{N} E(R_n X_n)E\left[\chi_{(L_{n-1}<F<L_N)}\right]
$$

$$
= \sum_{n=2}^{N} \frac{r\,\lambda}{a^{n-2}}P[L_{n-1}<U<L_N]
$$

$$
= \sum_{n=2}^{N} \frac{r\,\lambda}{a^{n-2}}\left[F_{n-1}(U)-F_N(U)\right] .
$$

which is (4.3).   ■

Lemma 4.4 *If $L_N > T$, then the expected repair cost is*

$$
E\left[\left(\sum_{n=1}^{\eta-1} C_n Y_{n-1}\right)\chi_{(L_N>T)}\right] = \sum_{n=1}^{N-1} \frac{c\,\mu}{b^{n-2}}\left[F_{n-1}(T)-F_N(T)\right] . \qquad (4.4)
$$

Proof. Consider

$$
E\left[\left(\sum_{n=1}^{\eta-1} C_n Y_{n-1}\right)\chi_{(L_N>T)}\right] = E\left[\left(\sum_{n=1}^{N-1} C_n Y_{n-1}\right)\chi_{(L_{n-1}<T<L_N)}\right]
$$

$$
= \sum_{n=1}^{N-1} E(C_n Y_{n-1})E\left[\chi_{(L_{n-1}<T<L_N)}\right]
$$

$$
= \sum_{n=1}^{N-1} \frac{c\,\mu}{b^{n-2}}P[L_{n-1}<T<L_N]
$$

$$
= \sum_{n=1}^{N-1} \frac{c\,\mu}{b^{n-2}}\left[F_{n-1}(T)-F_N(T)\right]
$$

which is (4.4).   ■

Lemma 4.5 *If $L_N \leq T$, then the expected repair cost is*

$$
E\left[\left(\sum_{n=1}^{N-1} C_n Y_n\right)\chi_{(L_N\leq T)}\right] = \sum_{n=1}^{N-1} \frac{c\mu}{b^{n-1}}F_N(T) . \qquad (4.5)
$$

Proof. Consider

$$
\begin{aligned}
E\left[\left(\sum_{n=1}^{N-1} C_n Y_n\right) \chi_{(L_N \leq T)}\right] &= E\left[E\left(\sum_{n=1}^{N-1} C_n Y_n | L_N\right) \chi_{(L_N \leq T)}\right] \\
&= \int_0^T E\left(\sum_{n=1}^{N-1} C_n Y_n \,\middle|\, L_N\right) dF_n(u) \\
&= \int_0^T \sum_{n=1}^{N-1} E(C_n Y_n) dF_N(u) \\
&= \sum_{n=1}^{N-1} E(C_n Y_n) \int_0^T dF_N(u)
\end{aligned}
$$

which on simplification yields (4.5). ∎

The Long-run Average Cost under Policy (T^+, N)

By the renewal reward theorem, the long-run average cost per unit time under the bivariate replacement policy-(T^+, N) for a multistate degenerative system is given by

$$
\begin{aligned}
\mathcal{C}(T^+, N) &= \frac{\text{the expected cost incurred in a cycle}}{\text{the expected length of a cycle}} \\
&= \frac{\left[\begin{aligned} &E\left\{\left(\sum_{n=1}^{N-1} C_n Y_n - \sum_{n=1}^{N} R_n X_n\right) \chi_{(L_N \leq T)}\right\} + R \\ &+E\left\{\left(\sum_{n=1}^{\eta} C_n Y_{n-1} - \sum_{n=1}^{\eta} R_n X_n\right) \chi_{(L_N > T)}\right\} + c_p E(Z) \end{aligned}\right]}{E(W)}
\end{aligned}
$$

Using Lemma 4.1 to 4.5, we obtain

Theorem 4.1 *For the model described in Section 2, under the assumptions* **2.1 - 2.8***, the long-run average cost per unit time under the bivariate replacement policy (T^+, N) for a multistate degenerative system is given by*

$\mathcal{C}(T^+, N)$

$$= \frac{\left[\begin{array}{c} \sum\limits_{n=1}^{N-1} \dfrac{c\mu}{b^{n-1}} \left[(1-b)F_N(T) + bF_{n1}(T)\right] - \sum\limits_{n=2}^{N} \dfrac{r\lambda}{a^{n-2}} \displaystyle\int_0^T u \, dF_N(u) - r_1(\lambda + T) \\[4mm] + \sum\limits_{n=2}^{N} \dfrac{r\,\lambda}{a^{n-2}} \left[F_{n-1}(T) - F_N(T)\right] + c_p\,\tau + R \end{array}\right]}{\left[\begin{array}{c} \displaystyle\int_0^T u \, dF_N(u) + \dfrac{F(T)}{\overline{F}(T)} \sum\limits_{n=1}^{N-1} \dfrac{\lambda}{a^{n-1}} \left[F_n(T) - F_N(T)\right] \\[4mm] + \sum\limits_{n=1}^{N-1} \dfrac{\mu}{b^{n-1}} \left[(1-b)F_N(T) + bF_n(T) + \tau\right] \end{array}\right]}$$

$$\tag{4.6}$$

Deductions

Here $\mathcal{C}(T, N)$ is a bivariate function. Obviously, when N is fixed, $\mathcal{C}(T, N)$ is a function of T. For fixed $N = m$, it can be written as

$$\mathcal{C}(T, N) = C_m(T), \quad m = 1, 2, \ldots \, .$$

Thus, for a fixed m, we can find T_m^* by analytical or numerical methods such that $C_m(T_m^*)$ is minimized. That is, when $N = 1, 2, \ldots, m, \ldots$, we can find $T_1^*, T_2^*, T_3^*, \ldots, T_m^*, \ldots$, respectively, such that the corresponding $C_1(T_1^*), C_2(T_2^*), \ldots, C_m(T_m^*), \ldots$ are minimized.

Because the total lifetime of a multistate degenerative system is limited, the minimum of the long-run average cost per unit time exists. So we can determine the minimum of the long-run average cost per unit time based on $C_1(T_1^*), C_2(T_2^*), \ldots, C_m(T_m^*), \ldots$. For example, if the minimum is denoted by $C_n(T_n^*)$, we obtain the bivariate optimal replacement policy $(T, N)^*$ such that

$$\mathcal{C}((T, N)^*) = \min_n C_n(T_n^*).$$

5. The Policy(U^-, N)

Under the policy (U^-, N), we will replace the multistate degenerative system at the failure point just before the total repair time exceed U or at the occurrence of the N-th failure, whichever occurs earlier.

Virtual Repair Times

In the policy (U, N), an optimal policy may be such that we will have to replace the system, in the middle of a repair, after (say) s units of repair time. Then the question naturally arises whether it would not have been more profitable to replace the system at the failure point itself, as we might have been saved the repair cost. In fact, Stadje and Zuckerman [1992] have proved for their policy U that if Y_n's are $NBUE$, then there is an optimal replacement policy that does not replace at the middle of a repair period. Since no additional costs are involved for replacing at failure in our policies, it is profitable not to replace the system in the middle of an operating interval.

The length of a Cycle and its Mean

The length of a cycle W under the bivariate replacement policy (U^-, N) is

$$W = \left(\sum_{n=1}^{N} X_n + \sum_{n=1}^{N-1} Y_n \right) \chi_{(M_N \leq U)} + \left(\sum_{n=1}^{\eta} X_n + \sum_{n=0}^{\nu} Y_n \right) \chi_{(M_N > U)} + Z,$$

where $\eta = 1, 2, \ldots, N-1$ is the number of failures before the total repair time exceeds U and $\nu = 0, 1, \ldots, N-1$ is the number of repairs before the total repair time is expected to exceed U. If $M_n \leq U < M_{n+1}$ for $n = 1, 2, \ldots, N-1$, then $U - M_n$ will be the virtual repair time.

Lemma 5.1 *The mean length of the cycle under policy (U^-, N) is*

$$E(W) = \sum_{n=1}^{N-1} \frac{\lambda}{a^{n-1}} G_{n-1}(U) + \frac{\lambda}{a^{N-1}} G_N(U) \tag{5.1}$$

$$+ \int_0^U u dG_N(u) + \frac{G(U)}{\overline{G}(U)} \sum_{n=0}^{N-1} \frac{\mu}{b^{n-1}} [G_n(U) - G_N(U)] + \tau.$$

Proof. Consider

$E(W)$

$$= E\left[\left(\sum_{n=1}^{N} X_n + \sum_{n=1}^{N-1} Y_n \right) \chi_{(M_N \leq U)} \right] + \left[\left(\sum_{n=1}^{\eta} X_n + \sum_{n=0}^{\nu} Y_n \right) \chi_{(M_N > U)} \right] + E(Z)$$

$$= \sum_{n=1}^{N} \frac{\lambda}{a^{n-1}} G_N(U) + \int_0^U u \, dG_N(u) + E\left[\sum_{n=1}^{\eta} X_n \chi_{(M_N > U)} \right]$$

$$+ E\left[\sum_{n=0}^{\nu} Y_n \, \chi_{(M_N > U)} \right] + E(Z)$$

$$= \sum_{n=1}^{N} \frac{\lambda}{a^{n-1}} G_N(U) + \int_0^U u \mathrm{d}G_N(u) + \sum_{n=1}^{N-1} E(X_n) P\left[M_{n-1} \leq U < M_N\right]$$

$$+ \sum_{n=0}^{N-1} E(Y_n|\nu) P(M_i \leq U < M_n) + E(Z)$$

$$= \sum_{n=1}^{N} \frac{\lambda}{a^{n-1}} G_N(U) + \int_0^U u \, \mathrm{d}G_N(u) + \sum_{n=1}^{N-1} \frac{\lambda}{a^{n-1}} \left[G_{n-1}(U) - G_N(U)\right]$$

$$+ \sum_{n=0}^{N-1} E(Y_n) E(\nu - 1) \left[G_n(U) - G_N(U)\right] + \tau$$

$$= \sum_{n=1}^{N} \frac{\lambda}{a^{n-1}} G_N(U) + \int_0^U u \, \mathrm{d}G_N(u) + \sum_{n=1}^{N-1} \frac{\lambda}{a^{n-1}} \left[G_{n-1}(U) - G_N(U)\right]$$

$$+ \frac{G(U)}{\overline{G}(U)} \sum_{n=0}^{N-1} \frac{\mu}{b^{n-1}} \left[G_n(U) - G_N(U)\right] + \tau,$$

which on simplification yields (5.1) . ∎

The Long-run Average Cost under the Policy (U^-, N)

By the renewal reward theorem, the long-run average cost per unit time under the bivariate replacement policy-(U^-, N) for a multistate degenerative system is given by

$$\mathcal{C}(U^-, N) = \frac{\text{the expected cost incurred in a cycle}}{\text{the expected length of a cycle}}$$

$$= \frac{\left[E\left\{ \left(\sum_{n=1}^{N-1} C_n Y_n - \sum_{n=1}^{N} R_n X_n\right) \chi_{(M_N \leq U)} \right\} + R \right.}{E(W)} \left. + E\left\{ \left(\sum_{n=0}^{\nu} C_n Y_n - \sum_{n=1}^{\eta} R_n X_n\right) \chi_{(M_N > U)} \right\} + c_p E(Z) \right]} .$$

Using Lemma 3.2 to 3.5, and 5.1, we have the following result.

Theorem 5.1 *For the model described in Section 2, under the assumptions* **2.1 - 2.8***, the long-run average cost per unit time under the bivariate replacement policy* (U^-, N) *for a multistate degenerative system is given by*

$$
\mathcal{C}(U^-, N) = \frac{\left[\begin{array}{l} \displaystyle\sum_{n=1}^{N-1} \frac{c\mu}{b^{n-1}} G_{n-1}(U) - \sum_{n=2}^{N} \frac{r\lambda}{a^{n-2}} \int_0^U u\, dG_N(u) \\[2ex] -r_1(\lambda + U) + \displaystyle\sum_{n=2}^{N-1} \frac{r\,\lambda}{a^{n-2}} \left[G_{n-1}(U) - G_N(U) \right] + c_p\,\tau + R \end{array}\right]}{\left[\begin{array}{l} \displaystyle\sum_{n=1}^{N-1} \frac{\lambda}{a^{n-1}} G_{n-1}(U) + \frac{\lambda}{a^{N-1}} G_N(U) + \int_0^U G_N(u)\, du \\[2ex] +\dfrac{G(U)}{\overline{G}(U)} \displaystyle\sum_{n=0}^{N-1} \frac{\mu}{b^{n-1}} \left[G_n(U) - G_N(U) \right] + \tau \end{array}\right]}
$$

$$(5.2)$$

Deductions

The bivariate optimal replacement policiy (U^-, N) is as similar as (U, N)

6. Conclusion

By considering a repairable system for a monotone process model of a one component multistate degenerative system, explicit expressions for the long-run average cost per unit time under a bivariate replacement policies $(U, N), (T^+, N)$ and (U^-, N) with varying cost structures are derived. Optimality conditions are deduced.

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Growth and Characterization of Brushite Crystal using Silica gel Medium

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Abstract

Brushite is found quite frequently in urinary stones. These crystals were grown by the single diffusion gel growth technique in sodium metasilicate gel. The crystals were found to be having platelet and broad needle type morphologies. The crystal morphology, structure and elemental composition of the grown crystals have been analyzed using SEM -EDAX and powder XRD studies. Functional groups present in the grown crystals have been confirmed from the FTIR spectrum. The thermal properties were studied by employing the thermo gravimetric and differential thermal analysis. The selected platelet was studied by SEM for the growth morphologies indicating that the crystals grew in the form of leaflets having prominent (010) faces. This was in agreement with earlier reported studies.

Keywords: Urinaryl stones, Brushite crystal, growth parameters, Powder XRD, FTIR, thermal studies, surface morphology and EDX.

1. Introduction

Kidney stones, one of the most painful of the urologic disorders, are not a product of modern life. Scientists have found evidence of kidney stones in a 7,000-year-old Egyptian mummy. Kidney stone or urinary calculi disease is common disease found in most countries. This Kidney disorder affects up to 15% of the population over a life time and 75% of patients will have a chance of recurrence [1, 2]. The main components of urinary calculus are calcium oxalate (mono and dihydrate), calcium phosphate, magnesium ammonium phosphate hexahydrate, Uric acid and Cystine. Brushite $[CHPD, CaHPO_4 \cdot 2H_2O]$, hydroxyapatite $[HAP, Ca_5(PO_4)_3(OH)]$, octacalcium phosphate $[OCP, Ca_8H_2(PO_4)_6 \cdot 5H_2O]$ and monetite $[DCPA, CaHPO_4]$ and are different crystalline phases of calcium phosphates present in various concentrations in urinary stones [3].

2. Materials and Methods

A gel is defined as a two component system of a semi-solid in nature, rich in liquid. It is also termed as loosely inter-linked polymer. Importance of gel medium are as follows:

Crystal can be grown in room temperature. Hence it will have lower concentration of non- equilibrium defects, than those grown at elevated temperature. Crystal can be observed practically in all stages of growth. It forms three dimensional structure entrapping water. It remains chemically inert, prevents turbulence. Rate of reaction is controlled. Concentration of reactants can be easily varied. Crystals of different morphologies and sizes can be obtained by changing the growth condition. The grown crystal can be easily harvested, without damaging the crystal face. This method is extremely simple and inexpensive. Silica gel is the best and most versatile growth media [4].
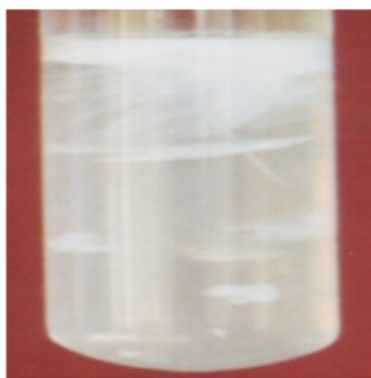
Figure 1: As Grown Crystal

Figure 2: Harvested Crystal

A stock solution of sodium meta silicate is prepared by adding 100ml of distilled water to 60 grams of sodium meta silicate powder ($Na_2SiO_3 \cdot 9H_2O$). Using this solution one can prepare gels of various specific gravity. Very dense gels produce poor crystals and gels of insufficient density take a long time to form crystal and are mechanically unstable. A specific gravity of 1.02 g/cm appears to be the lower practical limit.

Brushite or Calcium dihydrogen phosphate dihydrate crystals are grown by taking 1.5M of Ortho phosphoric acid and 1.0M of Calcium Acetate solution as inner and outer reactants respectively. Density of the stock solution is 1.03 g/cc. Several trails are taken by varying pH of the inner reactant for a given concentrations of inner and outer reactant. It is observed that larger crystals are formed for 5.5 pH. Fig.1 and 2 represent as grown and harvested brushite crystal.

3.   Results and discussion

3.1.   Powder XRD analysis

The powder X-ray diffraction pattern of needle shaped crystal is shown in Fig. 3. The d values obtained from the reflections of harvested needle shaped crystal agree well with that of brushite (JCPDS data 72-0713). The brushite crystals belong to monoclinic system with space lattice Ia. Lattice parameters, $a = 5.812\mathring{A}, b = 15.180\mathring{A}, c = 6.239\mathring{A}$ and $\beta = 116.25°$ [5].
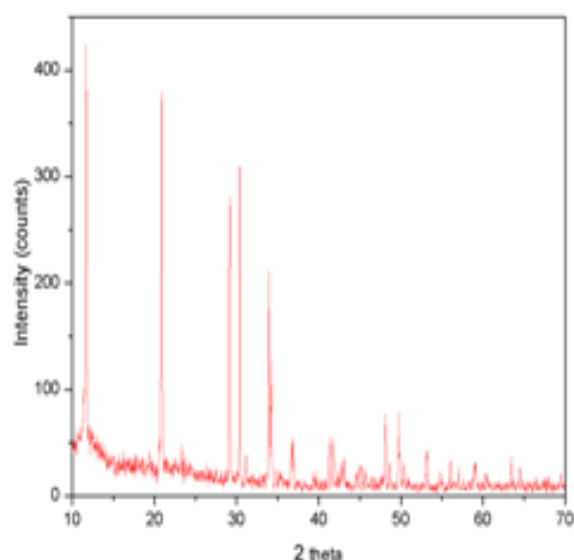
Figure 3: Powder XRD pattern of CHPD crystal
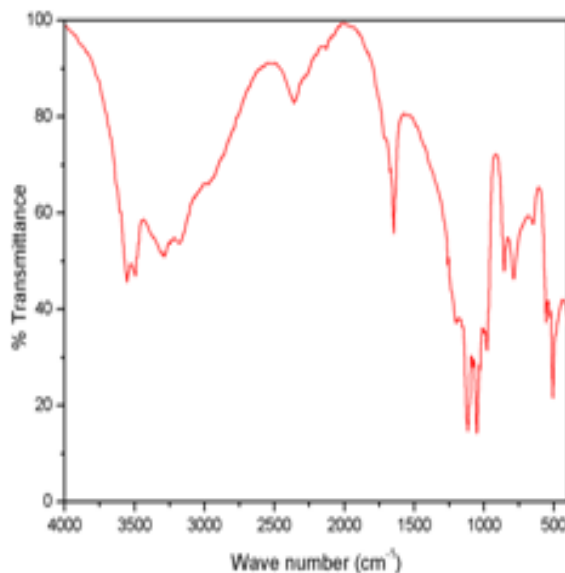
Figure 4: FTIR spectrum of CHPD crystal

3.2.   FTIR spectrum of CHPD crystal

FT-IR spectra of the gel grown brushite crystal is shown in Fig. 5. The presence of water of crystallization was referenced from absorptions at 3543.16, 3487.57 and 3282.79 cm^{-1}, which are due to intermolecular and weakly H bonded OH. The absorption at 1650.29 cm^{-1} is due to $H-O-H$ symmetric bending vibrations and P=O associated stretching vibrations were observed at wave numbers 1211.2, 1129.96 and 1064.34 cm^{-1}. Likewise, the P-O-P asymmetric stretching vibrations were observed at 873.10 and 790 cm^{-1}. The absorption at 665 cm^{-1} is due to (H-O-) P=O and the strong absorption at 578 and 525 cm^{-1} are due to acid phosphates.

3.3.   Thermal Analysis of gel grown Brushite Crystal

The thermogravimetric analysis (TGA) was performed on powdered samples. The thermogram was obtained by heating a sample from room temperature to 800° C, in an atmosphere of nitrogen, with heating rate of 15° C/min. using a $-Al_2O_3$ as standard reference. The thermogram is shown in Figure (6). From this figure one can notice that hydrated calcium phosphate becomes anhydrous at 294° C, thereafter, at 554° C it turns into calcium pyrophosphate ($Ca_2P_2O_7$). The melting point of $Ca_2P_2O_7$ is 1230° C, therefore, it is expected to remain stable up to the end of the analysis, that is, 800° C. The following chemical reactions are expected to occur during the dehydration and

decomposition stages.

$$2CaHPO_4 \cdot H_2O \quad \rightarrow \quad 2CaHPO_4 + 4H_2O \uparrow$$

$$2CaHPO_4 \quad \rightarrow \quad Ca_2P_2O_7 + H_2O \uparrow$$
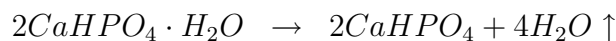
Table 1 gives the comparison of experimentally obtained and theoretically calculated weight loss values at different temperature. The TG-DTA curve of CHPD shows weight loss in two stages. The major weight loss of about 20% occurs between 123° C and 191° C which indicate the loss of water of hydration. The endothermic peak in DTA around 123° C with the associated shoulders indicates the stepwise removal of water during this temperature range. Subsequently in the high temperature range of 191-441° C, two molecules of $CaHPO_4$ combine and result in the elimination of a water molecule leading to the formation of calcium pyrophosphate and nearly 74% of the sample was stable. The observed mass loss corresponds well with the DSC curve.

Temperature	Decomposition of CHPD crystal	% weight loss	
		Theoretical	Observe
Room Temperature	$CaHPO_4 \cdot 2H_2O$	100	100
294° C	$CaHPO_4$	79.08	79.4
554° C	$Ca_2P_2O_7$	73.83	75.72

Table. 1 Comparative Values of CHPD Crystal at different Temperatures
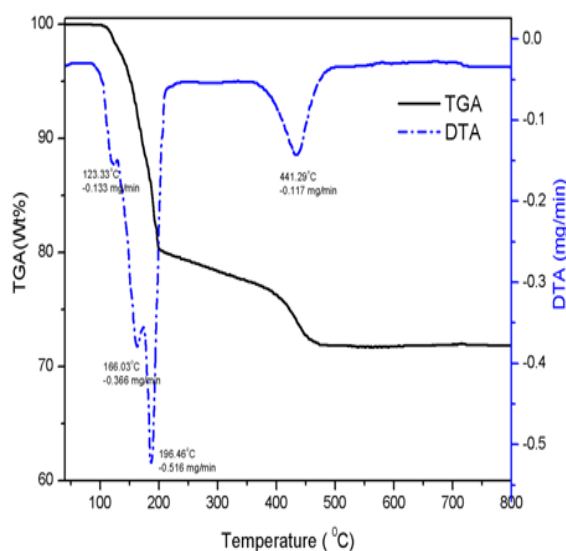
Figure 5: Thermogram of Brushite crystal

3.4.   SEM and EDX studies

The CHPD/Brushite crystal has a plate-like morphology dominated by (010) faces and the structure within the (010) plane is composed of two corrugated rows of Ca^{2+}
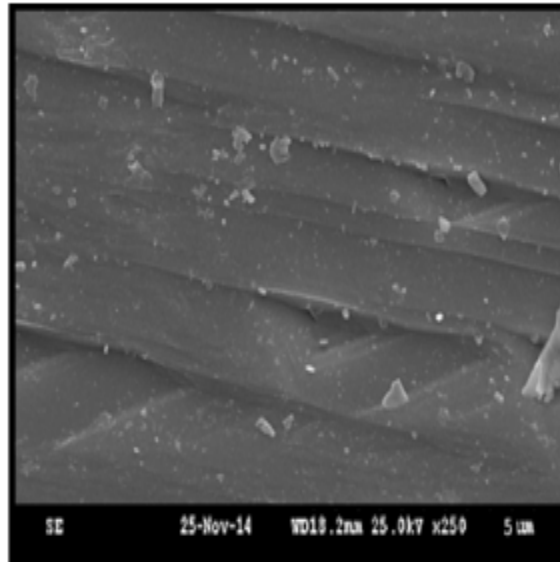
Figure 6: SEM Picture of CHPD crystal
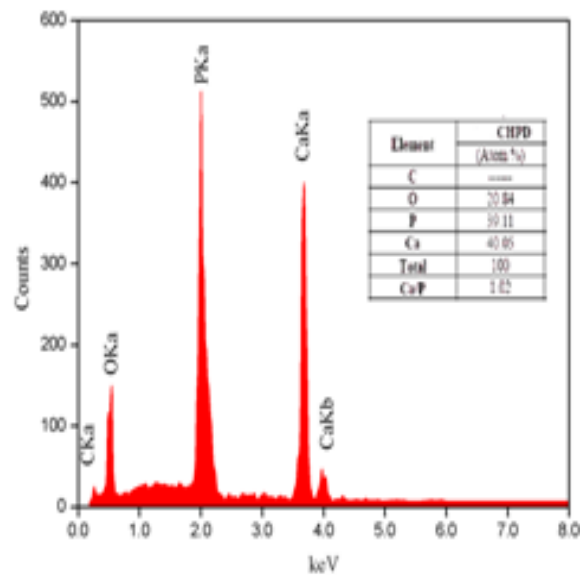
Figure 7: EDX Pattern of CHPD crystal

and HPO_4^{2-} that are offset in the (010) direction. Between these calcium and phosphate containing sheets, are layers of water molecules bound to the calcium ions above and below the (010) plane [9]. Figure 7 and 8 give the Scanning electron microscope image and EDX spectrum of grown crystal respectively. The Energy Dispersive X-ray Spectroscopy (EDX) analysis of brushite crystals revealed the presence of 0% of Carbon atoms along with expected Oxygen (20.84%), Phosphorous (39.11%) and Calcium (40.05%) atoms.

4. Conclusion

Brushite crystals have been grown in SMS gel by using Ortho Phosphoric acid and calcium acetate as reactants. Growth parameters are standardized. Powder XRD analysis confirm the crystal nature of the gel grown crystal and the lattice parameters have been determined. FTIR studies reveal the presence of various functional groups. TGA and DTA studies explain the thermal stability of the crystal. Surface morphology and compositional details are studied using SEM and EDX studies.

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SCLC Conduction Mechanism in Indium Selenide Thin Films and its Dependence on Local Structure

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Abstract

This paper deals with the effect of substrate temperature on the structural, optical, surface morphological and electrical conduction properties of thermally evaporated amorphous like and polycrystalline InSe thin films. Also an effort has been made to determine the effect of small clusters in the determination of band gap by theoretical calculations. X-ray diffractogram, transmission spectra and Scanning Electron Microscopy were used to analyze the prepared films. The composition of the deposited film was verified by EDAX. Current-Voltage studies (160-360 K) on both the a-InSe and poly-InSe films have been performed using an Al/InSe/Al sandwich structure. The dominance of the variable conduction mechanism of Mott's type was identified in both amorphous like (210-310 K) and polycrystalline films (160-260 K) under low electric field ($\sim< 1 \times 10^5 V cm^{-1}$) condition. In the intermediate higher temperature range and at the same low field condition, Seto's thermionic emission was observed. At higher fields ($\sim> 1 \times 10^5 V cm^{-1}$) and at higher temperatures, a region of space charge limited current (SCLC) conduction mechanism was observed. The exponential decrease of density of states from the conduction band edge towards the Fermi level in both the amorphous and polycrystalline films was confirmed based on the SCLC measurements. From the theoretical calculations the band gap was found to be low ($\sim$ 1.3 eV) which may

be due to the presence of small clusters.

Keywords: LC, Inse, Local Structure, Conduction Mechanism.

1. Introduction

Indium selenide, a binary chalcogenide alloy of the type III - VI, has been an active research subject of considerable interest mainly due to its potential for optoelectronic and photovoltaic applications [1, 2]. InSe is one of the most suitable candidates for photovoltaic conversion because of its energy gap (1.3 eV) and in addition, there are related ternary and quaternary phases such as $CuInE_2$ and $CuIn1\text{-}_xGa_xE_2$ (E = S or Se) with uses in solar cells. InSe has a hexagonal bonding structure and in order to satisfy the octet rule for sp^3 hybridization, one third of the cation sites are vacant [3]. Although the structural, electronic and optical properties of InSe are studied by many groups [4, 5] the results are rather confusing and contradictory, because of the coexistence of several In-Se phases and most measurements have been done on multiphase films.

The large influence of the microstructure and secondary phases (surface layers) on the transport properties contributes further to the confusion [6]. Due to this, an attempt has been made to understand these problems by theoretically evaluating the influence of the structure on the optical and electronic properties [7, 8]. Even though there have been many studies of film formation by several other techniques like flash evaporation, chemical vapor deposition [9], Van der Waals epitaxy [10], molecular beam epitaxy [11] and thermal evaporation of InSe, still, the conditions are unsolved due to the complex nature of the problems. The problems associated in preparing single-phase films are the different crystalline phases that exist for In_2Se_3 and the high vapor pressure of Se along with the effect of the smaller crystallites, which can be interpreted as quantum size effects in the matrix [12]. In many of the previously reported studies, the substrate temperature was maintained only in a low temperature range (from less than 473 to 573 K). In this study we have deposited the InSe films on substrates kept at a temperature higher than that of previously reported ones. It was found that hexagonal single-phase polycrystalline InSe films were formed at T_{sb} = 673 K. Also very few reports are available in the literature on the systematic study of the transport properties of both amorphous and polycrystalline InSe thin films [13-15].

In this article we report the structural, optical, composition as well as electrical characteristics and nature of conduction mechanism at low and high fields over a temperature range of 130-360 K for amorphous like and polycrystalline In-Se thin films. The concept of amorphous has been vastly used purely based on the X-ray pattern but actually small crystal structures (clusters) which are found to be basics for the electronic and photonic behavior [16] and in fact the nanometric clusters have proved to induce quantum mechanical effects as electron confinement [17] that influence the size and structure [18]. In order to understand the effects on structure during the deposition and how this is related to the electronic structure, we used quantum mechanic calculations

for the crystal assuming the first stages of crystalline formation, which generated better precision than the previous reports [19,20]. With the help of these simulations we can identify the relation between the cluster size and the corresponding band-gap.

2. Experimental and Theoretical Methods

InSe Film Deposition

The In - Se alloy was prepared from its own constituent elements. Appropriate weights of indium and selenium (purity 99.999%, Nuclear Fuel Complex, Hyderabad) were mixed together and placed in a quartz ampoule, which was then sealed under a vacuum of 10^{-5} Torr. The sealed quartz ampoule was placed in a rotating furnace at a temperature of 1073 K for 12 hours and then the compound was slowly cooled down to room temperature. $In_{50}Se_{50}$ thin films were deposited onto well-cleaned glass substrates held at room temperature and also at elevated substrate temperatures (673 K) using a conventional vacuum coating unit (12A4). Molybdenum boat was used as the source and the pressure inside the chamber was maintained at a level better than 10^{-5} Torr.

Film Characterization

The structural analysis has been done using a Philips X-ray diffractometer with CuK_{α} radiation ($\lambda = 1.542\dot{A}$) at 40 kV and 20 mA in the scanning angle (2θ) from $10°$ to $70°$ for room temperature deposited films and films coated at elevated substrate temperature (673 K). The composition of the film was verified using Energy Dispersive Analysis of X-ray (EDAX). For Surface morphological analysis a DSI 30 dual scan scanning electron microscope (SEM) was employed in which a beam of very small diameter $\sim$10 nm was produced by electron gun and electron lenses. Optical transmission studies were carried out to estimate the band gap of the semi-conductor films using a JASCO International Corp., UV-530 spectrophotometer in the wavelength range 300 - 1100 nm. Films for I-V measurements were deposited onto glass substrates previously equipped with coplanar aluminum electrodes to form an Al / InSe / Al sandwich structure. All measurements were taken in the temperature range of 160 to 360 K using standard techniques and automated systems. The thicknesses of the films were measured by using multiple beam interference (MBI) technique.

Theoretical calculations

Molecular simulation analysis was made considering the crystal as unit cell and three different small clusters with one and two layers in order to evaluate the effect of the configuration on the electronic structure and to recognize the possible quantum size effects. The unit cell model was built using the parameters for the hexagonal configuration (space group R3m, C_{3v}^{5}); besides models of small clusters with one

and two slabs and an amorphous low energy configuration. The single point energy was calculated using the Dmol3 software based on the density functional theory [19], considering all the electrons relativistic, the local density approach (LDA) and the Perdew-Wang functional [20] with a convergence tolerance of 10^{-6} eV, for each model. The corresponding frontier orbitals were localized and the band gap energy was calculated for each case, besides their corresponding binding energy in order to understand the preferential structures produced.

3.   Results and Discussion

Structural parameters

Fig.   1 shows the XRD patterns of InSe films grown at room temperature (A) and at 673 K (B). Films prepared on cold substrates are apparently amorphous with the presence of small crystalline clusters but they show evidence of becoming polycrystalline when the substrate temperature was increased to 673 K denoting crystallization process. At higher substrate temperatures, the films exhibit a diffraction pattern typical of hexagonal crystal structure [9]. The strong diffraction peak around $2\theta = 21.35°$ corresponds to diffraction from the (004) planes while the other peaks at $2\theta = 10.8°$ and $27.5°$ are the result of diffraction from the (002) and (101) planes respectively. The XRD results indicate that the thermally evaporated single-phase poly-InSe films belong to hexagonal unit cells [4, 5].

From the XRD profiles, the crystallite size (D) of the films was calculated using the Debye Scherrer's formula from the full-width at half-maximum (FWHM)β for the (004) plane. The strain is calculated from the slope of $\beta \cos\theta$ versus $\sin\theta$ plot using the relation

$$\beta = \frac{\lambda}{D\cos\theta} - \varepsilon\theta \tag{1}$$

The dislocation density (δ) is defined as the length of dislocation lines per unit volume of the crystal and has been calculated by using the relation $\delta = 1/D^2$. The grain Size, dislocation density and strain were calculated as 19.38 nm, 2.66×10^{15} lin/m^2 and 2.098×10^{-3} lin$-^2$ m^{-4} respectively.

The surface analysis of the layers has been carried out visually by scanning electron microscopy. Fig. 2 shows the SEM image of poly-InSe film grown on glass substrates. The amorphous films have smooth surface while the films deposited at $T_{sb} = 400°$ C reveal polycrystalline structure with hexagonal shaped grains of InSe [9]. The image shows two main domain sizes, one corresponding to bigger aggregates in the order of ∼500 nm, while the existence of smaller grains of 10-50 nm is also evident, as it can be observed in the selected magnified area (i). In fact, using the amplification, it can be determined that the films are constituted of granular shape structures and the substrate heating process must produce the coalescence of these zones to produce the polycrystalline film. The EDAX spectrum shows the values of the constituent elements

as In = 47.75% and Se = 52.25% in the room temperature deposited and In = 40% and Se = 60% in poly-InSe films. The increase in the selenium concentration at higher substrate temperature may be attributed to the higher sticking coefficient of Se compared to In.
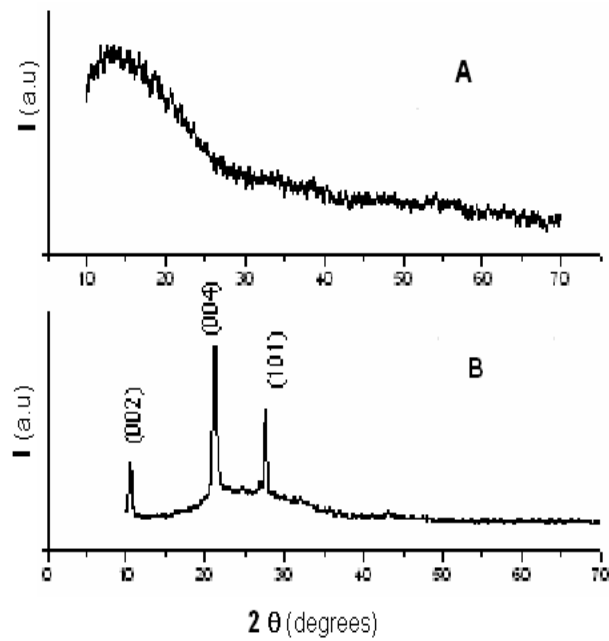
Fig. 1 X-ray diffraction pattern of the InSe deposited at room temperature (a) and at a substrate temperature ($T_s b$) of 673 K (b)
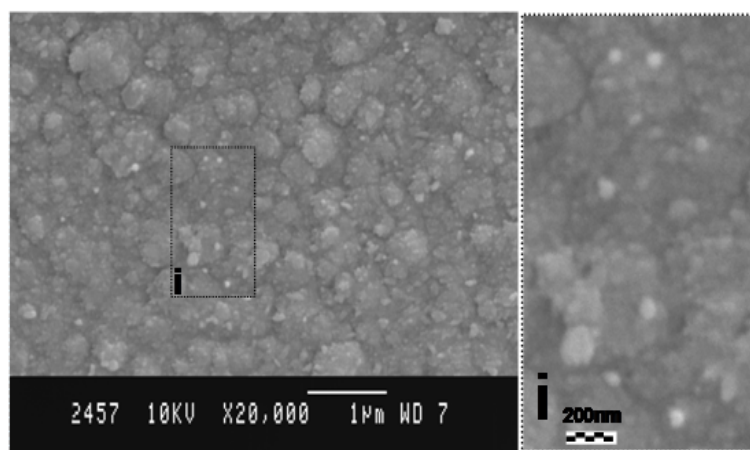
Fig. 2 Scanning electron microscopy image of the polycrystalline InSe thin film. The magnified image of a selected portion from the deposited sample on right

Theoretical analysis of the structure

From the SEM images and the X-ray diffraction patterns, we can distinguish the formation of small clusters in the initial stages of film formation, where there must exist the smallest possible ordered aggregates of materials; while at higher substrate temperatures the crystallization process is more rapid making it detectable by the X-ray diffraction technique. In order to understand the effect of each type of clusters, models have been simulated assuming the hexagonal unit cell, small nanoparticles with one and two layers and an amorphous low energy configuration, all of them with similar number of atoms. Two views of the models used for (a) unit cells, (b) two layer, (c) one layer and (d) amorphous configurations are shown in Fig 3. The quantum mechanics calculations of these structures denote the stability and the corresponding band gap, which is clearly different for the smallest structures. In table 1 we can find the values for the calculated binding energy, HOMO, LUMO and the corresponding gap in eV, for the considered models. It must be noticed that our method includes the relativistic effects of the electrons improving the exactitude of the calculi as it can be seen in the band gap of the unit cell, which is 1.3413 eV that matches with the experimental measurements for single-crystal materials. Besides the values for the nanometric structures the corresponding gap decrease significantly until 0.2368 eV for the amorphous clusters, while the layered materials have 0.3045 eV and 0.4935 eV as the values for the double and single slabs respectively.

Binding Energy per atom	HOMO (eV)	LUMO (eV)	Band Gap (eV)	Model
	-4.6041	-3.2628	1.3413	Crystal
-2.1110	-5.2792	-4.9747	0.3045	Two layers
-2.2198	-5.4103	-4.9168	0.4935	One layer
-2.0704	-5.1177	-4.8809	0.2368	Amorphous

Table. 1 Theoretical values of binding energy, band gap and HOMO-LUMO gaps

Moreover the stability can be distinguished by the binding energy per atom, which denotes the most stable configuration as the single layer material and the two layers and the amorphous as the highest energy structure. The energy obtained implies that the material behavior search to produce small aggregates with the slab formation since the smallest configurations, so the material must be an early produced disordered matrix of small clusters and the layers can be generated with low energy and the extra temperature allows the ordering and the re-crystallization of the samples. This behavior is also involved with the difference of gap between the types of materials, which must be related to the inclusion of small clusters in the polycrystalline sample.
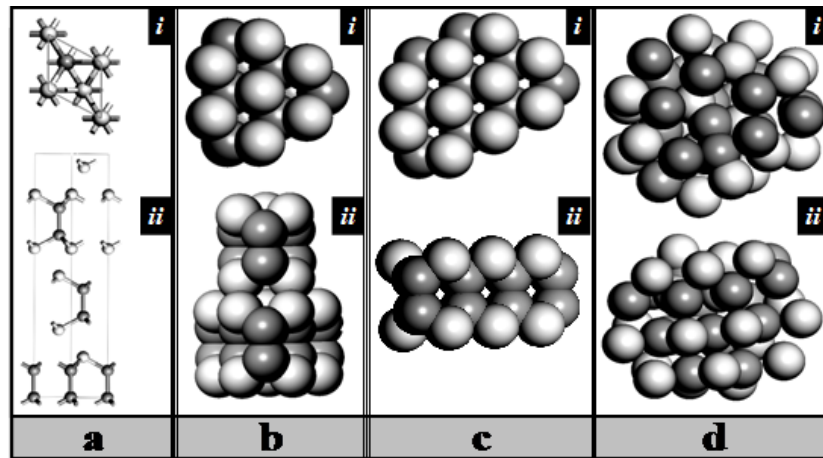
Fig. 3 Models of the InSe structures; from a) unit cell, and small clusters with
b) two layers, c) single layer and d) amorphous configurations in the views
where (i) the hexagons are evident, and (ii) after a rotation of 90°
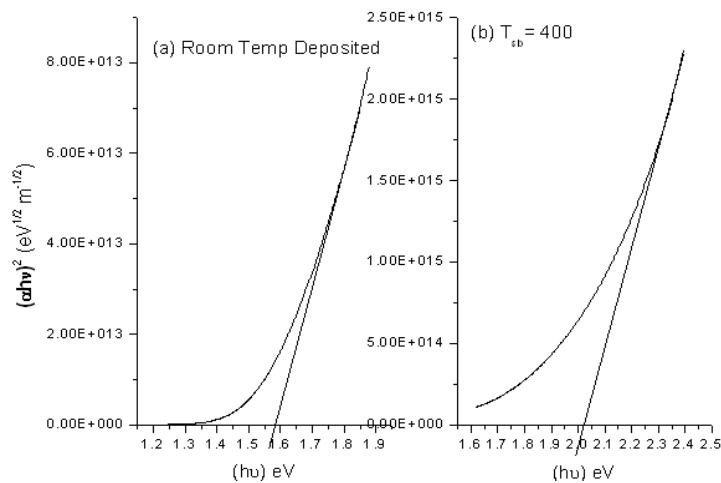
Fig. 4 Plot to evaluate the optical band gap of a) amorphous like
and b) polycrystalline InSe thin films

Optical Characterization

The experimental band gap energy (E_g) was estimated on the basis of the recorded
optical spectra using the relation, $\alpha h v = A(h v - E_g)^n$, where A is a constant, α is
the absorption coefficient, $h v$ is the photon energy, and n depends on the nature of the
transition. For direct transition $n = 1/2$ or $3/2$, while for the indirect case $n = 2$ or 3,
depending on whether they are allowed or forbidden, respectively. The best fit to the
experimental data was obtained for $n = 1/2$. This is in agreement with the literature

data; according to which InSe is a semiconducting material with a direct band gap. The relation $(\alpha h v)^{1/2}$ versus $h v$ yields a straight line [Fig. 4a and b], which means that the fundamental absorption edge can be described by the direct-allowed transition. The direct energy gap value of amorphous and polycrystalline films have been determined as 1.58 and 2.01 eV respectively [5, 21], which almost coincides with the theoretical value given in table 1 for the crystals.

The observed change of the room temperature and substrate temperature deposited films can be partially explained - as done for amorphous like InSe thin films on the basis of the model of the density of states in amorphous solids proposed by Mott and Davis [22]. According to this model, the width of the localized states near the mobility edges depends on the degrees of disorder and the defects present in the amorphous structure. In particular, it is known that unsaturated bonds together with some saturated bonds (like dative bonds) are produced as a result of an insufficient number of atoms deposited in the amorphous films. The unsaturated bonds are responsible for the formation of some defects in the films. Such defects produce localized states in the amorphous solids. The presence of a high concentration of localized states in the band structure is responsible for the low value of Eg$^{\text{opt}}$ in the case of room temperature deposited amorphous like films. In the films deposited at higher substrate temperature i.e., in polycrystalline films, the unsaturated defects are gradually annealed out producing a large number of saturated bonds. The reduction in the number of unsaturated defects decreases the density of localized states in the band structure, consequently increasing the optical gap along with the electronic confinement of each constituent element [23]. In fact, the energy of the unsaturated bonds and the energy required for the formation of small clusters imply a behavior based on the reduction of energy by re-crystallization.

Conduction Studies

Low field
The investigation of the conduction mechanism of deposited films in the temperature range 160 to 360 K was carried out, assuming that at least one of the following three possible conduction mechanisms is dominant at different temperature ranges. They are

  (i) thermionic emission in which $\sigma T^{1/2}$ varies exponentially with inverse temperature,

 (ii) tunneling for which varies as T^2 and

 (iii) variable range hop-ping in which $\ln(\sigma T^{1/2})$ depends on temperature as $T^{-1/4}$.

The temperature-dependent conductivity data were used to determine the temperature intervals over which one of the above theories was applicable. The dominance of the variable conduction mechanism of Mott's type was identified in both amorphous (210 - 310 K) and polycrystalline films (160 - 260 K) under low electric field ($\sim< 1 \times 10^5$

Vcm^{-1}) condition. The activation energies of conductivity E$_a$ for the films were found to be 198 and 77 meV respectively. E_σ for polycrystalline film is found to be less than that of the amorphous film similar to the formation of local arrays.

In the higher temperature region, the variation of conductivity with temperature for amorphous like and polycrystalline materials was found to obey Seto's extended version of the Petritz model

$$\sigma\sqrt{T} = \sigma_0 \ \exp\left(\frac{E_\sigma}{kT}\right) \tag{2}$$

E_σ, being the activation energy of conductivity. In this model, the trapped charges at the grain boundaries produce carrier depletion and this is the main cause of grain boundary potentials. The height of the barrier at the grain boundaries and its temperature dependence has been examined by Gunal and Mamikoglu [24]. It was found that the grains in the high temperature region are spatially depleted and the transport is mainly due to thermionic emission of carriers over the grain boundaries.

In the low temperature region, between 160 and 310 K, the observed σ - T variation is studied using the variable range hopping theory established by Mott. A good fit of conductivity - temperature relation is given by [25]

$$\sigma\sqrt{T} = \sigma_0 \exp\left[-\left(\frac{T_0}{T}\right)^{1/4}\right] \tag{3}$$
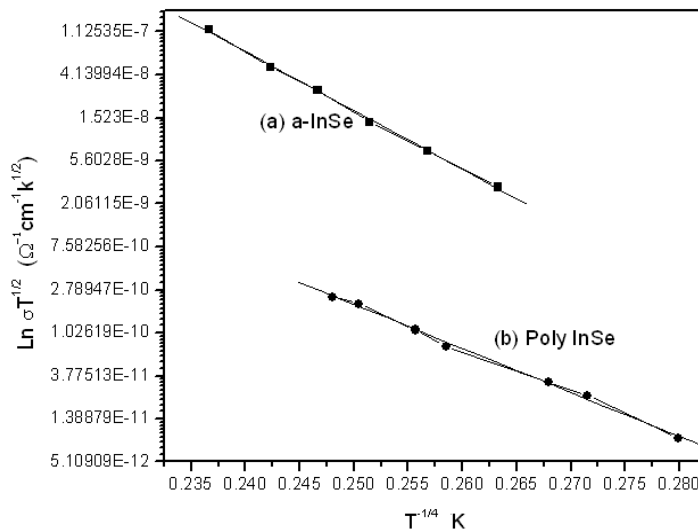
Fig. 5 Variation of σ with $T^{-1/4}$ for (a) amorphous like InSe (210 - 310 K) and (b) poly crystalline InSe (160 - 260K) film at low field ($< 1 \times 105$ V cm^{-1})

In the present investigation, in the low temperature region, the conduction may be due to variable range hopping, since the plot of $\sigma T^{1/2}$ Vs $T^{-1/4}$ fits well. Figs. 5 (a) and (b) respectively show the plot of $T^{1/2}$ Vs $T^{-1/4}$ for the amorphous like (210-310 K) and polycrystalline (160-260 K) InSe thin film samples at low field ($\sim\ < 1 \times 10^5$ Vcm^{-1}). For this reason, $\sigma T^{I/2}$ was plotted as a function of $T^{-1/4}$ on a semi logarithmic scale; a straight line was obtained indicating that the conduction at these temperatures may be due to hopping between localized states. From the slopes and intercepts of these plots, Mott's parameters were calculated and shown in (Table.2).

Inse Films	Hopping dimension	Mott temp $T_0(K)$	Localization radius $a\mathring{A}$	$N(E_F)$ $(cm^{-3}eV^{-1})$	R_{hop} (cm)	W_{hop} (eV)	E_σ (eV)
a-InSe	3D	3.5×10^8	14	1.908×10^{17}	1.8×10^{-6} at 240 K	0.719 at 240 K	0.198 (270-360 K)
Poly InSe	3D	1.0×10^8	231	1.892×10^{14}	2.13×10^{-5} at 240K	0.511 at 240K	0.077 (270-360 K)

Table. 2 Mott's parameter for the amorphous like and polycrystalline InSe films

In these calculations, a typical phonon frequency of $10^{13}s^{-1}$ was assumed. The values of γR and W satisfy Mott's requirements ($\gamma R > 1$ and $W > kT$) for variable range hopping. The value of localization radius for amorphous material is assumed by various investigators as $10\mathring{A}$ even though it varies from 10 to $20\mathring{A}$ [26]. However, in the present investigation it has been calculated, based on observation, to be $14\mathring{A}$ and this value has been used in the calculation of $N(E_F)$. For polycrystalline states, the estimated localization radius is $231\mathring{A}$. It is found that the localization radius increases with rise of substrate temperature revealing the improvement of crystallinity. This observation closely matches with the crystallite size calculated from the XRD data. The values of $N(E_F)$ reported by other researchers also match closely with the present result.

High Field
Space-Charge-Limited Current (SCLC)
SCLC predicts (Lambert's theory) that valuable information can be obtained from the current-voltage (I-V) dependence of materials [27]. This method has been used in the evaluation of electronic properties of high-resistively materials. SCLC measurements were performed on both amorphous and polycrystalline InSe films at high electrical field $\left(\sim> 1 \times 10^5 V cm^{-1}\right)$ and for temperature region 300 - 360 K. Typical SCLC characteristics at 320K for amorphous and polycrystalline InSe samples

of thickness 230 nm are reported in Fig. 6 (a) and (b) respectively in the form of log (I) versus log (V) plots. In general, these curves show a gradual transition from an Ohmic region, where I is proportional to V, to a space-charge-trap-limited current region where I is proportional to V^n with $n > 2$.

In the ohmic region the I-V dependence should be of the form [28]

$$I = Aq\mu_p p_0 \, \frac{V}{d} \tag{4}$$

where A is the electrode active area of $(4.2 \times 10^{-2} cm^2)$, q is the electronic charge, p_o is the hole concentration, d is the sample thickness and p is the hole mobility which can be found from the following equation [29]

$$I = 6.510 \times 10^{11} \, \frac{AV^2 \mu_p \, T^{3/2}}{d^3 N_t} \, e^{-E_t/kT} \tag{5}$$

Equation (5) predicts that in the square-law region, it is obtained from the plot of $\log_{10}$ I vs. T^{-1} should give a straight line provided the $\mu_p T^{3/2}$ product is a weak temperature dependent factor. Knowing N_t, E_t and μ_p can be determined from the slope and intercept of such plots. The current versus temperature data at a selected voltage are retrieved from the collected data. The fit of equation (5) to these data for the same selected voltage. The mobility value $(7.263 \times 10^{-12} cm^2 V^{-1} s^{-1})$ reported here from the present studies on the amorphous like film agrees with those reported from Hall mobility studies of the III-VI materials [26]. When the same material becomes polycrystalline, the mobility is found to increase $(1.516 \times 10^{-11} cm^2 V^{-1} s^{-1})$ by an order of magnitude. Using p values, equation (4) yields $p0_a$ (amorphous like) and $p0_p$ (polycrystalline) in the ohmic regions (Table 3). In the square law region where I-V characteristic is controlled only by the shallow levels, the current is given by [30]

$$I = \frac{9}{8} \, \frac{A\varepsilon_s \mu_p \theta V^2}{d^3} \tag{6}$$

where s is the static permittivity of the material and is the ratio of free to shallow trapped charges [31]. The steep rise in current preceded by the square law region occurs at

$$V_{TFL} = \frac{qN_t d^2}{2\varepsilon_s} \tag{7}$$

where V_{TFL} is the trap-filled limited voltage, estimated as 5.6 V [32] and 4.56 V for polycrystalline and amorphous films respectively.

For a single level of shallow traps, whose density is N_t, the dominant trap level $(E_t - E_v)$ above the hole mobility edge is calculated from the relation [33],

$$\theta = \left(\frac{N_v}{N_t}\right) \exp\left(\frac{-(E_t - E_v)}{kT}\right) \tag{8}$$

where $N_c = 2(2m * kT/h^2)^{3/2}$ is the effective density of states at the conduction band edge. The value of $N_c = 9.749 \times 1018cm^{-3}$ was calculated by taking $m* = 0.5m$ and $T = 320K$. According to Lambert's theory, the I-V characteristic consist of an ohmic region at low voltages, followed by a super linear region in which the current density expression holds the expression

$$J \propto \frac{V^{i+1}}{d^{2i+1}} \tag{9}$$
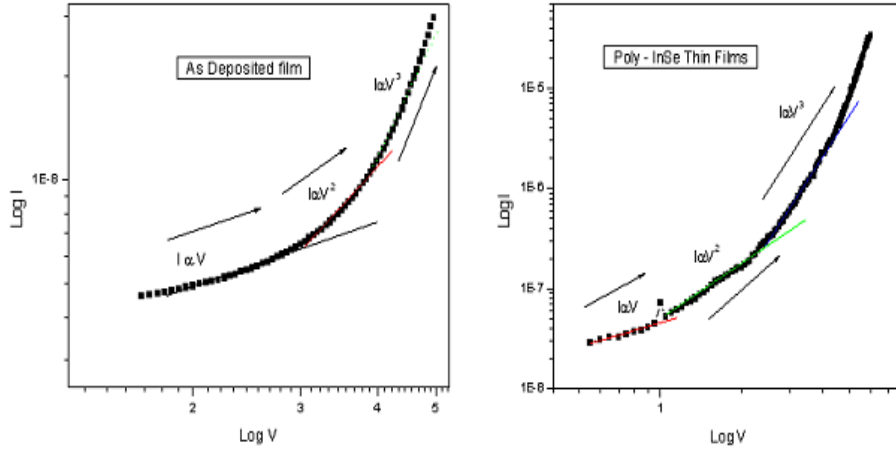
Fig. 6 The plot log I versus log V for room temperature deposited (amorphous like) and polycrystalline InSe films

Inse Films	μ $(cm^2V^{-1}s^{-1})$	V_{FTL} (V)	P_0 (cm^{-3})	N_t (cm^{-3})	N (E) $(cm^{-3}eV^{-1})$
Amorphous	7.263×10^{-12}	4.56	4.83×10^{18}	8.255×10^{17}	9.02×10^{17}
Poly Inse	1.516×10^{-11}	5.6	1.42×10^{19}	1.99×10^{16}	2.01×10^{18}

Table. 3 SCLC parameter for the amorphous like and polycrystalline InSe Films

where $l + 1 = n$ is known as power law gradient and l is equal to the ratio T_t/T, T is the absolute temperature and T_t is a temperature characterizing the exponential trap distribution $N(E)$ described by

$$N(E) = N_0 \exp\left(-\frac{E}{kT_t}\right) \tag{10}$$

where N_0 is the value of $N(E)$ at the valence band edge. The total concentration of traps N_t is the integral over the exponential distribution $N(E)$, and is given by [34],

$$N_t = N_0 k T_t \tag{11}$$

The transition voltage V_{tr} is given by [35]

$$V_{tr} = \left(\frac{n_0}{N_c}\right)^{1/l} \frac{d^2 q N_0 k T_t}{\varepsilon_s} \tag{12}$$

The gradients in the SCLC region are 4.31 and 4.7 for amorphous and polycrystalline films and this suggests an exponential trap distribution.

Using these gradients, T_{ta} and T_{tp} are determined as 1059 and 1150 K respectively. Using the calculated values of T_{ta}, T_{tp}, V_{tra} and V_{trp} and the earlier reported value of p_o, the values of N_o are evaluated from the equation (12) for amorphous films. The determined values agree well with the reported for the same material [36]. All the calculated values are tabulated in Table 2. The total concentration of traps (N_t) in the exponential distribution are obtained from equation (11) as $8.255 \times 10^{17} cm^{-3}$ and $1.99 \times 10^{16} cm^{-3}$ for amorphous and polycrystalline InSe thin films respectively.

4. Conclusion

We have prepared phase-pure InSe thin films by the simple vacuum evaporation method. The room temperature deposited InSe films were amorphous in nature with small crystal clusters. Single-phased and hexagonal shaped polycrystalline films were obtained by keeping the substrate at higher temperature. The optical energy gap value was found to be higher in the poly-InSe film (2.01 eV) than the a-InSe film (1.58 eV). The local ordering of the materials was understood by theoretical calculations that determined the presence of small clusters. Considering the binding energy involved in the different configurations, which allowed identifying the re-crystallization process from the film formation stage and should be amorphous matrix with immersed small aggregates mainly formed by fractioned slabs. These slabs and small domains must be reordered with the extra energy of the heated substrate to produce the polycrystalline samples. The conductivity of poly-InSe sample has been found to be higher than in a-InSe sample. At low field and in lower temperature range, the VRH conduction of Mott's type was found to be prevalent in both a-InSe and in poly-InSe. At higher voltage and temperature, the SCLC region was observed. When the material turns into polycrystalline state from amorphous state, the mobility was found to increase by an order of magnitude. Comparison of $N(E)$ and $N(E_F)$ in case of both of these forms of the material confirms the exponential decrease of density of states from the conduction band edge towards the Fermi level.

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Theoretical Investigations on the Molecular Structure, Infra Red Andraman Spectral Analysis of 4-Methylbenzylcyanide

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Abstract

Quantum chemical calculations of energies, geometrical structure and vibrational wave numbers of 4-methylbenzylcyanide (4-MBC) were carried out by ab initio HF and DFT (B3LYP) method with 6-311++G(d,p) and 6-311G(d,p) as basis set. The scaled wave numbers are in close agreement with each other. The calculated HOMO and LUMO energies also confirm that charge transfer occurs within the molecule. Finally the theoretical FT-IR, FT-Raman and spectra of title molecule have also been constructed. The Mulliken charges were also calculated.

Keywords: DFT, Molecular Geometry, Mulliken Charges

1.   Introduction

Benzylcyanide and its derivatives are of chemical, pharmaceutical and spectroscopic importance and a number of benzylcyanide derivatives have important applications. Benzylcyanide has been used as versatile precursor to many derivatives. The title compound 4-methylbenzylcyanide is extensively used in many areas of which Food safety and quality proves to be a significant importance. However the properties of this compound have been less studied so far. The compound 4MBC is an electron donating in nature.

Agathe et al., [1] discovered a reaction giving access to a new thio substituted carbohydrate, via an interesting rearrangement mechanism. Molecular orbital computations were performed parallel with the experimental work to better explain the formation of the product. The experimental and theoretical studies of vibrational dynamics and molecular structure of 4-n-pentylphenyl-4′-n-octyloxythiobenzonate

were carried out by Kacper et al., [2]. FT-Raman and FT-IR spectra were recorded for the sample in the solid state. The equilibrium geometries, harmonic vibrational frequencies, IR and the Raman scattering intensities were computed using the Gaussian 03 package.

Conformational and vibrational analysis of 2-methoxy ethanol and 2-methylthio ethanol by DFT method is reported by Hiroshi et al., [3]. The energies, molecular geometries and vibrational wavenumbers were calculated by the BLYP, B3LYP and B3PW91 methods using the 6-31G* basis set. The calculations by the HF and MP2 methods were also carried out. The experimental large wavenumber difference between 2-methoxyethanol and 2-methylthioethanol of the intra-molecular hydrogen bonded O-H stretching than with the *ab initio* MO calculations. Olga et al., [4] conducted a theoretical and experimental study on Molecular structure and conformational composition of 1-[(methylthio)methyl]-2-nitrobenzene.

A Raman spectroscopic study of the low-frequency vibrations in anisole-d5 and anisole-d8 was conducted by Tylli et al., [5]. Low frequency Raman spectra of solid anisole and solid anisole-d3 have been recorded at 130K by Tylli et al., [6]. The methyl torsional mode was observed at $285 cm^{-1}$ in the spectrum of solid anisole and at $183 \ cm^{-1}$ in the spectrum of anisole-d3. Vibrational spectra and torsional barriers of anisole and some monohalogen derivatives were studied by Owen et al., [7]. The torsional barriers restricting rotation about the phenyl-O bond have been calculated from the torsional frequencies for the pure liquids.

Literature reveals that to the best of our knowledge DFT calculation studies on 4MBC molecule have not been reported so far. Therefore, the present work deals with IR, Raman, and NMR spectroscopic investigation of 4MBC utilizing DFT (B3LYP) method with 6-311G(d,p) and 6-311++G(d,p) as basis sets. The HOMO and LUMO analysis have been used to elucidate information regarding charge transfer within the molecule.

2.   Computational Details

For meeting the requirements of both accuracy and computing economy, theoretical methods and basis sets should be considered. DFT has proved to be extremely useful in treating electronic structure of molecules. The density functional three parameter hybrid model (DFT/B3LYP) at 6-311G(d,p) and 6-311++G(d,p) basis sets level along with HF/6-311++G(d,p) method was adopted to calculate the properties of the studied molecule in this work. All the calculations were performed using the Gaussian 03W program package [8] with the default convergence criteria without any constraint on the geometry [9].

3. Results and Discussion

Molecular Geometry

A complete geometry optimization was performed with C1 point group symmetry. The optimized molecular structure of 4-NTA is shown in Fig. 3.1. The corresponding global minimum energy obtained by the B3LYP/6-311++G(d,p) method is -403.104 a.u. Since no experimental values are available, the geometrical parameters of 4-MBC have been investigated by theoretical methods such as HF/6-311++G(d,p), B3LYP/6-311G(d,p) and B3LYP/6-311++G(d,p) level and the values are given in Table 3.1. The C6-C11 bond possesses higher value comparing to other bond length values [1.518, 1.524, 1.539 Åby HF/6-311++G(d,p), B3LYP/6-311G(d,p) and B3LYP/6-311++G(d,p) respectively] which may be due to the methyl group and nitrogen attached to it. The highest bond angle possessed by C11-C18-N19 [179.2, 179.9 and 179.9 at HF/6-311++G(d,p), B3LYP/6-311G(d,p) and B3LYP/6-311++G(d,p) respectively. In the absence of experimental values the theoretically calculated bond lengths, bond angles and dihedral angles are mutually correlate with each other.

Parameter	HF/6-311++ G(d,p)	B3LYP 6-311 G(d,p)	B3LYP 6-311++ G(d,p)
Bond length			
C1-C2	1.379	1.395	1.393
C2-C3	1.394	1.394	1.396
C3-C4	1.383	1.401	1.398
C4-C5	1.390	1.388	1.400
C5-C6	1.381	1.398	1.400
C6-C1	1.391	1.391	1.400
C3-C14	1.510	1.509	1.529
C14-H15	1.086	1.094	1.070
C14-H16	1.087	1.091	1.070
C14-H17	1.083	1.093	1.070
C6-C11	1.518	1.524	1.539
C11-C18	1.473	1.459	1.489
C11-H12	1.082	1.095	1.070
C11-H13	1.084	1.095	1.070
C18-N19	1.129	1.152	1.203
C1-H7	1.076	1.084	1.077
C2-H8	1.076	1.085	1.077
C5-H10	1.076	1.085	1.077
C4-H9	1.076	1.085	1.077

Parameter	HF/6-311++ G(d,p)	B3LYP 6-311 G(d,p)	B3LYP 6-311++ G(d,p)
Bond Angle			
C1-C2-C3	121.16	121.40	120.97
C2-C3-C4	117.90	117.76	120.06
C3-C4-C5	121.06	121.06	119.96
C4-C5-C6	120.70	120.70	119.98
C5-C6-C1	118.54	118.60	120.06
C6-C1-C2	120.61	120.41	119.94
C5-C6-C11	120.72	118.48	119.88
C1-C6-C11	120.71	122.90	120.05
C11-C18-N19	179.29	179.95	179.97
C11-H12-H13	36.45	36.86	35.22
C14-H16-H17	36.03	36.08	35.25
C14-H15-H17	36.05	36.37	35.26
Dihedral Angle			
C1-C2-C3-C4	0.08	−0.07	−0.11
C2-C3-C4-C5	0.05	0.08	0.07
C3-C4-C5-C6	−0.05	−0.03	−0.07
C4-C5-C6-C1	0.00	0.00	0.00
C5-C6-C1-C2	0.07	0.02	0.05
C6-C1-C2-C3	−0.07	0.02	0.05
C2-C3-C14-H17	178.41	156.69	149.85
N19-C18-C11-C6	145.9	125.32	107.34
C1-C6-C11-H13	−55.11	−67.32	−89.41

Table 3.1 Comparison of geometrical parameters of 4-methylbenzocyanide performed at the HF/6-311++ G(d,p), DFT/ B3LYP 6-311 G(d,p) and DFT/B3LYP 6-311++ G(d,p)

Vibrational Assignments

Vibrational assignments were performed on the basis of recorded FT-IR and FT-Raman spectra based on theoretically predicted wave numbers by density functional B3LYP/6-311G(d,p) method and are collected in Table 3.2. We know that ab initio HF and DFT potentials systematically overestimate the Vibrational wave numbers. These discrepancies are corrected by introducing proper scale factors [10, 11]. There are 51 normal modes of vibrations in the molecule.

Literature survey reveals that C-H stretching, in-plane and out-of-plane bending appeared in the range 3100-3000 cm^{-1}, 1300-1000 cm^{-1}, 1000-750 cm^{-1} respectively [12, 13]. The vibrational frequencies in the range 3025-3184 cm^{-1} [mode nos: 43-51]

by B3LYP/6-311++G(d,p) method are assigned to C-H stretching vibrations. The C-H stretching vibrations appear to be at 3054 cm^{-1}. The N-H stretching appears at 3149 cm^{-1}. The computed values are in good correlation with the literature values [14]. The computationally recorded FT-IR and FT-Raman spectra were shown in Fig. 3.2 and Fig. 3.3 respectively.
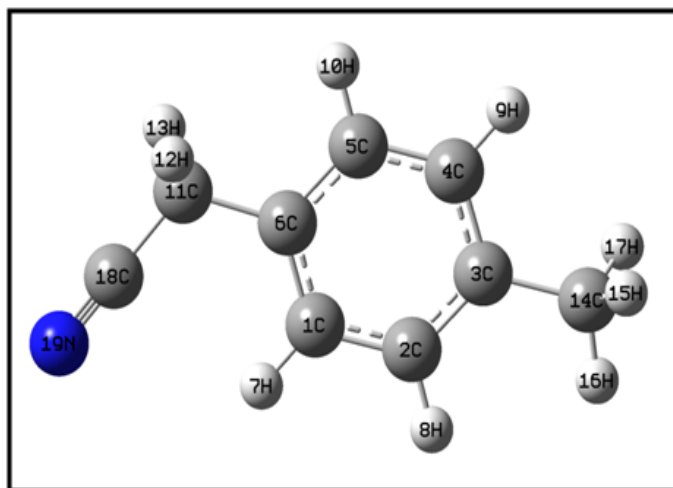
Fig. 3.1 Optimized Structure obtained by B3LYP/6-311++G(d,p)of 4-MBC

Mode No.	Freq. scaled	Intensity		Red. Mass	Force const	Vibrational Assignment
		IR	Raman			
v_1	16	5	1	3.02	0.00	$H_{17} - H_{18}$ rocking
v_2	28	1	1	1.13	0.00	CH_2 rocking
v_3	121	5	3	7.26	0.06	$C \equiv N$ twisting
v_4	126	5	0	2.83	0.02	CH_2 rocking
v_5	277	1	2	4.21	0.19	CH_2 wagging
v_6	296	0	3	2.95	0.15	CH_2 twisting
v_7	374	0	5	3.97	0.32	$N - H$ asymmetric stretch
v_8	380	0	0	3.08	0.26	$C_4 - N_{13}$ torsion
v_9	411	1	3	6.93	0.69	CCCopb
v_{10}	417	0	0	2.94	0.30	CCC ipb
v_{11}	496	21	0	2.53	0.36	$C \equiv N$ twisting
v_{12}	582	0	4	6.16	1.23	CCC ipb
v_{13}	656	0	6	6.98	1.77	CCC opb
v_{14}	719	0	1	3.17	0.96	CH_2 symmetric stretch
v_{15}	753	0	1	4.09	1.36	$C - N$ asymmetric stretch
v_{16}	807	35	0	1.31	0.50	CH ipb

Computed at B3LYP/6-31G(d,p)

Mode	Computed at B3LYP/6-31G(d,p)					
No.	Freq. scaled	Intensity		Red. Mass	Force const	Vibrational Assignment
		IR	Raman			
v_{17}	838	0	33	5.29	2.19	CH ipb + CH_2 wagging
v_{18}	853	0	1	1.24	0.53	CH_2 asymmetric stretch
v_{19}	938	3	0	1.57	0.81	CH scissoring
v_{20}	959	1	0	4.05	2.19	CH ipb
v_{21}	975	1	0	1.41	0.79	CH opb
v_{22}	985	2	0	1.46	0.84	CH opb
v_{23}	1008	3	1	1.43	0.86	$N - CH_2$ asymmetric stretch
v_{24}	1041	5	0	2.86	1.83	Ring breathing
v_{25}	1063	5	0	1.54	1.02	CH opb
v_{26}	1145	5	0	1.32	1.02	$C = C$ stretch
v_{27}	1197	1	14	2.74	2.31	CH_2 asymmetric stretch
v_{28}	1215	2	3	1.18	1.02	CN symmetric stretch + CH twisting
v_{29}	1234	3	9	2.65	2.37	CCC ipb
v_{30}	1242	0	4	1.09	0.99	CCC opb
v_{31}	1298	2	9	2.57	2.55	$C = C$ stretch
v_{32}	1339	0	3	2.16	2.28	CH_2 rocking
v_{33}	1358	2	2	1.55	1.68	CH_2 scissoring
v_{34}	1417	0	20	1.24	1.47	CH_2 twisting
v_{35}	1446	3	2	2.37	2.91	CH_2 scissoring
v_{36}	1465	10	12	1.08	1.37	CH_2 rocking
v_{37}	1489	7	13	1.04	1.36	Ring breathing
v_{38}	1498	13	12	1.12	1.49	CH ipb coupled with C=C stretch
v_{39}	1549	33	1	2.49	3.52	CH_2 asymmetric stretch
v_{40}	1619	3	5	5.68	8.78	$C \equiv N$ asymmetric stretch
v_{41}	1660	0	36	5.78	9.39	Aromatic $C - H$ stretch
v_{42}	2363	9	88	12.6	41.5	CH_2 symmetric stretch
v_{43}	3025	29	251	1.03	5.59	CH_2 asymmetric stretch
v_{44}	3027	7	163	1.05	5.71	$C - H$ asymmetric stretch
v_{45}	3054	2	76	1.10	6.05	$C - H$ stretch
v_{46}	3074	19	102	1.09	6.12	$C - H$ stretch
v_{47}	3105	17	63	1.10	6.25	$C - H$ stretch
v_{48}	3149	11	60	1.08	6.34	$N - H$ stretch
v_{49}	3162	14	64	1.08	6.41	$C - H$ twisting
v_{50}	3167	18	154	1.09	6.46	$C - H$ symmetric stretching
v_{51}	3184	3	116	1.08	6.53	$C - H$ symmetric stretching

Table 3.2 The computed FT-IR, FT-Raman frequencies (cm^{-1}), IR, Raman intensities (Km/mol), reduced mass (amu)and force constants (mdyn/Å) of 4-MBC by using B3LYP/6-311++ G(d,p)
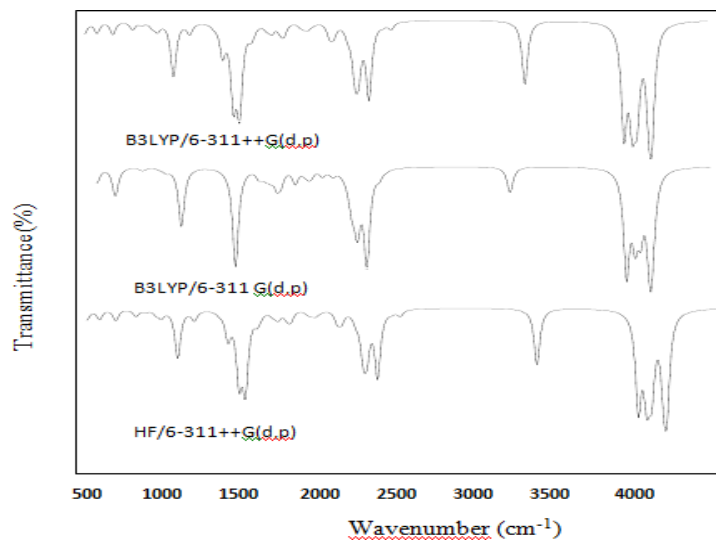
Fig. 3.2 Comparison of the computed FT-IR spectra
of 4-MBC at different basis set
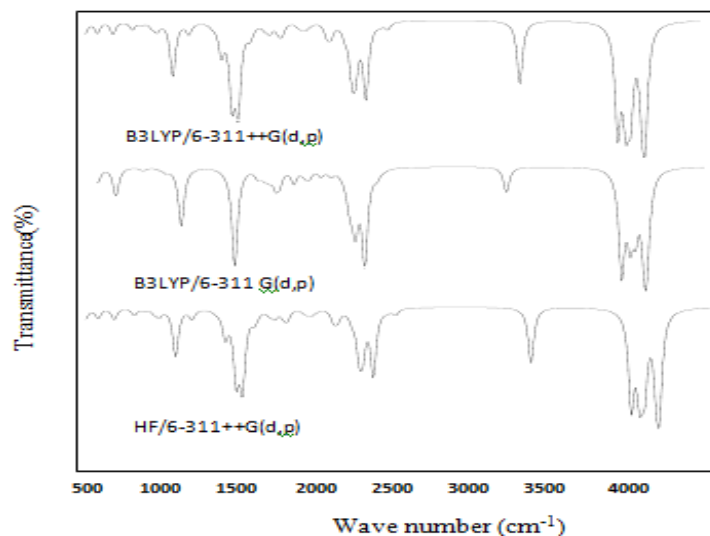
Fig. 3.3 Comparison of the computed FT-Raman spectra
of 4-MBC at different basis set

HOMO-LUMO Analysis

HOMO and LUMO are the very important parameters for quantum chemistry. We can determine the way the molecule interacts with other species; hence, they are called the frontier orbitals. HOMO, which can be thought the outermost orbital containing electrons, trends to give these electrons such as an electron donor. On

the other hand; LUMO can be thought the innermost orbital containing free places to accept electrons [15]. The HOMO and LUMO energy calculated by B3LYP/6-311G(d,p)/6-311++G(d,p) and HF/6-311++G(d,p) method are shown in Table 3.3. This electronic transition absorption corresponds to the transition from the ground to the first excited state and is mainly described by an electron excitation from the HOMO to the LUMO.The atomic compositions of the frontier MO are shown in Fig. 3.4. The calculated self-consistent field (SCF) energy of 4-MBC is -403.10 a.u.

Methods	B3LYP 6-311 G(d,p)	B3LYP 6-311++ G(d,p)
HOMO	-0.375	-0.370
LUMO	-0.202	-0.198
Energy Gap (ΔE)	-0.173	-0.166

Table 3.3 HOMO LUMO energy calculated by DFT methods
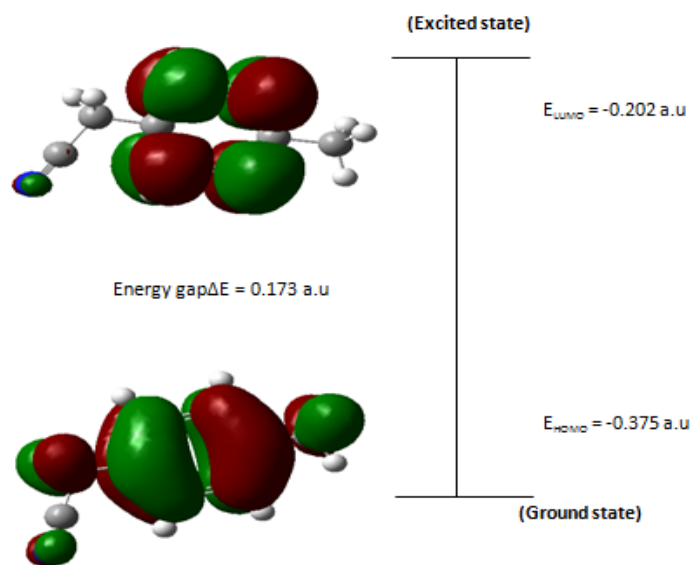
Fig. 3.4 HOMO, LUMO values of 4MBC under B3LYP/ 6-311 g(d,p) Methods

Mulliken Charges

The calculation of atomic charges plays an important role in the application of quantum mechanical calculations to molecular systems [16]. Our interest here is in the comparison of different methods to describe the electron distribution in 4-MBC as broadly as possible, and to assess the sensitivity of the calculated charges to changes in

(i) the choice of the basis set;

(ii) the choice of the quantum mechanical method.

Charges	HF / 6-311 ++G(d,p)	B3LYP / 6-311 G(d,p)	B3LYP / 6-311 G(d,p)
1C	−0.356	−0.035	−1.102
2C	0.152	−0.070	−0.454
3C	0.440	−0.096	0.579
4C	−0.971	−0.076	−0.456
5C	−0.573	−0.068	−0.010
6C	0.926	−0.143	1.136
7H	0.214	0.106	0.141
8H	0.214	0.090	0.167
9H	0.183	0.087	0.153
10H	0.201	0.083	0.157
11C	0.082	−0.081	−0.299
12H	0.197	0.173	0.155
13H	0.183	0.160	0.201
14C	−0.688	−0.255	−0.536
15H	0.158	0.133	0.167
16H	0.152	0.107	0.139
17H	0.152	0.115	0.139
18C	−0.312	−0.004	−0.062
19N	−0.360	−0.226	−0.217

Table 3.4 Calculated Mulliken charges of 4-MBC by HF and DFT methods
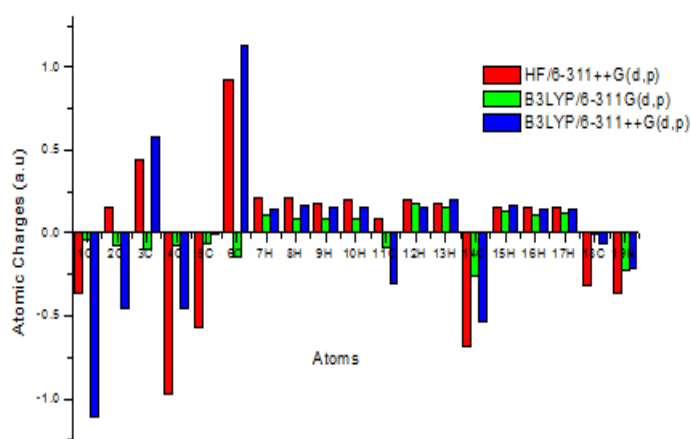
Fig. 3.5 Comparison of different methods for calculated atomic charges of 4-MABN

Mulliken charges are calculated by determining the electron population of each atom as defined in the basis functions. The Mulliken charges calculated at different levels and at different basis sets are listed in the Table 3.4. The results can, however, better be represented in graphical form as shown in Fig. 3.5. We have observed a change in the charge distribution by changing different basis sets. The Mulliken charges at the C_4 and C_{14} atoms show more negative and C_6 posses more positive charge.

Thermodynamic Properties

The calculated thermodynamic parameters are presented in the Table 3.5. Scale factors have been recommended [17] for an accurate prediction in determining the zero-point vibrational energies and the entropy S. The variation in the zero-point vibrational energies seems to be insignificant. The total energies are found to decrease with increase of the basis sets. The changes in the total entropy of 4-MBC at room temperature at different basis sets are only marginal.

Parameters	HF / 6-311 ++G(d,p)	B3LYP / 6-311 G(d,p)	B3LYP / 6-311 G(d,p)
Total Energies (a.u)	-400.47	-403.10	-403.12
Zero point energy (kcal / mol)	103.14	96.64	96.62
Rotational constants (GHz)	3.74	3.93	3.93
	0.71	0.71	0.71
	0.65	0.61	0.61
Entropy (cal/mol/K)			
Total	97.67	99.79	99.74
Translational	40.52	40.52	40.50
Rotational	29.60	29.60	29.58
Vibrational	27.54	29.66	29.66
Dipole moment (D)	4.56	4.16	4.15

Table 3.5 Theoretically computed energies, zero-point vibrational energies, rotational constants, entropies and dipole moment for 4-NTA

4. Conclusion

The spectral studies such as FT-IR, FT-Raman for 4-MBC was carried out for the first time. Minimum energy conformational analysis was carried out by using B3LYP/6-311++G(d,p) method. A complete vibrational and molecular structure analysis has been performed based on the quantum mechanical approach by *ab initio* HF and DFT (B3LYP) calculations. The calculated absorption maxima values at *ab initio* DFT (B3LYP) level almost correlate with the experimental value. HOMO and LUMO

orbitals have been visualized. Finally the atomic charges, thermodynamic properties and energy band gap have also been determined.

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Stabilization of Superparamagnetic Iron Oxide Nanoparticles by Polysaccharides: Prepartion, Characterization and Magnetic Studies

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Abstract

Super paramagnetic iron oxide (SPION) with appropriate surface chemistry has been extensively used for numerous applications. In this study, SPION stabilized by different polysaccharides and are prepared by co-precipitation method. The structure, size, morphology, magnetic property of the SPION-polysaccharide is characterized systematically by means of XRD, FTIR, UV-VIS, HRSEM, HRTEM and VSM respectively. The results revealed that Fe_3O_4 is encapsulated by polysaccharides and the average particle size obtained from the HRTEM micrographs is 5, 6 and 8 nm for the Glucose - Fe_3O_4 (GF), Fructose- Fe_3O_4 (FRF) and Sucrose- Fe_3O_4 (SUF) respectively. The saturation magnetization Ms= 38.43 emu/g of FRF was much lower than that of GF (M_s = 41.69 emu/g) and SUF (M_s = 42 emu/g). This high M_s may be due to the binding of Fe_3O_4 nanoparticles to polysaccharides macromolecule strands as visually confirmed by HRTEM. The SPION-polysaccharide exhibited an extremely small hysteresis loop and low coercivity.

Keywords: SPION, Glucose, Fructose, Sucrose

1. Introduction

The study of SPION material is one of the most important research and development frontiers in modern science. In order to improve the stability of nanomaterials, Nanotechnology is now widely used in the pharmaceutical industry, medicine, electronics, robotics, and tissue engineering. The use of super paramagnetic iron oxide nano (SPION) materials offers many advantages due to their unique size and physical properties [1] such as super paramagnetism, low toxicity and small size, etc. Many stabilizers, including solvents such as hexane and decane [2-3] are presently in use. Nanoparticles have been used to deliver drugs to target tissues and to increase stability against degradation by enzymes. The superparamagnetic nanoparticle is one of this material, which can be manipulated by an external magnetic field that can lead to the target tissue [4]. Based on their unique mesoscopic physical, chemical, thermal, and mechanical properties, super paramagnetic nanoparticles offer a high potential for several biomedical applications [5-7].

One of the most widespread techniques used to synthesize iron oxide is co-precipitation. In this process, nanoparticles are obtained by the addition of a base (such as NaOH, KOH,) to an aqueous solution of iron salts under vigorous stirring in the presence of inert gas (especially nitrogen) atmosphere [8,9]. The synthesis procedure is easier and the yield is more than other techniques such as thermal decomposition, hydrothermal reaction, micro emulsion [10]. The Fe_3O_4 is ferromagnetic in nature. Spinel structure of magnetite has the oxygen anions forming face center closed packing queue with iron located at the interstitial and octahedral sites.

In this paper, three polysaccharides (Glucose, Fructose and Sucrose) which are used individually as stabilizers during the synthesis of super paramagnetic iron oxide (SPION) in order to improve the stability, biocompatibility and biodegradability are reported. This work is focused on the preparation of the polysaccharide-Fe_3O_4 nanoparticles and characterization of them using FT-IR spectroscopy, X-ray diffractometry, UV-VIS, SEM, High resolution transmission electron microscopy (HRTEM) and Vibrating Sample Magnetometers (VSM) testing of magnetic properties.

2. Materials and Methods

Glucose, Fructose and Sucrose were obtained from Fishur Scientific, India. The reagents, including $FeCl_3 \cdot 6H_2O, FeSO_4 \cdot 7H_2O, NH_3H_2O$ and ethanol were of analytical grade from Fishur Scientific, India.

A polysaccharide (Glucose, Fructose and Sucrose) of 1.2g was added to 200 ml distilled water. The mixture was heated at $90°$ C for about 10 min with constant stirring

for dissolution of the polysaccharide. The solution was subsequently cooled to the room temperature and $FeCl_3 \cdot 6H_2O$ (1.49 g) and $FeSO_4 \cdot 7H_2O$ (0.765 g) were added into the solution, which was then heated at 60° C under nitrogen atmosphere. An ammonia-water solution (8 mol / l) was added dropwise and a suspension was obtained. The pH of the final mixture was controlled in the range of 10. The mixtures were heated at 60° C for 4 h and the suspension was then centrifuged at 10,000 rpm for 10 min. The settled polysaccharide-Fe_3O_4 was washed three times using distilled water to remove byproducts and excess polysaccharides. The polysaccharide-Fe_3O_4 particles were then washed two times with distilled water and then with ethanol. The obtained hybrids were dried in an oven at 100° C for 3 h and labelled as GF, FRF and SUF, respectively.

The crystal structure of the products was characterized by X-ray Diffraction (XRD) Bruker Model: D8 advance diffractometer with Cu Kα radiation (1.5406 Å) operating at 40 kV and 30mA. The IR spectra were obtained using a BRUKER10049391 IR Spectrometer instrument at room temperature in the 4000-400 cm^{-1} range. The UV visible spectra of the sample were taken in wavelength range from 200 to 2500 nm using Varian cary 5000 spectrophotometer. The morphology of the Fe_3O_4 materials were examined by Scanning Electron Microscope-Energy Dispersive X Ray Spectrometry (SEM) JEOL-JSM-6390 LV. High resolution transmission Electron Microscope (HR-TEM) JEOL JEM 2100 was used for characterizing the size of nanoparticles. The magnetic properties of the Fe_3O_4 materials were studied by Vibrating Sample Magnetometers (VSM) Lakeshore 7410 at room temperature.

3.   Results and Discussion

XRD Analysis

The powder XRD patterns of GF, FRF and SUF are shown in figure 1. All the peaks of XRD patterns were analyzed and indexed using ICDD data base (JCPDS No.82-1533), comparing with magnetite standards [11, 12]. The lattice constant a was found to be 8.310 Å, which was compared with the lattice parameter of magnetite (8.39 Å.) Finally, the analysis of the diffraction pattern showed the formation in the sample of a cubic spinel structure, due to the strongest reflection that proceeds from the (311) plane, characteristic of such a phase [13].

The peaks indexed as planes (220), (311), (400), (333) and (440) corresponded to a cubic unit cell, characteristic of a cubic spinel structure [14,15]. Therefore, it was confirmed that the crystalline structure of obtained magnetite nanoparticles, agreed with the structure of an inverse spinel type oxide. Crystallite size measurements were determined from the full-width at half maximum (FWHM) of the strongest reflection of the (311) peak, using the Scherrer approximation, which assumes the small crystallite

size to be the cause of line broadening

$$D_N = K\lambda / \beta \cos\theta \qquad (1)$$

here, D_N is the crystallite mean size, k is a shape function for which a value of 0.9 is used, λ is the wavelength of the radiation, β the full width at half maximum (FWHM) in radians in the 2θ scale, and θ the Bragg angle. The crystallite size calculated employing Debye-Scherer formula was 3.4, 5.2 and 4.8 nm for GF, FRF and SUF respectively.
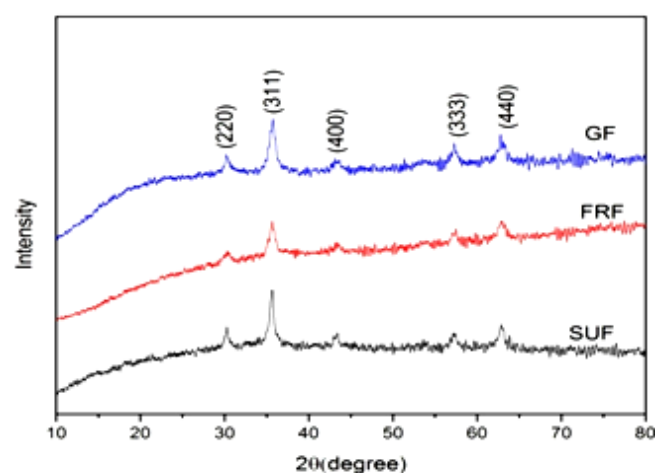
Fig. 1 X-diffraction pattern of GF, FRF and SUF

FTIR Analysis

Fig.2 shows the FTIR spectra of FRF, GF and SUF. In the ?ngerprint region of the fructose there were three peaks characteristic of -C-O- stretching. The peak at 1163 cm^{-1} was ascribed to C-O bond stretching of the C-O-H group, and the two peaks at 1527 and 1020 cm^{-1} were attributed to C-O bond stretching of the C-O-C group in the anhydroglucose ring [16]. In FTIR spectra of FRF, there was a high intensity broad band at around 629 cm^{-1}, due to the Fe_3O_4 peak [17]. The -C-O- stretching peaks of fructose shifted in the presence of Fe_3O_4 indicating that an interaction existed between the fructose and Fe_3O_4 in FRF, but no obvious covalent bonds were formed [18]. The absorption bands between 1000 and 1200 cm-1 were characteristic of -C-O- stretching on a polysaccharide skeleton in the FTIR spectra of Sucrose and Glucose. In the FTIR spectra of SUF, the two peaks appearing at 1522 and 1382cm^{-1} corresponded to the symmetrical and asymmetrical stretching vibrations of the carboxylate groups [19], while Glucose FTIR spectra shows the peak at 1635cm^{-1} which was due to stretching of the conjugated peptide bond formed by amine (NH) and acetone (CO) groups[20]. The above-mentioned peaks of Sucrose and Glucose are also shifted and the characteristic

peak of Fe_3O_4 at 578 and $626 cm^{-1}$ appeared in FTIR spectra of FRF and GF, indicating that there was an interaction between Fe_3O_4 and SUF.
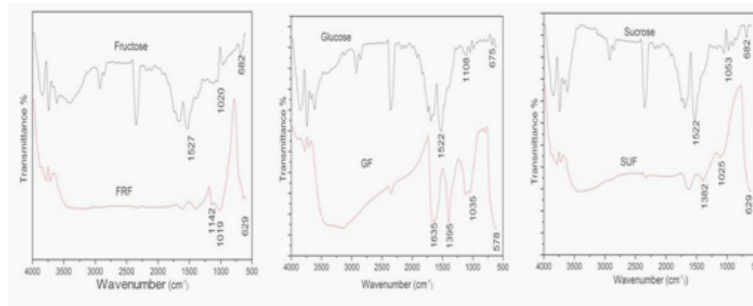
Fig. 2 FTIR spectra of FRF, GF and SUF

UV-Optical Properties Analysis

The UV-Vis absorption spectra were studied to investigate Polysaccharide doping effect on magnetite nanoparticles optical properties such as optical absorption and band gap (Figure 3). Due to the presence of Glucose, Fructose and Sucrose Polysaccharide sharp absorption edges appear in this region due to light absorption and scattering by nano-particles.
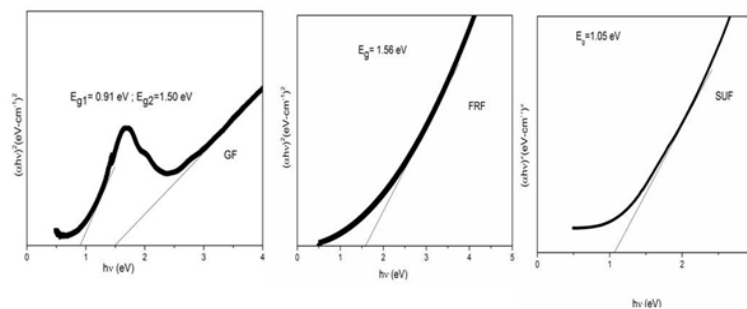
Fig. 3 Plots of $(\alpha h v)^2$ versus $h v$ - direct transition for GF,FRF and SUF

As demonstrated, pure Fe_3O_4 NPs do not reveal sharp absorption edges in UV region. As doping increases optical absorption decreases that reflects the presence of different Polysaccharide (Glucose, fructose and sucrose) incorporation in Fe_3O_4 lattice. Indirect band gap of the nanoparticles are calculated by Tauc equation

$$\alpha h v = A(h v - Eg)^2 \tag{2}$$

where α is the absorption coefficient, A is a constant, h is Planck's constant, v is the photon frequency and E_g is the energy [21]. In Tauc equation; when $\alpha h v = 0, h v = E_g$.

So E_g might be calculated by plotting a diagram of $(\alpha h v)^{1/2}$ versus hv and then extrapolating their linear region (Figure 3). Band gap studies reveal that Eg value in different Polysaccharide (Glucose, fructose and sucrose) doped Fe_3O_4 nanoparticles is higher that of pure Fe_3O_4. Based on literature, indirect band gap of Fe_3O_4 is 0.1 eV [22]. As doping percent increases, indirect band gap value decreases from SUF=1.05 eV, GF= 0.91 eV to 1.50 eV and FRF= 1.56 eV.

HRSEM Analysis

The surface morphologies of the prepared GF, FRF and SUF were studied using high resolution scanning electron microscope, as shown as in Figure 4. HRSEM images of Fe_3O_4, in the picture appear that Fe_3O_4 particles composed of small crystalline from which it was observed the size as 5-10 nm. Fe_3O_4 synthesized by co-precipitation with different reagent ($FeCl_3 \cdot 6H_2O$, $FeCl_2 \cdot 4H_2O$, propylene glycol and ammonium hydroxide) indicated the mean size of particles was 8 nm [23]. The control of the monodisperse size was very important because the properties of nano crystal strongly depend upon the dimension of nanoparticles [24].
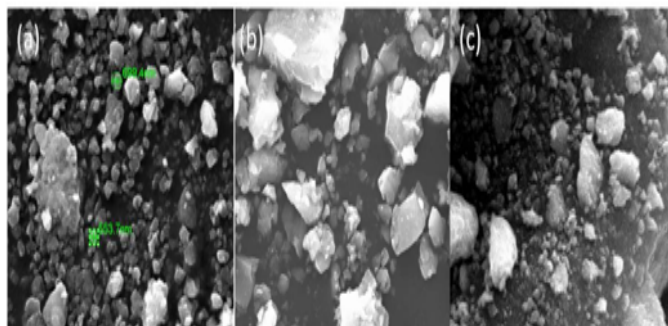
Fig. 4 HRSEM images of Fe_3O_4 nanoparticles (a) GF b) FRF (c) SUF

TEM -Analysis

The image of central black spot and the light-colored edge shown in figure 5 represent Fe_3O_4 nanoparticles and polysaccharides, respectively, clearly showing that the Fe_3O_4 nanoparticles were encapsulated by polysaccharides. It was clearly observed that the magnetite nanoparticles exhibit aggregation indicates that the nanoparticles have a semispherical shape and was monodispersed. The average particle size obtained from the HRTEM micrographs was 5, 6 and 8 nm for GF, FRF and SUF. Since polysaccharides could form hybrids with metal ions, due to their high number of coordinating functional groups (hydroxyl and glucoside groups) [25], it was likely that the majority of the iron ions closely associated with the polysaccharide molecules; therefore nucleation and initial crystal growth of Fe_3O_4 may have occurred preferentially on polysaccharides. In addition, polysaccharides present interesting

dynamic supramolecular associations facilitated by inter and intra-molecular hydrogen bonding, which could act as templates for the growth of nanoparticles [26]. SUF nanoparticles exhibited an approximately spherical morphology with a mean size of less than 5 nm in GF, while SUF and FRF nanoparticles were larger. This may be related to the polysaccharide structures, sucrose was mainly composed of branched amylopectin, while Glucose and Fructose contain a more linear-polysaccharide structure in aqueous solution. Sucrose formed more interactions with iron ions than Glucose and Fructose that exerted more restriction on the growth of Fe_3O_4 particles.
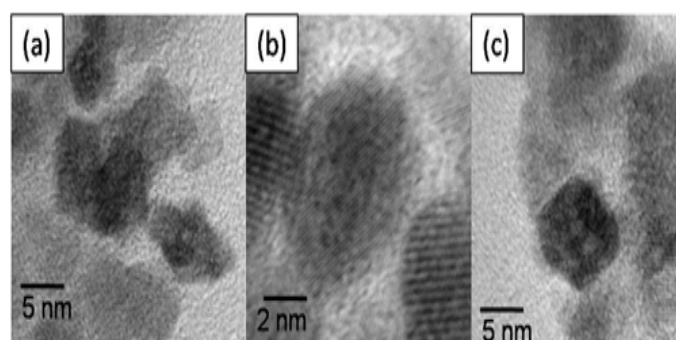
Fig. 5 HRSEM images of Fe_3O_4 nanoparticles (a) GF b) FRF (c) SUF

Magnetic Properties

Figure 6 shows the magnetization of SUF, GF and FRF as a function of the applied magnetic field at 300 K. Magnetization increased with an increase in the magnetic field.
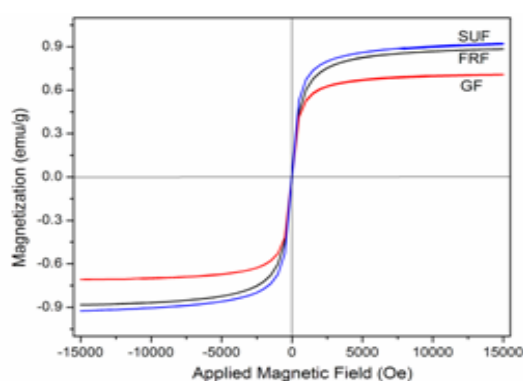
Fig. 6 Magnetization curves of SUF,GF and FRF

The saturation magnetism (M_s) was 42 emu/g, remanence (M_r) was 0.0098 emu/g, and the coercivity (H_c) was 9.13 Oe for SUF; M_s was 41.69 emu/g, Mr was 0.0004 emu/g,

and H_c was 0.55 Oe for GF; and for FRF M_s was 38.43 emu/g, σr was 0.004 emu/g and H_c was 4.42 Oe. GF exhibited extremely small hysteresis loop and low coercivity, which was typically a characteristic of super paramagnetic particles.

In the case of SUF and FRF, both exhibited larger hysteresis loops and coercivity, further confirming that the Fe_3O_4 particle size of GF was smaller than those of SUF and FRF [27]. This was also consistent with the findings from TEM and XRD. As a conventional magnet for magnetic separation, SUF, GF and FRF possessed reasonably good saturation magnetization, although the saturation magnetization (38.43 emu/g) of FRF was much lower than that of GF (41.69 emu/g) and SUF (42 emu/g). Polysaccharide-Fe_3O_4 with super paramagnetic properties would therefore be promising material biological engineering and biomedical applications.

4.   Conclusion

The superparamagnetic iron oxide (SPION) was synthesized in the presence of various Polysaccharide templates. Fructose, Glucose, and Sucrose were very important Polysaccharide that plays stabilization role in the synthesis of Fe_3O_4 nanoparticles. It is evident from FTIR spectra that there was a good interaction between Fe_3O_4 and polysaccharide functional groups. TEM and XRD confirmed that SUF exhibited a smaller size than FRF and GF. In addition, SUF, FRF and GF possessed reasonably good saturation magnetization, although SUF and FRF had slightly larger hysteresis loops and coercivity. Using the technique described in this study, polysaccharide (Fructose, Glucose, and Sucrose) can be enforced for stabilizing the magnetic properties. Secondly, it can be used as porous polysaccharide materials for the removal of hazardous substances by magnetic separation. Many interesting and potential applications for polysaccharide-Fe_3O_4 nanoparticles are to be further explored.

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Dielectric Polarization Studies of H-Bonded Complexes of Alkyl Methacrylate with O-Substituted Benzoic Acids

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Abstract

The dipole moment of the 1:1 complexes of alkyl methacrylate *(Methyl methacrylate, Ethyl methacrylate and Butyl methacrylate) with orthosubstituted benzoic acid (2-Fluro benzoic acid, 2-Iodo benzoic acid, 2-Chloro benzoic acid, 2-Bromo benzoic acid, and 2-Nitro benzoic acid)* at 303K have been determined by using Huysken's method based on the Onsager theory. The dipolar increments of the systems were computed from the bond angle data available from molecular orbital theory. The enhancement of the dipole moment values confirms the hydrogen bonding between all the systems.

Keywords: H-bonding; Dipolar increment; Polarization effects; Alkyl metha crylates, orthosubstituted benzoic acid.

1. Introduction

Hydrogen bonding, in general, is recognized as a specific interaction between an A-H bond of one molecule, described as the proton donor and an atom B of another molecule, described as proton acceptor. The broad classifications of the methods to study H-bonding are chemical, crystallographic, spectroscopic and theoretical.The chemical methods are mainly concerned with the thermodynamic properties like enthalpy, entropy, heat of mixing, etc. The crystallographic studies are mostly related to the conformation of the structure in H-bonded systems by X-ray, neutron diffraction and electron diffraction methods.The spectroscopic effects consider the physical aspects of H-bonding like molecular potentials, barrier to internal rotation, the vibrational energies of the bonds which are modified by the potential field, etc.Dielectric studies of interacting solutes in an inert solvent provide valuable information regarding molecular complex formation in solution. In hydrogen bonding of proton donor-acceptor complexes, a redistribution of electron density takes place and the dipole

moment of the H-bonded systems is no more additives [1-3].

The most important characteristic of the hydrogen bond is the increase in the distance of O-H accompanied by the enhancement of the bond moment $\Delta\mu$ [4]. The dipole moment ab of the complex does not exactly correspond to the vector addition of the moment's aand bof the separated compounds due to the charge separation. The earliest authors to study this problem were Smith and coworkers [5] the determination of the dipole moment will indicates the type of complex, since the dipolar increment is a function of pKa. Pioneering work in this area was done by Sobczyk and his coworkers [6] and Huyskenset. al. [7]. The excess dipole moment in many O-H. . . N and O-H. . . O complexes is due to either polarization effect [8] or charge transfer effect [9] or partial proton transfer effect [10] or complete proton transfer effect [11]. The reaction field effect of the environment is also a major cause of the change in dipole moment of the complexes in a polar medium [12]. From IR spectral studies, Malarski et al. [13] showed that the plot of μ versus Δ PKa is sigmoidal and is quite general for many O-H—N and O-H—O bonds indicating a shift from normal complexation to proton transfer complexation. Excellent reviews have appeared on the nature of such complexes [14].

A survey of literature showed that the complexing ability of Ortho substituted benzoic acids with Alkyl methacrylate was not studied especially with reference to the dipole moment changes that accompany such complexation. We report here the results of our investigation on the H-bonded complexes of Ortho substituted benzoic acids with Alkyl methacrylate in 1, 4 - Dioxane.

2.   Materials and Methods

E- Merck variety of Methyl methacrylate, Ethyl methacrylate, Butyl methacrylate and 1, 4 - Dioxane And 2 -Fluro benzoic acid, 2- Iodo benzoic acid, 2 -Chlorobenzoic acid, 2 - Bromo benzoic acid, 2 - Nitrobenzoic acid were purchased from sigma Aldrich. Chemicals were used without purification. The static dielectric constants where measured by heterodyne beat method at room temperature using a commercial instrument, Dipole meter (supplied by Mittal enterprises - New Delhi). The refractive indices were measured using Abbe's refractometer. Densities were determined using a 10-ml specific gravity bottle and aK-Roy microbalance.The uncertainties in the measurement of dielectric constants, refractive indices and densities were 0.0005, 0.0002 and 0.0001g/cm^3 respectively.

Theory

Huyskens et al. [15] have developed a method to obtain the overall dipole moment of a system of solute-solvent mixtures. The method is well suited for ternary mixtures

of two polar components A (donor) and B (acceptor) in an apolar solvent in the liquid phase, where a great mobility is envisaged. Using the Onsager theory [16], the overall dipole moment [M] of a solution containing polar substances and an apolar solvent (subscript-S) is given by

$$M^2 = \frac{9KTv}{4\pi} \left[\frac{(\varepsilon - n_D^2)(2\varepsilon + n_D^2)}{\varepsilon_0 (n_D^2 + 2)^2} - \frac{C_S}{\overline{C_S}} \frac{(\varepsilon_0 - n_D^2)(2\varepsilon_s + n_D^2)}{(n_D^2 + 2)^2} \right] \quad (1)$$

Where C_s is the actual concentration of the polar solvent in the solution and $\overline{C_s}$ is its concentration in the pure state, v is the molar volume of the solute. If μ_a, μ_b and μ_{ab} are the dipole moments of the proton donor, proton acceptor and their 1:1 complex, respectively and a and at concentrations where the self association of the polar components are negligible and the Kirkwood correlation factor of the individual components tends to unity, Huysken's showed that

$$M^2 = vN_A \left\{ \left(\overline{\mu}_{ab}^2 - \overline{\mu}_b^2\right) C_A + \overline{\mu}_b^2 C_B \right\} \quad (2)$$

where, CA and CB are the formal concentrations of the proton donor and acceptor, respectively. Comparing equations (1) and (2), we get

$$C_a\mu_a^2 + C_b\mu_b^2 + C_{ab}\mu_{ab}^2 = \frac{9KT}{4\pi N_A} \left(\frac{1}{C_B}\right) \times \left\{ \frac{(\varepsilon_0 - n_D^2)(2\varepsilon_0 + n_D^2)}{\varepsilon_0 (n_D^2 + 2)^2} \right.$$
$$\left. - \frac{C_s}{\overline{C_s}} \frac{(\varepsilon_s - n_D^2)(2\varepsilon_s + n_{Ds}^2)}{\varepsilon_s (n_{Ds}^2 + 2)^2} \right\} \quad (3)$$

The right hand side of equation (4) contains experimentally measurable quantities. Let us call it as Ω_B. It should be noted that if higher order complexes other than 1:1 like A_2B, AB_2 are present, the curve is no longer a straight line. This serves as the criterion for choosing the proper concentration C_A and C_B of the proton donor and proton acceptor for 1:1 complexation. If the formal concentration C_B of the proton acceptor is far greater than the formal concentration C_A of the proton donor such that

$$C_B - C_A \gg K^{-1} \quad (4)$$

where K is the equilibrium constant for 1:1 complexation, the above equation is valid. Thus, from the experimentally observed values of ε_0, n_D, s and n_{DS}, it is possible to obtain the values of Ω_B for different C_A/C_B values. A curve is plotted with C_A/C_B along the X axis and Ω_B along the Y-axis. Intercept of the curve in the Y-axis gives μ_b^2 and the slope of the curve gives $\mu_b^2 - \mu_{ab}^2$.

3. Results and Discussion

The values of dielectric constants at static (ε_0) and infinite (ε_∞) frequencies and Ω_B for varying concentrations of proton donor are recorded in table (1-3). The value of Ω_B is computed through the right hand side of equation (3).

$C_B Mol L^{-1}$	ε_0	n_D	d in g/cm^3	C_A/C_B	Ω_B
2-Bromo benzoic acid + Methyl methacrylate + 1,4-Dioxane					
0.12	3.4167	1.4717	0.8834	0.8333	8.9234
0.31	3.4232	1.4723	0.8745	0.3226	9.2345
0.53	3.4467	1.4727	0.8833	0.1887	9.9344
0.75	3.4656	1.4736	0.8912	0.1333	10.5676
0.93	3.4789	1.4743	0.8998	0.1075	11.6723
2-Chloro benzoic acid + Methyl methacrylate + 1,4-Dioxane					
0.14	3.4324	1.4725	0.8934	0.7143	9.2341
0.32	3.4476	1.4729	0.9067	0.3125	9.5432
0.51	3.4756	1.4731	0.9123	0.1961	10.1234
0.72	3.4867	1.4742	0.9198	0.1389	11.2341
0.92	3.4967	1.4749	0.9205	0.1087	12.3122
2-Iodo benzoic acid + Methyl methacrylate +1,4-Dioxane					
0.15	3.4532	1.4731	0.9045	0.6667	9.4352
0.34	3.4678	1.4735	0.9123	0.2941	9.6234
0.51	3.4856	1.4739	0.9198	0.1978	10.3123
0.76	3.4982	1.4748	0.9234	0.1316	11.3241
0.95	3.5123	1.4753	0.9305	0.1053	12.5432
2-Floro benzoic acid + Methyl methacrylate + 1,4-Dioxane					
0.14	3.4678	1.4735	0.9156	0.7143	9.5342
0.36	3.4738	1.4742	0.9189	0.2778	9.7456
0.52	3.4967	1.4747	0.9238	0.1923	10.4356
0.72	3.5123	1.4751	0.9368	0.1389	12.3456
0.91	3.5324	1.4759	0.9456	0.1099	13.2342
2-Nitro benzoic acid + Methyl methacrylate + 1,4-Dioxane					
0.17	3.5346	1.4740	0.9268	0.5882	10.2342
0.38	3.5567	1.4746	0.9345	0.2632	11.2341
0.59	3.5723	1.4753	0.9456	0.1695	12.3452
0.73	3.5823	1.4758	0.9509	0.1370	12.8567
0.95	3.5990	1.4763	0.9634	0.1053	13.2341

Table. 1 Value of dielectric Constant, density, refractive index, ratio of formal concentration and Ω_B (Ortho substituted benzoic acids with Methyl methacrylate in 1,4-Dioxane)

$C_B Mol L^{-1}$	ε_0	n_D	d in g/cm^3	C_A/C_B	Ω_B
2-Bromo benzoic acid + Ethyl methacrylate + 1,4-Dioxane
0.15	3.4362	1.4722	0.9045	0.8667	9.0782
0.34	3.4456	1.4732	0.9089	0.3824	9.3456
0.56	3.4578	1.4742	0.9145	0.2321	10.2312
0.73	3.4789	1.4755	0.9167	0.1781	10.6784
0.96	3.4891	1.4761	0.9178	0.1354	11.7894
2-Bromo benzoic acid + Ethyl methacrylate + 1,4-Dioxane
0.14	3.4546	1.4731	0.9147	1.0062	9.3456
0.32	3.4634	1.4739	0.9234	0.3421	9.6234
0.51	3.4956	1.4742	0.9345	0.2281	10.3456
0.72	3.5089	1.4752	0.9456	0.1711	11.7891
0.92	3.5123	1.4761	0.9578	0.1398	12.5678
2-Iodo benzoic acid + Ethyl methacrylate +1,4-Dioxane
0.11	3.4623	1.4739	0.9267	1.1818	9.5678
0.36	3.4789	1.4748	0.9378	0.3611	9.7891
0.57	3.4934	1.4755	0.9456	0.2281	10.4235
0.73	3.5069	1.4762	0.9578	0.1781	11.5672
0.92	3.5345	1.4778	0.9783	0.1413	12.6789
2-Floro benzoic acid + Ethyl methacrylate + 1,4-Dioxane
0.16	3.4756	1.4742	0.9356	0.8125	9.6789
0.37	3.4834	1.4754	0.9478	0.3514	9.8563
0.53	3.5045	1.4763	0.9578	0.2453	10.5674
0.74	3.5297	1.4773	0.9634	0.1757	12.5672
0.92	3.5487	1.4786	0.9834	0.1340	13.3456
2-Nitro benzoic acid + Ethyl methacrylate + 1,4-Dioxane
0.15	3.5477	1.4749	0.9456	0.8667	10.8673
0.31	3.5689	1.4758	0.9657	0.4194	11.3456
0.52	3.5856	1.4769	0.9789	0.2500	12.4567
0.75	3.5957	1.4779	0.9879	0.1733	13.1230
0.91	3.6123	1.4792	0.9950	0.1429	13.3678

Table. 2 Value of dielectric Constant, density, refractive index, ratio of formal concentration and Ω_B (Ortho substituted benzoic acids with Eethyl methacrylate in 1,4-Dioxane)

$C_B Mol L^{-1}$	ε_0	n_D	d in g/cm^3	C_A/C_B	Ω_B
2-Bromo benzoic acid + Butyl methacrylate + 1,4-Dioxane					
0.18	3.4478	1.4786	0.9156	0.8345	9.1672
0.36	3.4589	1.4813	0.9256	0.4167	9.4892
0.52	3.4768	1.4834	0.9324	0.2885	10.4567
0.75	3.4892	1.4878	0.9412	0.2000	10.8965
0.91	3.5134	1.4889	0.9479	0.1648	11.9763
2-Chloro benzoic acid + Butyl methacrylate + 1,4-Dioxane					
0.15	3.4648	1.4798	0.9178	1.0034	9.4567
0.31	3.4756	1.4824	0.9298	0.4839	9.7234
0.52	3.5078	1.4842	0.9369	0.2885	10.5689
0.73	3.5145	1.4881	0.9512	0.2055	11.9234
0.94	3.5267	1.4892	0.9934	0.1596	12.7234
2-Iodo benzoic acid + Butyl methacrylate +1,4-Dioxane					
0.13	3.4698	1.4812	0.9289	1.1538	9.7865
0.37	3.4834	1.4832	0.9390	0.4054	9.8345
0.54	3.5123	1.4857	0.9485	0.2778	10.7892
0.70	3.5278	1.4895	0.9645	0.2143	12.3456
0.99	3.5421	1.4899	0.9879	0.1515	12.8321
2-Floro benzoic acid + Butyl methacrylate + 1,4-Dioxane					
0.11	3.4798	1.4823	0.9398	1.3636	9.8976
0.33	3.4856	1.4842	0.9496	0.4545	9.9567
0.56	3.5234	1.4868	0.9599	0.2679	10.9678
0.77	3.5356	1.4899	0.9689	0.1948	12.6789
0.91	3.5589	1.4902	0.9902	0.1648	13.4561
2-Nitro benzoic acid + Butyl methacrylate + 1,4-Dioxane					
0.12	3.5498	1.4834	0.9468	1.2501	10.9123
0.34	3.5756	1.4856	0.9673	0.4412	11.5678
0.55	3.5934	1.4877	0.9798	0.2727	12.5672
0.72	3.6023	1.4923	0.9889	0.2083	12.3456
0.97	3.6234	1.4945	0.9997	0.1546	13.5678

Table. 3 Value of dielectric Constant, density, refractive index, ratio of formal concentration and Ω_B (Ortho substituted benzoic acids with Butyl methacrylate in 1,4-Dioxane)
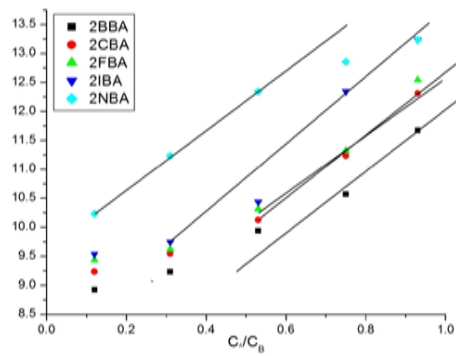
Figure. 1 Plot of Ω_B vs C_A/C_B for 2-Substituted benzoic acids + Methyl methacrylate + 1, 4-Dioxane
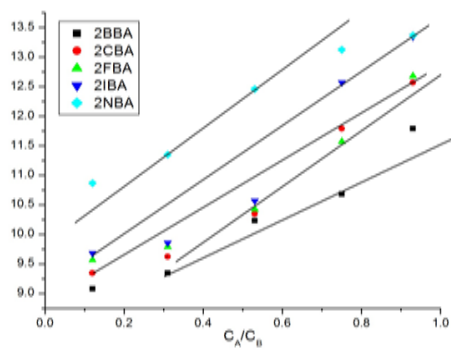
Figure. 2 Plot of Ω_B vs C_A/C_B for 2-Substituted benzoic acids + Ethyl methacrylate + 1, 4-Dioxane
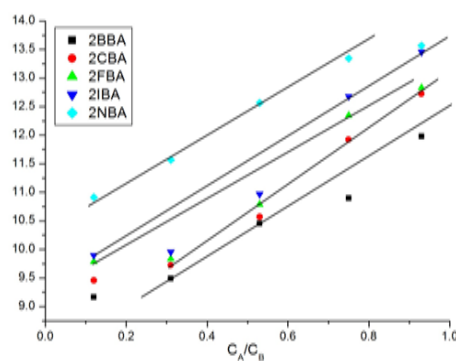
Figure. 3 Plot of Ω_B vs C_A/C_B for 2-Substituted benzoic acids + Butyl methacrylate + 1, 4-Dioxane

Using least square fitting method, (C_A/C_B) is plotted against Ω_B. From the slopes and intercepts of the graph (Fig.1- 3), values of μ_{ab} and μ_b were evaluated.

Calculation of Dipolar Increment

The vectorial relation for the dipole moment of the complex and its partners and the dipolar increment as discussed by Huyskens [15] is given in Fig. 4.
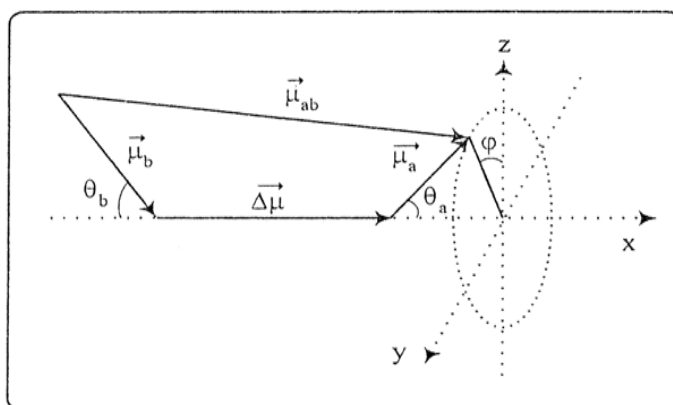
Figure. 4

When a proton donor of dipole moment forms aa H-bond with a proton acceptor of dipole moment μ_b the direction μ_a and μ_b with respect to the A-H—- B axis can be defined by θ_a and θ_b, respectively. If θ_a and θ_a, differ from 0, one can define the azimuthal angle ϕ which describes the rotation position of μ_b around the H-bond with respect to the plane formed by this bond and μ_b. The formation of the H-bond is accompanied by the dipole moment of nuclei involved in H-bonding and the displacement of the electron. As a consequence the dipole vector of the complex is different from the vector sum and may be given by a dipolar increment.

$$\overrightarrow{\mu_{ab}} = \overrightarrow{\mu_a} + \overrightarrow{\mu_b} + \Delta\mu \tag{5}$$

If a single H-bond is formed between the partners, it can be presumed that has the direction of the hydrogen bond. The vector equation can be transformed in the form

$$\Delta\overrightarrow{\mu} = \left[\overrightarrow{\mu_{ab}}^2\,\overrightarrow{\mu_a}^2 \sin^2\theta_a - \overrightarrow{\mu_b}^2 \sin^2\theta_b - 2\overrightarrow{\mu_a}\overrightarrow{\mu_b} \sin\theta_a \sin\theta_b \langle\cos\varphi\rangle\right]^{\frac{1}{2}}$$
$$-\overrightarrow{\mu_a}\cos\theta_a - \overrightarrow{\mu_b}\cos\theta_b \tag{6}$$

The mean value of $\langle\cos\varphi\rangle$, was found to be - 0.5 for O-H—-O bonds [15]. Ab initio calculations for H bond complexes [17] involving O-H—O=C bonds, showed that conformation with θ_b, approximately $60°$ are the most stable.

Using these data, we have calculated the dipolar increment for all ortho substituted benzoic acids - Alkyl methacrylate complexes, vecto-rially. The bond angle θ_a, the measured dipole moment values of proton donor, proton acceptor and the complexes and the calculated values of the dipolar increments of the ortho substituted benzoic acids are given in Table 4.

Donors	θ_a	μ_a	Methyl Metacrylate			Ethyl Metacrylate			Butyl Metacrylate		
			μ_b	μ_{ab}	$\Delta\mu$	μ_b	μ_{ab}	$\Delta\mu$	μ_b	μ_{ab}	$\Delta\mu$
2-Bromo Benzoic acid	25	1.87	3.78	5.73	0.076	3.88	6.23	0.391	4.12	6.89	0.934
2-Chloro Benzoic acid	25	1.88	3.81	5.97	0.312	3.90	6.31	0.594	4.24	7.23	1.023
2-Iodo Benzoic acid	30	2.15	4.21	7.34	1.034	4.78	8.12	1.234	4.98	9.08	2.045
2-Floro Benzoic acid	35	2.28	4.38	8.12	1.342	5.09	9.23	1.987	5.56	10.45	2.349
2-Nitro Benzoic acid	40	3.23	5.23	11.34	2.891	5.56	11.89	3.234	6.12	12.52	3.238

Table. 4 Dipole moment value of acceptor (μ_a), donor (μ_b) complex (μ_{ab}) and dipolar increments of the 1:1 complexes $(\theta_b = 60°)$

4. Conclusion

When a proton donor of dipole moment a is mixed with a proton acceptor of dipole moment μ_b in a non-polar solvent, a complex may be formed. The dipole moment may be enhanced by an amount $\Delta\mu$. The magnitude of $\Delta\mu$ determines the nature of complexation. The complexation may be either due to polarization effects or charge transfer effects. For the range of concentrations studied, the plot of Ω_B with C_A/C_B is a straight line. This indicates the formation of a 1:1 complex. Computed values of $\Delta\mu$ are reported in Table 4.

Values of $\Delta\mu$ are found to be small and positive. This explains the absence of charge transfer effects. If charge transfer effect exist, then $\Delta\mu$ would have been greater than 10D [18-19]. Since $\Delta\mu$ is small and less than 10 D, the complexation may be only due to the redistribution of electrons due to polarization effects. Similar conclusions were drawn [20] for the mixture of phenols with substituted piperidines. Similar results were reported by Thenappan [21] and Sabesan [22] for the alcohol mixtures.

The value of μ_{ab} and $\Delta\mu$ increase in the order of Butyl methacrylate > Ethyl methacrylate > Methyl methacrylate. The increase μ_{ab} and $\Delta\mu$ in may be due to the

increase in effective radius of the rotating unit. The observed higher value of butyl methacrylate (BMA) can be attributed to the large size of BMA molecule in comparison to methacrylate (MMA) molecules.

The dipolar increments $\overrightarrow{\Delta\mu}$ reported for all the systems studied here indicated that neither the charge transfer theory nor the polarization theory would be sufficient to describe the nature of the interactions. Our results show that the mechanism of charge transfer is not restricted to the bonding site only. The whole molecule seems to be influenced by the dipolar interactions. The results canbe interpreted on the basis of the existence of a tautomerism between two forms of H-bonding, i.e. the normal or electrostatic one where the proton is more in the vicinity of a A nucleus and the other where the proton jumped to a position near the B nucleus, the second one giving rise to a large dipolar increment. the equilibrium between these two types depends on the scidity of the proton donor.

The dipolar increment increases with increasing acidity of proton donor in complex system. The dipolar increments of alkyl methacrylate with 2 - Nitro benzoic acid is greater than that of alkyl methacrylate with other ortho substituted benzoic acid complex, which is due to peripheral effect and greater inductive effect. Our results shows that the mechanism of charge transfer is not restricted to the bonding site only. The whols molecules seems to be influenced by the dipolar interactions The dipolar increments of the substituted benzoic acid is increases in the order 2-Nitro benzoic acid NO_2 > 2-Floro benzoic acid > 2-Iodo benzoic acid > 2-Chloro benzoic acid > 2-Bromo benzoic acid.

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FT-Raman and FT-IR Spectra, NBO Analysis, *ab initio* and Density Functional Studies of 4 cyanothioanisole

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Abstract

The optimized molecular structure, vibrational frequencies, corresponding vibrational assignments and thermodynamic properties of 4-cyanothioanisole (4CTA) have been investigated by using *ab initio* HF/6-311G(d,p) and DFT/B3LYP method at 6-311G(d,p) and 6-311++G(d,p) basis sets. The energy and oscillator strength calculated by TD-DFT method. The computed 1H and 13C NMR calculations of the 4 CTA molecule were carried out by using B3LYP functional with 6-311G(d,p)and 6-311++ G(d,p)basis set and also HF with 6-311++G(d,p)basis set. Moreover, we have not only simulated HOMO and LUMO, but also determined the transition state and energy band gap. The stability of the molecule arising from hyperconjugative interaction and charge delocalization has been analyzed using natural NBO analysis. Mulliken charges of 4CTA are also calculated. IR and Raman intensities have also been reported.

Keywords: B3LYP, HOMO, LUMO, NBO, NMR.

1.   Introduction

Anisole is an aromatic compound containing an ether group. The IUPAC name of thioanisole is methyl phenyl sulphide. Its molecular formula is $C_6H_5SCH_3$. Its molecular weight is 124.20. Anisole and its derivatives are used as solvents and in perfumery, insect repellant, oxicide,photo indicators and agrochemicals. Decontamination of toxic chemicals [1, 2] is done by oxidation of thioanisole.The title is about 4-cyanothioanisole used as solvent of both extraction and reaction as well as an intermediate for the synthesis of textile chemicals, pharmaceuticals and agrochemicals.

Anisole, anisic acid and their derivatives are widely used in chemical reaction as intermediates to obtain target materials such as dyes, pharmaceuticals, perfumes, photo initiators and agrochemicals. Spectroscopic investigation of anisole [3, 4] and

its derivatives have received considerable attention as the former is a representative model compound for a number of chemically and biologically interesting systems. For example, the wood constituent ligin contains units of the methoxyphenyl type [5], structure-activity relationships of one-ring psychotomimetics depend on the number of methoxyphenyl substituents [6] and their orientation is known to be of importance for their pharmacological properties [7].

Agathe etal., [8] discovered a reaction for new thio substituted compounds. The minimum energy structures were fully utilized and the MP2 method was used to analyze the DFT results. The equilibrium geometries IR and Raman scattering intensity were computed using the Gaussian 03 package.

Many attempts have been made to study the various types of spectra arising from anisole and its substituents. Information from various sources shows that DFT calculation on 4-acetyl thioanisole have not been reported so far. Theoretical studies of vibrational assignments and molecular structure of 4-cyanothioanisole were carried out by Kacper et al., [9]. FT-Raman and FT-IR spectra were recorded for the title molecule. The equilibrium geometries, harmonic vibrational frequencies, IR and the Raman scattering intensities were computed using the Gaussian 03 package. The molecular parameters (bond lengths, bond angles, the HOMO energy (EHOMO), LUMO energy (ELUMO), the energy gap between EHOMO and ELUMO, dipole moment and charges on the atoms of the title compound were studied by HF and B3LYP methods using several basis sets. The redistribution of electron density in different bonding and antibonding orbital's and E2 energies are calculated by Natural bond orbital(NBO) analysis using DFT method to give a clear proof of stabilization starting from the hyper conjugation of various intra molecular interactions. The theoretical NMR spectra and the Mulliken charge were calculated by the DFT method.

2.   Computation Details

To have accuracy and to get the desired result, theoretical methods and basis sets are employed. DFT is useful in finding the electronic structure of molecules. The density functional theory uses B3LYP/6-311G(d,p) and B3LYP/6-311++G(d,p) as basis sets. This method was also used to calculate the properties of studied molecules in this work. All the calculation was done using the Gaussian 03W program packages[10] with the default convergence criteria without any constraint on the geometry[11]. For B3LYP functional selected as the one which gives the most accurate results with the expanded 6-311G (d,p) and 6-311++G(d,p) as basis set and also HF with 6-311++G(d,p) as basis set.

3.   Results and Discussion

3.1.   Molecular Geometry

The optimized molecular structure of 4 CTA is shown in Figure-1. Since no experimental values are available, the geometrical parameters of 4 CTA have been investigated by theoretical methods such as B3YLP/6-311G (d,p) and B3LYP/6-311++G(d,p) as basis set and HF/6-311++G(d,p) the values are tabulated in Table-1.

Due to larger atomic radius of sulphur, the S13-C14 bond possesses higher value comparing to other bond length values (1.807 Å, 1.821 Åand 1.821) by HF/6-311++G(d,p),B3LYP/6-311G(d,p)and B3LYP/6-311++G(d,p) respectively.

The highest bond angle possessed by C3-C2-S13 (124.6, 124.5 and 124.6 at HF/6-311++G (d,p), B3LYP/6-311G(d,p) and B3LYP/6-311++G(d,p) respectively). In the absence of experimental values, the theoretically calculated bond lengths, bond angles and dihedral angles are mutually correlated with each other.
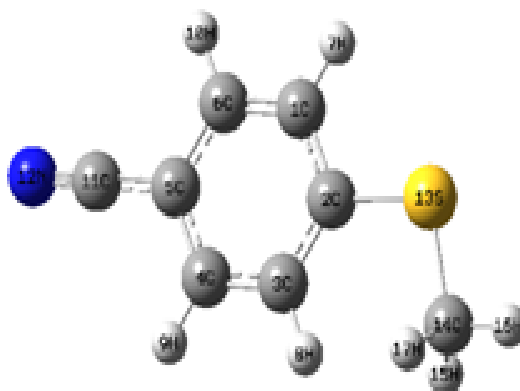
Figure 1: Optimized structure of 4CTA obtained by B3LYP/6-311++G(d,p)

3.2.   HOMO and LUMO Analysis

HOMO and LUMO are very useful parameters in quantum chemistry. They are known as frontier orbital's because of their interaction with other species. HOMO is an electron donor,while LUMO is an electron acceptor [12]. The HOMO and LUMO energy calculated by HF/6-311++G (d,p) B3LYP/6-311G(d,p) and B3LYP/6-311++G(g,p) method are mentioned in Table-2. This electronic transition absorption corresponds to the transition from the ground to the first excited state and is mainly described by an electron excitation from HOMO to LUMO. In the present study the HOMO values at HF/6-311++G (d,p),B3LYP/6-311G(d,p) and B3LYP/6-311++G(d,p)

Parameters	HF/ 6-311 ++G(d,p)	B3LYP/6-311 G(d,p)	B3LYP/6-311 ++G(d,p)
Bond length (Å)			
C1-C2	1.396	1.405	1.405
C1-C6	1.376	1.383	1.384
C1-H7	1.075	1.084	1.084
C2-C3	1.389	1.400	1.400
C2-S13	1.770	1.775	1.773
C3-C4	1.385	1.389	1.390
C3-H8	1.072	1.081	1.081
C4-C5	1.385	1.400	1.400
C4-H9	1.075	1.083	1.083
C5-C6	1.393	1.405	1.405
C5-C11	1.441	1.428	1.428
C6-H10	1.075	1.083	1.083
C11-N12	1.131	1.156	1.156
S13-C14	1.807	1.821	1.821
C14-H15	1.082	1.090	1.091
C14-H16	1.082	1.090	1.090
C14-H17	1.082	1.090	1.091
Bond angle (°)			
C2-C1-C6	120.6	120.7	120.7
C2-C1-H7	119.8	119.8	119.8
C6-C1-H7	119.6	119.6	119.6
C1-C2-C3	119.2	119.0	119.0
C1-C2-S13	116.3	116.4	116.4
C3-C2-S13	124.6	124.5	124.6
C2-C3-C4	120.2	120.4	120.4
C2-C3-H8	121.1	120.9	120.9
C4-C3-H8	118.7	118.8	118.8
C3-C4-C5	120.4	120.6	120.5
C3-C4-H9	119.8	119.9	119.8
C5-C4-H9	119.9	119.6	119.6
C4-C5-C6	119.6	119.1	119.1
C4-C5-C11	120.2	120.4	120.4
C6-C5-C11	120.2	120.5	120.4
C1-C6-C5	120.1	120.3	120.2
C1-C6-H10	120.1	120.1	120.0
C5-C6-H10	119.9	119.6	119.7
C2-S13-C14	104.4	103.8	103.8
S13-C14-H15	111.5	111.5	111.5
S13-C14-H16	105.2	105.1	105.1
S13-C14-H17	111.6	111.5	111.5

Parameters	HF/ 6-311 ++G(d,p)	B3LYP/6-311 G(d,p)	B3LYP/6-311 ++G(d,p)
H15-C14-H16	108.8	108.9	108.9
H15-C14-H17	110.7	110.8	110.7
H16-C14-H17	108.3	108.9	108.9
Dihedral Angle (°)			
C6-C1-C2-C3	0.0	−0.0	−0.0
C6-C1-C2-S13	180.0	−180.0	−180.0
H7-C1-C2-C3	180.0	−180.0	−180.0
H7-C1-C2-S13	−0.0	0.0	0.0
C2-C1-C6-C5	0.0	−0.0	−0.0
C2-C1-C6-H10	180.0	−180.0	−180.0
H7-C1-C6-C5	180.0	180.0	180.0
H7-C1-C6-H10	0.0	0.0	0.0
C1-C2-C3-C4	−0.0	0.0	0.0
C1-C2-C3-H8	180.0	−180.0	−180.0
S13-C1-C2-C3	180.0	180.0	180.0
S13-C2-C3-H8	0.0	180.0	−0.0
C1-C2-S13-C14	180.0	−180.0	−180.0
C3-C2-S13-C14	−0.0	−0.0	−0.0
C2-C3-C4-C5	0.0	−0.0	−180.0
C2-C3-C4-H9	180.0	−180.0	−180.0
H8-C3-C4-C5	180.0	180.0	180.0
H8-C3-C4-H9	0.0	0.0	0.0
C3-C4-C5-C6	0.0	−0.0	−0.0
C3-C4-C5-C11	−180.0	−180.0	−180.0
H9-C4-C5-C6	180.0	180.0	180.0
H9-C4-C5-C11	0.0	−0.0	−0.0
C4-C5-C6-C1	180.0	0.0	0.0
C4-C5-C6-H10	−180.0	180.0	180.0
C11-C5-C6-C1	180.0	180.0	180.0
C11-C5-C6-H10	−180.0	−0.0	−0.0
C2-S13-C14-H15	62.2	62.2	62.2
C2-S13-C14-H16	−180.0	180.0	180.0
C2-S13-C14-H17	−62.1	−62.2	−62.2

Table. 1 Geometric bond length, angle, dihedral angle of 4-CTA

are −0.299, −0.298 and −0.299 respectively. The LUMO values for the above mentioned parameters are -0.208, -0.209 and -0.210 respectively as tabulated in Table-2.The atomic compositions of the frontier molecular orbital are shown in Figure-2.
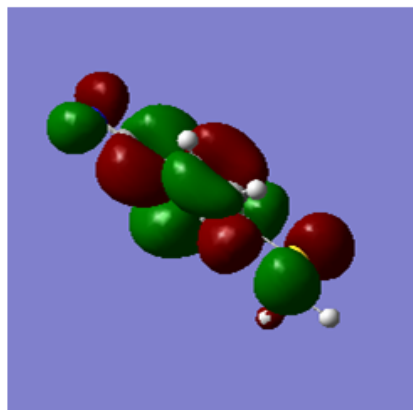
Figure 2: HOMO, LUMO values of 4CTA computed at B3LYP/6-311++G(d,p)

Methods	HF/6-311++G(d,p)	B3LYP/6-311++G(d,p)	B3LYP/6-311++G(d,p)
HOMO	-0.299	-0.298	-0.298
LUMO	-0.208	-0.209	-0.210
ENERGY GAP (ΔE)	-0.091	-0.089	-0.089

Table. 2 Theoretically computed values of HOMO and LUMO energy for 4CTA

3.3. NBO Analysis

NBO analysis gives the accurate possible natural Lewis structure picture of ϕ, because all orbital's are mathematically chosen to include the highest possible percentage of the ED. Interaction between both filled and virtual orbital spaces information is correctly explained bythe NBO analysis and it could enhance the analysis of intra and inter-molecular interactions.

The second order Fock matrix was carried out to evaluate donor (i) - acceptor (j) i.e. donor levelbonds to acceptor level bonds interaction in the NBO analysis [13]. The result of interaction is a loss of occupancy from localized NBO of the idealized Lewis structure into an empty non-Lewis orbital. For each donor (i) and acceptor (j), the stabilization energy E(2) associates with the delocalization $i \rightarrow j$ is estimated as:

$$E(2) = \Delta E_{ij} = q_i \, \frac{F(i,j)^2}{z_j - z_i}$$

where q_i is the donor orbital occupancy, ϵ_j and ϵ_i are diagonal elements; and $F(i,j)$ is the off diagonal NBO Fock matrix element.

Donor (i)	Type	ED/e	Acceptor (j)	Type	$E(2)^a$ (kJ mol^{-1})	$E(j) - E(i)^b$ (a, u)	$F(i, j)^c$ (a, u)
C1-C2	σ	1.98	C1-C6	σ^*	3.07	1.30	0.057
C1-C2			C1-H7		1.10	1.15	0.032
C1-C2			C3-H8		2.68	1.15	0.050
C1-C6	σ	1.97	C2-S13	σ^*	3.68	0.92	0.052
C1-C6			C6-H10		0.96	1.16	0.030
C1-H7	σ	1.98	C1-C2	σ^*	0.79	1.07	0.026
C1-H7			C6-H10		0.57	0.97	0.021
C2-C3	π	1.65	C3-H8	π^*	1.34	1.16	0.035
C2-S13	σ	1.98	C2-C3	σ^*	0.65	1.21	0.025
C3-C4	σ	1.97	C2-S13	σ^*	4.37	0.91	0.056
C4-C5	π	1.66	C3-C4	π^*	2.52	1.28	0.051
C4-C5			C11-N12		18.52	0.38	0.080
C5-C6	σ	1.97	C11-N12	σ^*	1.75	0.82	0.034
C6-H10	σ	1.98	C1-C6	σ^*	0.85	1.11	0.027
C11-N12	σ	1.99	C5-C11	σ^*	7.06	1.55	0.094
S13-C14	σ	1.99	C1-C2	σ^*	2.58	1.16	0.049
C14-H16	σ	1.99	C2-S13	σ^*	1.62	0.74	0.031

$^a E(2)$ means energy of hyper conjugative interaction (stabilization energy)
$^b E(j) - E(i)$ Energy difference between donor and acceptor i and j NBO orbitals
$^c F(i, j)$ is the Fork matrix element between i and j NBO orbitals.

Table. 3 Second order perturbation theory analysis of Fock matrix in NBO basis for 4-CTA using B3LYP/6-311++G(d,p)

NBO analysis provides an efficient method for studying intra and inter-molecular bonding and interaction among bonds, and also provides a convenient basis for investigating charge transfer or conjugative interaction in molecular systems. Some electron donor orbital,acceptor orbital and the interacting stabilization energy resulted from the second-order micro disturbance theory are reported [14, 15]. The larger $E(2)$ value the more intensive is the interaction between electron donors and acceptors i.e. the more donation tendency from electron donors to electron acceptors and the greater the extent of conjugation of the whole system [16]. Delocalization of ED between occupied Lewis - type (bond or lone pair) NBOs and formally unoccupied (anti bond or Rydeberg) non Lewis NBOs correspond to a stabilizing donor-acceptor interaction.

NBO analysis has been performed on the 4-ATA molecule at the DFT/B3LYP/6-311++G(d,p) level in order to elucidate, the intra-molecular rehybridization and delocalization of ED within the molecule. The C4-C5donor orbital has 1.97e as ED, which stabilizes themaximum energy of 18.52 kJ/mol during σ electron interaction with

antibonding C11-N12 orbital.

This occur a strong intra-molecular hyperconjugative interaction of π^* (C4-C5) which has avalue of ED as 1.66e that weakens the respective bond. The increased ED transfers less energyduring the intra-molecular interaction. The $E(2)$ values and types of the transition are shown in Table-3.

Atoms	HF/6-311++G(d,p)	B3LYP/6-311G(d,p)	B3LYP/6-311++G(d,p)
1C	64.83	55.91	55'05
2C	37.10	29.29	26.98
3C	65.66	56.09	55.81
4C	51.76	46.94	45.81
5C	73.01	61.70	60.92
6C	52.11	47.24	45.98
7H	24.40	24.47	24.43
8H	24.73	24.86	24.64
9H	24.08	24.33	24.21
10H	24.04	24.29	24.20
11C	69.49	63.90	61.70
12N	-32.89	-35.42	-26.80
13S	555.34	459.97	444.67
14C	183.47	171.58	171.55
15H	30.50	30.28	30.23
16H	30.54	30.30	30.26
17H	30.50	30.28	30.23

Table. 4 Theoritical NMR Spectra of 4-CTA [all values in ppm]

3.3.   NMR Spectra Analysis

The molecular structure of 4-CTA is optimized by using HF/6-311++G(d,p) B3LYP method with 6-311G(d,p) and 6-311++G(d,p). GIAO ^{13}C and ^{1}H chemical shift calculations of the title compound is made by using B3LYP method in conjunction with 6-311G(d,p) and 6-311++G(d,p) basis set [17]. The theoretical NMR Spectra calculations were performed by using the Gaussian 03 program package.

The Spectral value of all the atoms like Carbon, Sulphur and Hydrogen, shows different values for basis sets. In Carbon atom C14 has the maximum value of 183.47, 171.58 and 171.55 by using HF/6-311++G (d,p), B3LYP/6-311G(d,p) and B3LYP/6-311++G(d,p) respectively. In Hydrogen atom H16 has the maximum value of 30.54,30.30 and 30.26. In Sulphur atom, S13 has values -555.34, 459.97 and

444.67 by using HF/6-311++G(d,p), B3LYP/6-311G(d,p) and B3LYP/6-311++G(d,p) respectively.This shows that both the basis sets are in close agreement with each other. The calculated values of NMR spectra are shown in Table-4.

3.4. Vibrational Assignment

The Vibrational assignment were performed on the basis of recorded FT-IR and FT-Raman spectra based on theoretically predicted wave numbers by HF/6-311++G(d,p) density functional B3LYP/6-311++G(d,p) method are shown in the Table-5. We know that ab initio HF and DFT potentials systematically overestimate the vibrationalwave numbers.These discrepancies are corrected by introducing proper scale factors [18, 19]. There are 45 modes of vibrations in the molecule.

Literature survey reveals that C-H stretching, in-plane and out-of-plane bending appeared in the range 3100-3000 cm^{-1}, 1300-1000 cm^{-1}, 1000-750 cm^{-1} respectively. The vibrational frequencies are in the range 3190-3209 cm^{-1} [mode nos:43-45] by B3LYP/6-311++G(d,p) method are assigned to C-H asymmetrical stretching vibrations. The C≡N asymmetrical stretching vibrations appear to be at 2334 cm^{-1} C-S asymmetrical stretching vibrations appear to be at 1100 cm^{-1}. The computed values are in good correlation with the literature value [20].

Mode No.	Computed at B3LYP/6-311G(d,p)					Vibrational Assignments (%)
	Freq scaled	Intensity		Red Mass	Force Const.	
		IR	Raman			
v_1	44	0.85	0.39	3.36	0.00	S-CH$_2$ Rocking
v_2	85	4.32	0.04	9.12	0.04	CH$_2$ Rocking
v_3	132	4.37	2.45	6.83	0.07	C≡N twisting
v_4	210	1.47	2.20	3.67	0.10	CH$_2$ Rocking
v_5	210	1.07	0.02	1.67	0.04	C-S Scissoring
v_6	249	0.69	0.02	2.03	0.07	CH$_2$ Rocking
v_7	316	1.50	5.94	7.02	0.41	C-S asymmetrical stretching
v_8	379	1.75	3.39	6.31	0.53	C-S asymmetrical stretching
v_9	408	0.02	0.03	2.98	0.29	CH$_2$ twisting
v_{10}	449	2.03	1.59	4.70	0.56	CCC opb
v_{11}	566	21.73	3.69	3.79	0.71	CH$_2$ Wegging
v_{12}	570	1.08	2.73	7.66	1.46	C≡N Wegging
v_{13}	583	10.40	4.66	7.37	1.47	C-S asymmetrical stretching
v_{14}	658	0.02	9.03	7.44	1.90	CCC ipb

Mode	Computed at B3LYP/6-311G(d,p)					Vibrational
No.	Freq scaled	Intensity		Red Mass	Force Const.	Assignments (%)
		IR	Raman			
v_{15}	715	1.07	9.03	6.30	1.90	CCC asymmetrical stretching
v_{16}	722	3.06	0.38	4.15	1.27	S-CH$_2$ asymmetrical stretching
v_{17}	795	2.97	14.58	6.79	2.53	CCC Scissoring
v_{18}	831	35.86	0.57	1.47	0.60	CH$_2$ rocking
v_{19}	839	8.94	0.85	1.31	0.54	CH$_2$ rocking
v_{20}	967	2.04	1.83	1.32	0.73	CH$_2$ rocking
v_{21}	976	5.77	3.28	1.24	0.70	CH$_2$ rocking
v_{22}	980	1.81	0.90	1.28	0.73	CCC opb
v_{23}	991	6.72	12.45	1.31	0.76	CH$_2$ rocking
v_{24}	1032	5.83	0.12	3.02	1.90	CCC opb
v_{25}	1100	70.69	105.31	4.57	3.26	C-S asymmetrical stretching
v_{26}	1146	3.01	0.05	1.37	1.06	CH$_2$ scissoring
v_{27}	1206	5.77	81.90	1.37	1.18	CH$_2$ Nagging
v_{28}	1234	0.25	22.33	2.41	2.16	CCC asymmetrical stretching
v_{29}	1308	0.78	8.11	8.84	8.91	CCC asymmetrical stretching
v_{30}	1332	0.58	3.53	1.30	1.36	CCC opb
v_{31}	1365	1.88	4.67	1.17	1.29	C-S symmetrical stretching
v_{32}	1437	8.08	1.21	2.70	3.29	CH$_2$ rocking
v_{33}	1471	11.16	17.79	1.05	1.34	CH$_2$ rocking
v_{34}	1486	29.64	4.49	1.06	1.38	CH$_2$ scissoring
v_{35}	1522	50.65	2.76	2.19	2.98	CCC asymmetrical stretching
v_{36}	1582	1.90	4.02	6.19	9.12	CCC asymmetrical stretching
v_{37}	1638	100.76	357.88	5.49	8.68	CCC opb
v_{38}	2334	65.15	780.85	12.68	40.68	C≡N asymmetrical stretching
v_{39}	3044	19.11	167.71	1.03	5.62	CH$_2$ symmetrical stretching
v_{40}	3129	8.12	57.28	1.11	6.39	CH$_2$ asymmetrical stretching
v_{41}	3137	3.13	117.70	1.10	6.40	CH$_2$ asymmetrical stretching
v_{42}	3177	2.36	50.00	1.09	6.47	C-H stretch
v_{43}	3190	1.95	62.58	1.09	6.53	C-H asymmetrical stretching
v_{44}	3198	3.69	116.82	1.09	6.53	C-H asymmetrical stretching
v_{45}	3209	3.90	105.01	1.09	6.63	C-H asymmetrical stretching

Table. 5 The observed FT-IR, FT-Raman and computed frequencies (cm^{-1}), IR, Raman intensities Km/mol), reduced mass (amu) and force constants (mdyn/Å) of 4-CTA by using B3LYP/6-311G(d,p)
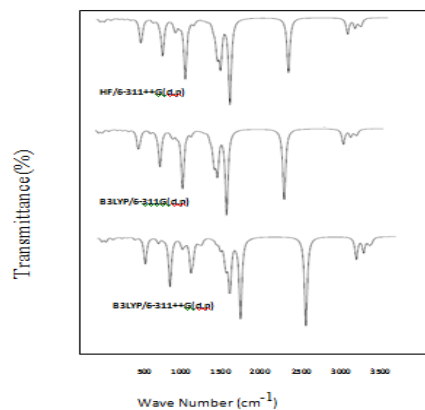
Figure 3: Comparison of the computed FT-IR Spectra of 4-CTA at different basis set
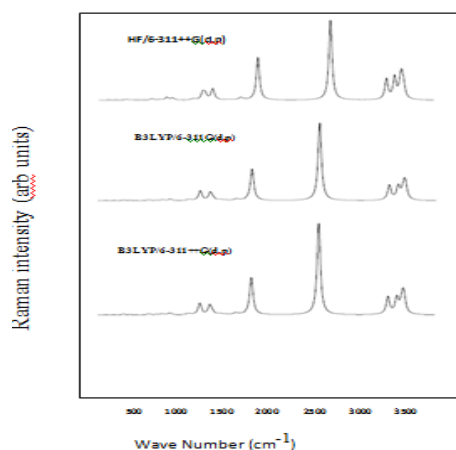
Figure 4: Comparison of the computed FT-Raman Spectra of 4-CTA at different basis set

3.5. Mulliken Charges

The calculation of atomic charges plays an important role in the application of quantum mechanical calculations to molecular systems [21]. Our interest here is in the comparison of different methods to describe the electron distribution in 4-CTA as broadly as possible, and to assess the sensitivity of the calculated charges to changes in (i) the choice of the basis set; (ii) the choice of the quantum mechanical method. Mulliken charges are calculated by determining the electron population of each atom as defined in the basis functions. The Mulliken charges calculated at different levels and

at B3LYP/ 6-311++G(d,p) basis set are listed in the Table -6a. The results can however, better be represented in graphical form as shown in figure 6a. The Mulliken charges at the C_{11} and S_{13} atoms show more negative due to the attached cyanide group and C_5 posses more positive charge.

Charges	HF/ 6-311++G(d,p)	B3LYP/ 6-311G(d,p)	B3LYP/ 6-311++G(d,p)
1C	− 0.178	− 0.073	− 0.287
2C	0.969	− 0.182	0.967
3C	− 0.193	− 0.070	− 0.075
4C	− 0.552	− 0.015	− 0.544
5C	1.863	− 0.081	1.681
6C	− 0.320	− 0.018	− 0.385
7H	0.240	0.113	0.186
8H	0.185	0.108	0.135
9H	0.274	0.113	0.222
10H	0.256	0.116	0.203
11C	−1.770	0.049	− 0.407
12N	−0.184	− 0.215	− 0.163
13S	−0.682	0.157	− 0.665
14C	−0.461	− 0.479	− 0.436
15H	0.172	0.155	0.183
16H	0.215	0.168	0.201
17H	0.172	0.155	0.183

Table. 6a Calculated Mulliken charges of 4-CTA by HF and DFT methods
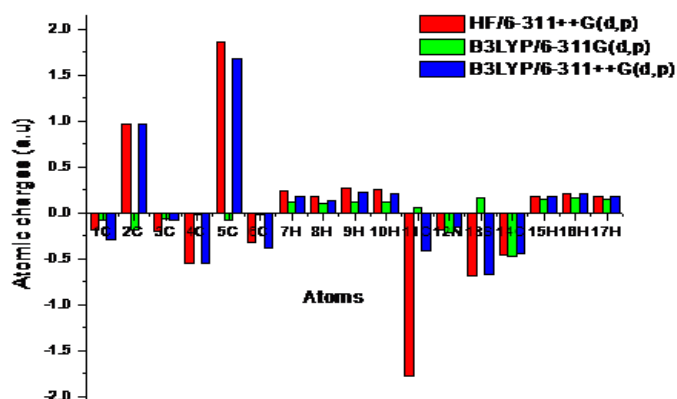
Figure 5: Comparison of different methods for calculated atomic charges of 4-CTA

On the basis of fully optimized ground state structure TD-DFT calculations have been used to determine the low-lying excited states of 4-CTA. The calculated results involving the vertical excitation energies, oscillator strength (f) and wavelength are carried out computationally. This is shown in Table 6b.

Excitation	CI Expansion Coefficient	Wave length (nm)		Oscillator Strength (f)
		Calc	Expt	
Excited State 1				
$38 \rightarrow 40$	0.1133	305.86	267.03	0.0066
Excited State 2				
$39 \rightarrow 40$	0.6013	280.55	267.03	0.3136
Excited State 3				
$39 \rightarrow 42$	0.7063	214.68	267.03	0.0000

Table. 6b Calculated electronic absorption spectrum of 4-CTA using TD-DFT/B3LYP/6-311++G(d,p)

3.6.   Thermodynamic Properties

The calculated thermodynamic parameters are presented in the Table 2.8. Scale factors have been recommended [22] for an accurate prediction in determining the zero-point vibrational energies and the entropy S. The variation in the zero-point vibrational energies seems to be insignificant. The total energies are found to decrease with increase of the basis sets. The changes in the total entropy of 4-NTA at room temperature at different basis sets are only marginal.

Parameters	HF/6-311++G(d,p)	B3LYP 311++G(d,p)	B3LYP 311++G(d,p)
Total Energies (a.u)	−758.98	−762.02	−762.02
Zero point energy (kcal/mol)	85.49	79.99	79.89
Rotational constants (GHz)	4.15	4.08	4.08
	0.56	0.56	0.56
Entropy (cal/mol/K)	0.50	0.49	0.49
Total	94.30	96.44	96.39
Translational	40.91	40.91	40.91
Rotational	30.01	30.05	30.05
Vibrational	23.38	25.48	25.43
Dipole moment (D)	5.26	5.25	5.53

Table. 7 Theoretically computed energies, zero-point vibrational energies, rotational constants, entropies and dipole moment for 4-CTA

4.   Conclusion

The spectral studies such as FT-IR, FT-Raman, and NMR for 4-CTA was carried out for the first time. A complete vibrational and molecular structure analysis has been performed based on the quantum mechanical approach by HF/6-311++G(d,p) (DFT) B3LYP calculations. Correlation between the ^{1}H, ^{13}C of theoretical values and the GIAO NMR calculations are found by using 6-311 G(d,p) and 6-311++G(d,p) are coinciding well. NBO shows the transfer of charge within the molecule during the intra-molecular interaction. Lewis and non-Lewis structure of NBOs show occupancy in s and p orbital's. HOMO and LUMO orbitals have been visualized and the energy band gap is calculated. Mulliken charge is also been determined. Finally the Thermo dynamical properties also been calculated.

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Synthesis of New Chitin Derivatives and their Application as Efficient Heavy Metal Adsorbents

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Abstract

Phenylisothiocyanate -chitin (PIC -chitin) and chloroacetonitrile -chitin (CAN - chitin) are synthesized by making chitin to react with the respective reagents along with 2-propanol and tetramehtyl ammonium hydroxide in benzene. These new derivatives of chitin have very good adsorption capacities over metal ions such as Iron and copper even under the lower pH conditions i.e.: at pH 3.0 for iron and at pH 1.4 for copper. This is against the sorption capacity of untreated chitin in the pH range of 6.0 - 8.0. The improved efficiency of new chitin derivatives is utilized for preconcentration of iron and copper metal ions by collecting the ions as their complexes in the column of the chitin derivatives. Iron is collected as its 1, 10-phenanthroline (phen) complex and copper is collected as its neocuproine (neoc) complex in the presence of tetraphenylborate as counter-ion. The elution of the metal ion complexes is successfully done with acetone - 1M acetic acid mixture and the concentration is determined spectrophotometrically by measuring the absorbance at 515 nm for iron and at 455 nm for copper. Beer's law limit for iron (II) is found to be 2.0 - 12g per 10 ml of eluent and it is 2.0 -20 g for copper (II). The interference of diverse anions and cations are also studied. The proposed method has been applied to determine the concentration of iron (II) and copper (II) in tap water.

Keywords: Chitin, Phenylisothiocyanate, Chloracetonitrile, Preconcentration.

1.   Introduction

Work on the preconcentration of trace metal ions on a number of adsorbents such as C18 - bonded glass beads[1-3], Amberlite XAD resin[4-6], ion exchange resin[7-15], thiol cotton[16], cellulose[17], green tea leaves[18], poly (vinyl chloride) film[19] and microcrystalline naphthalene[20] have been done. The natural polymer, chitin, adds

in this list for preconcentrating various metal ions by acting as anion exchanger[21-23] for some metal ions and as an adsorbent in the form of column support[24-27], for some more metal ions. Chitin is the most abundant acetylated aminopolysacchride having structural similarities with cellulose. It is the linear polymer of N- acetyl-D-glucosamine, source of which is the hard shells of sea crustaceans such as crab, shrimp, and lobster etc[28].

Chitin originally contains just 2.5% of amino groups amongst acetamido groups, thereby having limited sorption capacity. The adsorption efficiency of chitin can be improved by converting it into its derivatives such as chitosan and further into substituted derivatives [29-32]. When chitin is deacetylated to replace its acetamido groups into primary amino group, it will facilitate the synthesis of new derivatives by virtue of characteristic primary amino group reactions. The significance of chitin and chitin derivatives when compared with other mentioned adsorbents is that they are environment friendly. Chitin and its derivatives can be repeatedly used after desorbing the metal ions from them. Higher flow rate up to 10 mL/min was achieved with chitin derivatives as against 7 mL/min performed by microcrystalline naphthalene. This method using chitin derivatives is relatively rapid, economical, selective and sensitive when compared with other reported adsorbents.

Since higher degree of deacetylation will lead to dissolution of chitin, the hydrolysis is done at appropriate experimental conditions to get optimized percentage of deacetylation [33].Therefore; chitin is first deacetylated and then used for synthesizing Phenyl IsothioCyanate (PIC) and ChloroAcetoNitrile (CAN) derivatives. These new derivatives PIC-chitin and CAN- chitin are employed as adsorbents in the column for preconcentration of metal ions. The metal ions Cu (II) and Fe (II) are adsorbed as their coloured complexes and eluted in the small volume of eluent to be determined spectrophotometrically. Fe (II) is adsorbed as 1, 10-Phenanthroline complex where as Cu (II) as neocuproine complex. These chitin derivatives are found to be more efficient adsorbents than chitin itself with the additional advantage of working at very low pH region. Surfactant solutions in low concentrations are also added as counter ions to enhance the adsorption of metal ion complexes .The adsorption and desorption processes occur at significantly faster rate.

Our present work describes the method of synthesising two new chitin derivatives and their application in preconcentration of trace metals in tap water followed by their determination spectrophotometrically.

2. Materials and Methods

H^1 NMR (DMSO) Spectra were recorded on JOEL FX-90 Q FT NMR Spectrometer using TMS as an internal reference (Chemical Shift in ppm). IR Spectra (KBr pellets) were recorded on Bruker IFS 66V FT-IR Spectrophotometer.

A Systronics digital pH meter 335 was employed for pH measurements. The absorption measurements were done using Schimadzu 1240 UV/ Visible Spectrophotometer.

Pure chitin powder obtained from Central Institute of Fisheries Technology, Cochin, Kerala was further washed with 1M Hydrochloric acid, distilled water and acetone then dried at 40° C for 24 hours in a vacuum desiccator. 2-Propanol and benzene of SD fine chemical products were used as such. Extra pure reagent grade of Phenylisothiocyanate and Chloroacetonitrile were obtained from Lancaster Co.Ltd.

Deacetylation of Chitin

10 g of pure chitin was taken in RB flask; 100 ml of 40% NaOH solution was added and then refluxed at 100° C for 70 minutes to produce nearly 40% of deacetylated chitin This is the optimum deacetylated composition which can work at lower pH with improved efficiency of adsorption without the risk of being dissolved.

Preparation of PIC Chitin and CAN Chitin Derivatives

About 10 g of deacetylated chitin was taken in Erlenmeyer flask. Then 100 ml of benzene, 12ml of propanol were added into the flask, followed by the addition of 25 mL of phenylisothiocyanate or chloroacetonitrile. The flask was covered with Petri dish and was allowed to stand at room temperature for two days with continuous stirring by a magnetic stirrer. The contents were filtered through a Watman 40 filter paper. The filtered polymer derivative was washed with 2- Propanol several times and then dried at 40° C under reduced pressure for one day.

Standard Iron (II) solution (1mg/mL) was prepared by dissolving 3.56 g of ferrous ammonium sulphate hexahydrate in 50 mL of 1M hydrochloric acid and diluting to volume in a 500 mL standard flask. The phenanthroline solution (0.1M) was prepared by dissolving 2.347 g of 1, 10-phenanthroline hydrochloride (SD fine chemicals) in 100 mL water.

Standard copper (II) solution (1mg/mL) was prepared by dissolving 1.9644 g of AR cupric sulphate (SD fine chemicals) in water and diluting to volume in a 500 mL standard flask. The neocuproine (neoc) (0.1M) solution was prepared by dissolving

1.2236g of neocuproine hydrochloride in 50 mL water. All other chemicals used were of analytical grade.

The surfactant solutions of Tetraphenylborate (TPB), Sodiumlaurylsulphate (NaLS) and 1- naphthalene sulphonate (NS) were prepared from analytical grade quality.

To a 200 mL of sample solution containing iron in the range 2.0-12.0 g, 0.5 mL of 0.5 M hydroxylammoniumchloride (HA) and 1 mL of 0.1 phenanthroline were added after which the pH of the solution was adjusted to 4.0.Then 1 mL of 0.2 M EDTA and 0.5 mL of 0.05 surfactant solution TPB were added as counter ions.
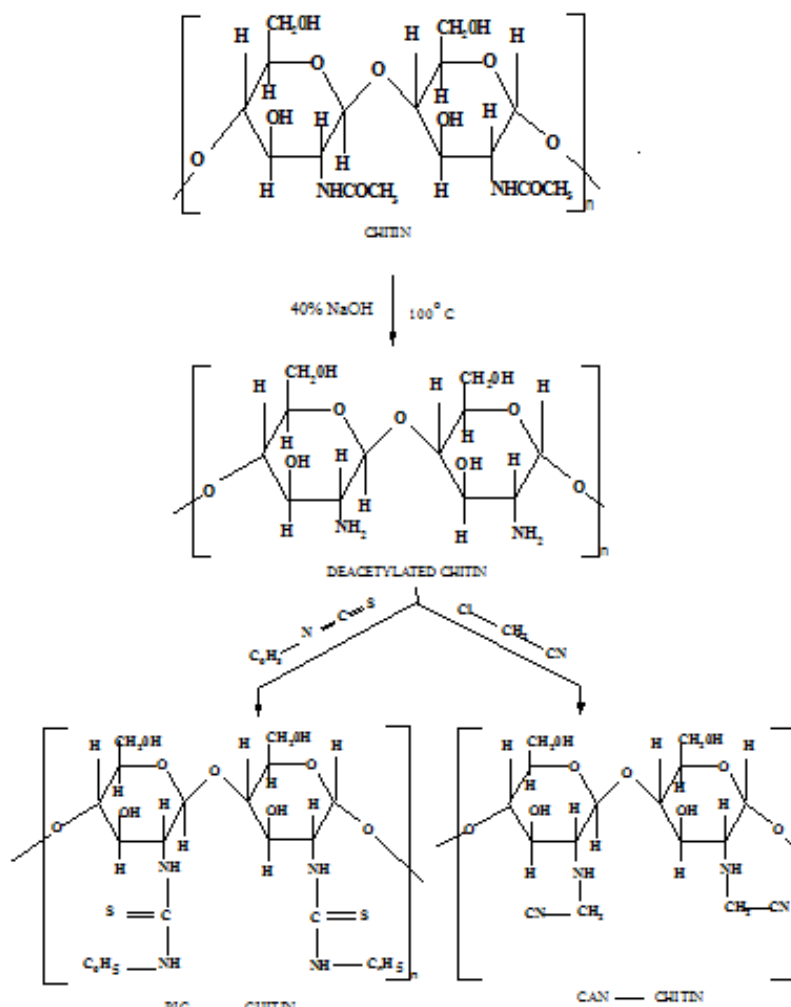
Scheme Synthesis of chitin derivatives from chitin

After standing for 5 minutes, the solution was passed through a column (polypropylene syringe, 12mm i.d, 60mm long) packed with 0.5g of either PIC-Chitin or CAN-Chitin derivatives at the flow rate of 10.0mL/min and 9.0mL/min respectively. The Iron-phen complex was eluted with 10ml of acetone - 1M acetic acid mixture (8:2 v/v) and the absorbance was measured for the eluate at 515nm. Another sample solution containing 2.0 - 20.0 g of copper in 200ml was subjected to similar procedure done for iron solution and the absorbance was measured at 455 nm.

Adsorption spectra of Iron-phen complex, copper-neoc complex and the reagent blank in the eluent measured against water are shown in fig.1. The iron complex has an absorption maximum at 515nm whereas the copper complex has at 455nm while the absorption of the reagent blank is negligible at these wavelengths. Therefore absorption measurements were carried out at 515nm for iron complex and at 455nm for copper complex.
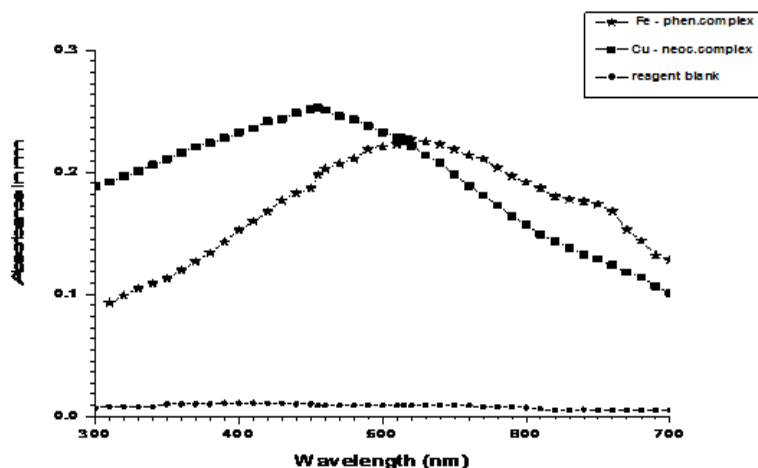
Fig 1: Absorption spectra of Fe(II)-phen and Cu(II)-neoc complexes

3. Results and Discussion

Spectral studies

In Chitin the free amino group is more nucleophilic than any other functional group. Therefore, the amino group attacks the reactant at thiocarbonyl carbon resulting in PIC-chitin formation. Similarly, the free amino group in Chitin reacts with chloroacetonitrile by preferentially attacking the methylene carbon resulting in CAN-Chitin.[34-37]

The FT-IR spectrum of pure PIC-Chitin indicates characteristic frequencies at 1373 cm^{-1} due to C = S stretch and 1492 cm^{-1} indicates the presence of N$-$C = S

group. Peak near 700 cm^{-1} indicates the presence of aromatic ring. Peaks at 3400 cm^{-1} and 1650 cm^{-1} indicates N$-$H stretching and N$-$H bending respectively.

In FT-IR spectrum of CAN- Chitin a characteristic peak at 2257 cm^{-1} indicates the presence of $-$ C $\equiv$ N group. A peak at 3020 cm^{-1} indicates C $-$ H stretching (methylene). A strong broad absorption peak at 3300 cm^{-1} corresponds to N $-$ H stretching and peak at 1650 cm^{-1} indicates N $-$ H bending.
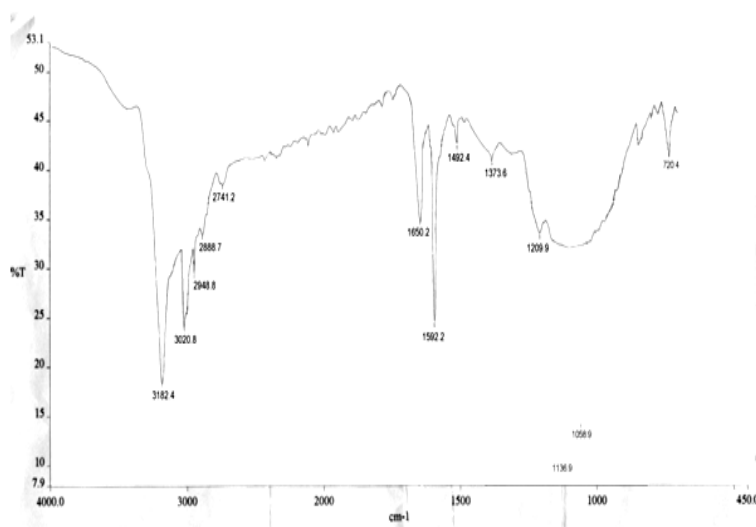
FT-IR Spectrum of PIC-Chitin
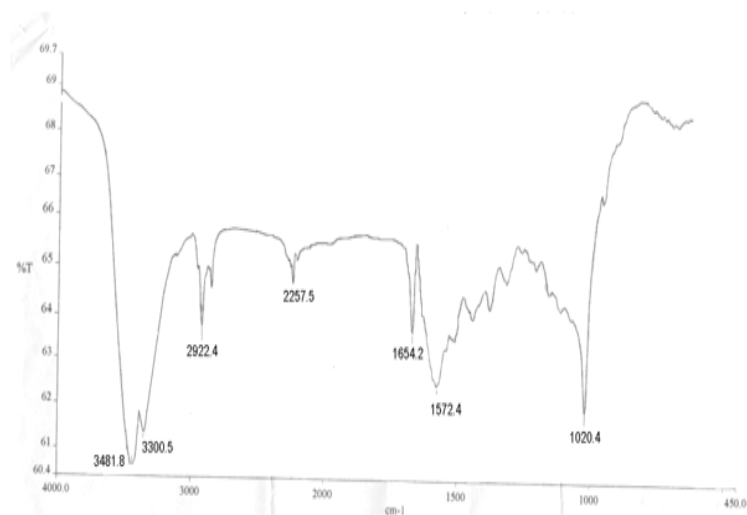
FT - IR Spectrum of CAN-Chitin

^{1}H NMR spectrum of PIC Chitin indicates the presence of aromatic protons at δ 7.5ppm and N - H proton is observed at δ 10.7 ppm along with chitin proton signals.

^{1}H NMR spectrum of CAN chitin observed N$-$H proton at δ 10.3 ppm and methylene proton at δ 4.3 ppm as doublet, because methylene group is attached to $C \equiv N$ and N$-$H groups.

Effect of pH on absorption

Fig2. Shows the effect of pH on the adsorption for the iron and copper complexes on Chitin derivatives- PIC-Chitin and CAN-Chitin. The pH was varied from 1 to12 and the retention of the coloured complexes on Chitin was measured in terms of absorbance at their respective wavelengths of maximum absorption. The pH was adjusted with the help of 1M H_2SO_4 and 5M ammonia solution as the case may be. The optimum pH ranges for the successful retention of Fe (II) ions on PIC-Chitin and CAN-Chitin were found to be 3.0-8.4 and 3.5-8.0 respectively (fig 2). For Cu (II) ions these pH ranges were 1.4 -6.8 and 2.0 -6.8 fig (3).These pH ranges were against the suitable pH ranges of successful adsorption on natural Chitin such as 6.8 - 8.0 for Fe (II) and 5.6 - 6.8 for Cu (II) ions. The above study reflects the fact that when the new derivatives are used as adsorbents in place of chitin, iron and copper ions can be adsorbed even in low pH region which is used to be normal acidic region in industrial effluents. This study also presents the essential presence of counter ions such as TPB, NaLS and NS under various concentrations. TPB was found to be helping maximum adsorption of metal ions in the concentration of 0 .05 M (fig 4).

The flow rate for the adsorption step was varied from 0.5 to 12 mL/min (natural flow). As these newly synthesized Chitin derivatives have better adsorption efficiency, the flow rate up to 10.0 mL/min for PIC-Chitin and up to 9.0 mL/min for CAN-Chitin gave excellent collection of metal complexes (fig 5). The elution of metal ions from the new derivatives was also quicker when the mixture of 1M acetic acid and acetone in 8:2 v/v was used. The absorbance values were reproducible and constant over longer period of time. Normally good results of absorbance are obtained when the complexing agent, Hydroxyl ammonium chloride and counter ion solutions are added in 60-, 50-, and 10-fold molar excess relative to the metal ions.

Calibration, Precision and other Parameters

Concentration ranges 2.0 - 12.0 μg for iron and 2.0 - 20.0 μg for copper in 10 ml eluate. The molar absorptivities were 1.04×10^4 l.mole^{-1} cm^{-1} and 7.96×10^3 l.mole^{-1}.cm^{-1} respectively. The relative standard deviation was 1.1% for 6 μg of iron and 2.0% for 10 μg of copper (six measurements). Recoveries of iron from various volumes (100 - 1000 ml) of solution were found to be constant for both iron and copper over this range of sample volume. Concentration up to 100 times was achieved.

Consistent results were obtained even after seven cycles of successive adsorption and desorption.
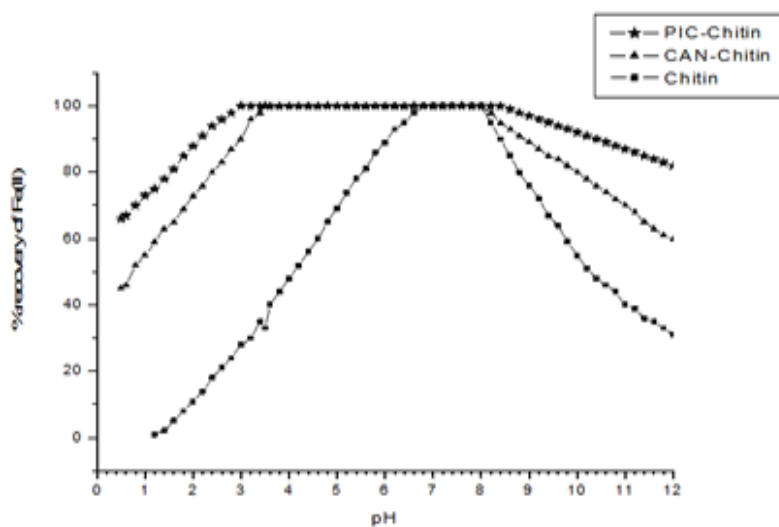
Fig 2: Effect of pH on the adsortion of Fe(II) on chitin and its derivatives
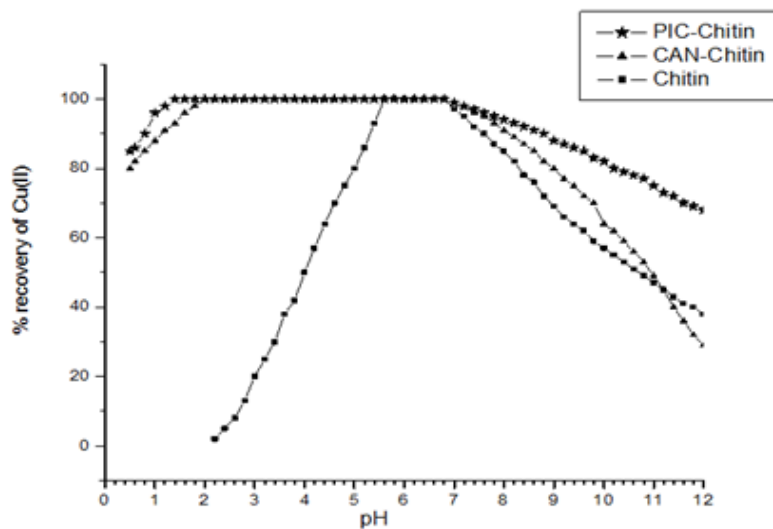
Fig 3: Effect of pH on the adsorption of Cu(II) on chitin and its derivatives
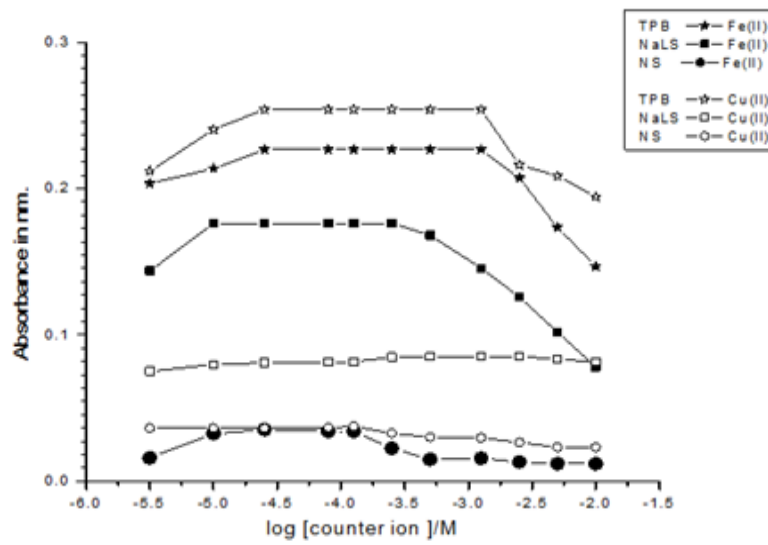
Fig 4: Effect of counter-ion concentration on the adsorption of Fe(II)& Cu(II) complexes
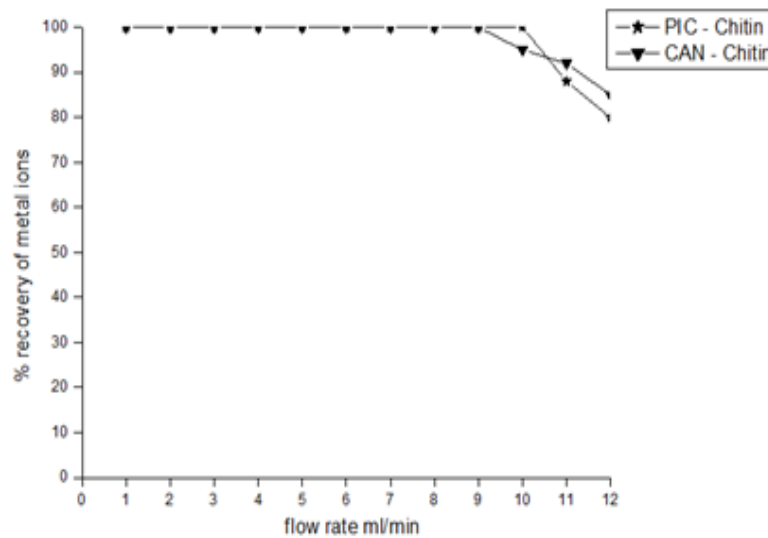
Fig 5 :Effect of flow rate upon the adsorption of metal ions

Effect of diverse ions

The effect of diverse ions was studied by adding their corresponding salt solutions. The error of $\pm 3\%$ in absorbance taken as the tolerance limit in the determination of the concentration of respective ions from the eluent. EDTA in the concentration of 1×10^{-3}M was added as masking agent after the complexation of metal ions. For the determination of 6.0g of iron the interference of Co(II), Ni(II) and Cu(II) is within the tolerance limit up to 20 times of concentration that of iron whereas for the determination 10.0g of copper, the interfering ions such as Al(III), Fe(III), Fe(II), Co(II), Ni(II), Zn(II), Cd(II) and Pb(II) is tolerable up to the concentrations of up to 500 times that of copper. The tolerance limit of fluoride, chloride per chlorate, nitrate, sulphate and phosphate ions are up to 500 times of concentrations more than that of both iron and copper ions.

Ion added	Ion/Fe (II) ratio	Ion/Cu (II)
Cu (II)	20	–
Fe (II), Fe (III)	–	500
Co (II), Ni (II)	20	500
Ca (II), Mg (II), Mn (II)	100	1000
Zn (II), Cd (II), Pb (II), Al (III)	100	500
Fe^-, Cl^-, ClO_4, NO_3, SO_4^{2-}, PO_4^{3-}	10^4	10^4

Table.1 Tolerance limit of interference in the determination of Cu (II) and Fe (II) ions

Analysis of Fe (II) and Cu (II) in tap water

The concentrations of Fe (II) and Cu (II) in tap water collected in Vellore district of Tamilnadu, India were determined using this method. Five replicate portions of sample of each metal ion were analysed individually by the reported procedure and the average calculated values were found to be 45 ng/ml for iron and 5ng/ml for copper. The standard deviations were found to be .5ng/ml for iron and .3ng/ml for copper.

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Synthesis and Characterization of Novel Biodegradable Aliphatic copolyesterspoly(butylene succinate-co-butylene adipate), poly(butylene succinate-co-ethylene succinate)

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Abstract

In this paper, we report on the synthesis of certain novel aliphatic biodegradable copolyesters namely poly(butylene succinate-co- butylene adipate) and poly(butylene succinate-co-ethylene succinate) were carried out using Poly(butylene Succinate), Poly(butyleneAdipate)and Poly(Ethylene Succinate) in presence of Poly Phosphoric acid. The polyesters were characterised by solubility, viscosity measurements, IR, 1H NMR and 13C NMR spectral methods. The thermal properties were studied using differential scanning calorimetry. The X-ray patterns were collected on X-ray diffractometer, The percentage of biodegradation of the synthesized copolyesters was investigated by enzymatic hydrolysis using the enzyme *Candida rugosa* lipase. The morphological analysis was carried out using Scanning Electron Microscope.

Keywords: poly(butylene succinate-co -butylene adipate), poly (butylene succinate- co- ethylene succinate), Poly(butylene Succinate), Poly(butylene Adipate), Poly(Ethylene Succinate),Aliphatic polyester.

1.   Introduction

In the world today, increasing volumes of polymers are manufactured and used for various applications because of their versatility and ability to be mass-produced.

However, they usually do not naturally decompose, and they are considered to cause some environmental problems. The biodegradable polymers have attracted considerable attention as green materials and biomaterials in pharmaceutical, medical and biomedical engineering applications including drug delivery systems, artificial implants and functional materials in tissue engineering. The production and consumption of synthetic polymeric materials have grown progressively due to their low cost, as well as their resistance to physical aging and biological attacks.

Aliphatic polyesters have been recognized as one of the most promising biodegradable materials because they are readily susceptible to biological attack and their degradation products, water-soluble oligomers and the starting diols and acid or hydroxyl acid, are non-toxic and can enter the metabolic cycles of bio-organisms.

The biodegradability of a polymer is based on the presence of hydrolyzable or oxidizable linkages in the backbone. The rate of biodegradation of polyesters depend on the chemical composition, sequence length, molecular weight, hydrophilic/hydrophobic balance, as well as on the morphology of the sample, e.g. degree of crystallinity, size of spherulites, surface area of the samples, additives, etc.

2. Experimental Section

Materials

Succinic acid (99%), Adipic acid (99%) were purchased from Aldrich used as such. Ethylene glycol and 1,4-Butanediol were supplied by Merck used as such.

Synthesis of Polyesters

Synthesis of aliphatic copolyesters was carried out by two stage direct melt polycondensation method in a three neck round bottom flask. At the first stage, the oligomers were prepared by using succinic acid or adipicacid and 1,4-Butanediol or ethylene glycol in a molar ratio 1/1 and the catalyst titanium tetrabutoxide was charged into the reaction flask of the polycondensation apparatus. The reaction mixture was heated at 190°C under nitrogen atmosphere and stirred at a constant speed, 500 rpm.

In the second polycondensation step, oligo(Butylene succinate) and oligo(Butylene adipate) were used in 1:1 weight ratio to synthesize P(BSu-co-BAd) copolymer. In this stage, polyphosphoric acid, a vacuum, 5.0 Pa was applied. The temperature was slowly increased to 230°C, while stirring speed was also increased to 720 rpm.Finally, the reaction was terminated when the viscosity of the reaction mixture is so high the rotation of the magnetic stirrer is not possible. The viscous slurry was cooled in the reaction flask. The crude copolyesters was dissolved in chloroform and precipitated

into a tenfold amount of vigorously stirred ice cold methanol to purify the copolyesters. The precipitated polyester was dried in a vacuum to constant weight.
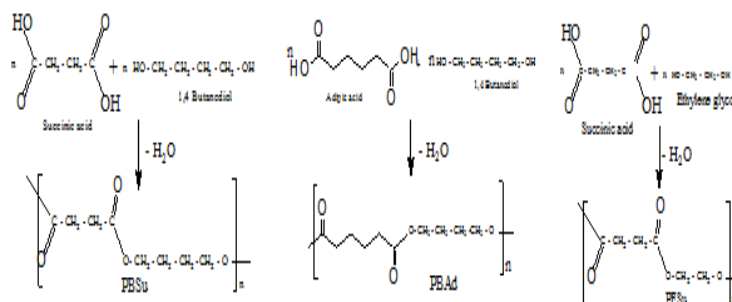
Scheme - I
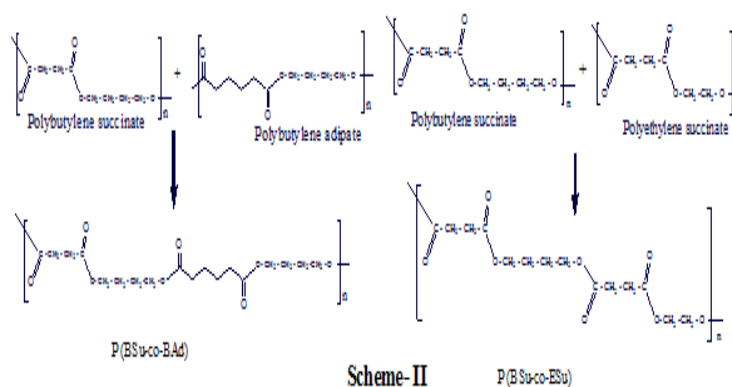
Scheme-II

Polymer Characterization

Solubility studies and Viscosity Measurements

      Solubility of polymers were determined in various organic solvents. 10mg of the polyester was taken in a small stoppered test tube and 1ml of the solvent was added. The solubility was noted in different solvents.Inherent viscosity of the copolyesters were measured in chloroform at 30°C $\pm 1°$ C using Ubbelhodeviscometer. For this flow times were determined for the pure solvent and 1% polymer solution by weight at room temperature.

Infrared spectroscopy

The IR spectra of polymers were recorded using Bruker IFS 66 V - IR spectrophotometer with KBr pellets in therange of 4000-400cm-1 at 25C.

Nuclear magnetic resonance spectroscopy

1H and 13C NMR spectra of co-polyesters were recorded using JOEL-GSX-400 spectrometer. CDCl3 was used as solvent and TMS was used as internal standard.

Thermal analysis

DSC thermograms were recorded on a PERKIN ELMER PYRIS-1 differential scanning calorimeter. About 2-4mg of the polymer sample was heated in an aluminium pan with pierced lid under nitrogen atmosphere at a scanning rate of $10°C/$ min between a temperature range of $-100°C$ and $450°C$.

Powder X-ray Diffraction (PXRD)

The X ray patterns were collected on a Shimadzu XRD-600 diffractometer, with Cu-Ka radiation (l = 1.54 Å), 30 kV potential and 20 mA current. The samples were analysed as powders.

Biodegradation

The percentage of biodegradation of the synesized copolyesters were investigated by enzymatic hydrolysis using the enzyme Candida rugosalipase. It appears that the key factor affecting the degradation was its crystallinity.

Scanning electron microscope (SEM)

The morphological analysis was carried out using a SS 550 Scanning Electron Microscope (Shimadzu). The acceleration voltage was 7 kV and the samples were sputtered with gold prior to the analysis. The samples were analyzed as thin film.

3.   Results and Discussion

Solubility

The copolyesters are freely soluble in chloroform and carbon tetrachloride, soluble in dichloromethane and tetrahydrofuran, sparingly soluble in N,N'-DMS and acetone. The prepared copolyesters are insoluble in water, hexane, diethyl ether and methanol.

3.2 Viscosity of the Polyesters

The inherent viscosity of the random copolyesters were calculated from the relative viscosity which were obtained from the flow time of the pure solvent and polyester solution using Ubbelohde viscometer in chloroformat $30°C$ and at the concentration of 0.10g/dL. The viscosity value of P(BSu-co-BAd)is higher than the P(BSu-co-ESu) polymer. Among polymers of comparable molecular weight, rigid polymers possess a higher viscosity value than flexible one.

Spectral studies

IR Spectra

The IR spectra have been recorded for all the synthesized polyesters and are presented in Fig 1-7. The IR spectra of the synthesized pre-polymers show a strong absorption bond at around 1730 cm^{-1}, which is characteristic absorptions of carbonyl stretching vibration of ester groups and thus confirmed the formation of polyesters. The bonds centered at around 2947 and 2932 cm^{-1} were assigned to methylene (-CH2-) groups for the diacids/diols and observed in all the spectra of the polyesters.The broad stretch at 3430 cm^{-1} was attributed to the stretching vibration of the hydrogen bonded carboxyl and hydroxyl groups.
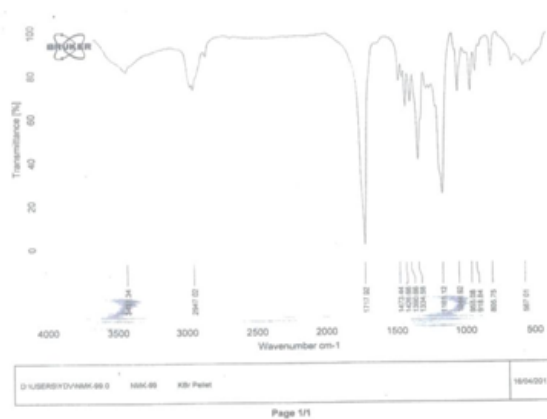
Figure 1: IR Spectrum of PBSu
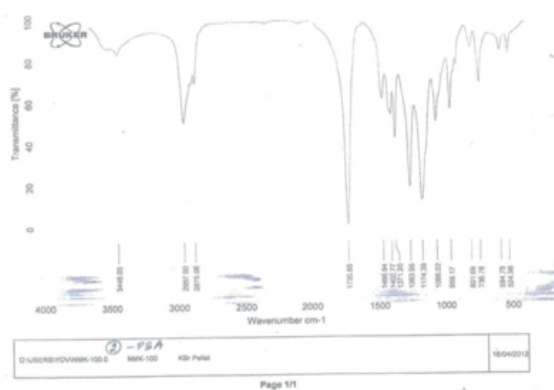
Figure 2: IR Spectrum of PBAd
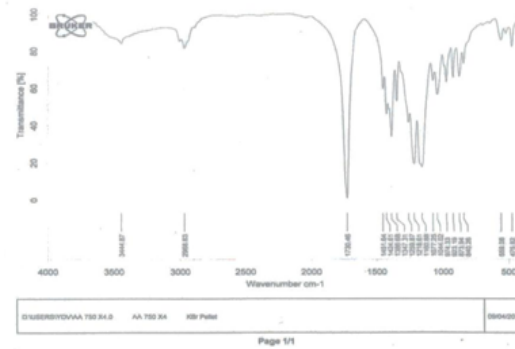
Figure 3: IR Spectrum of PESu
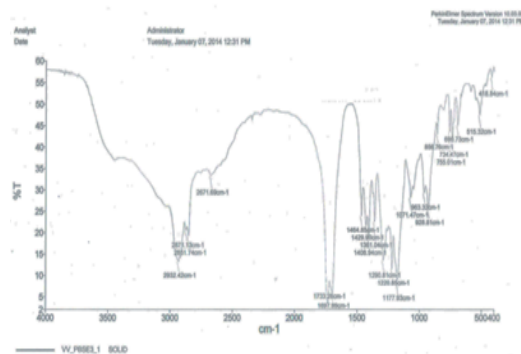
Figure 4: IR Spectrum of P(BSu-co-BAd)
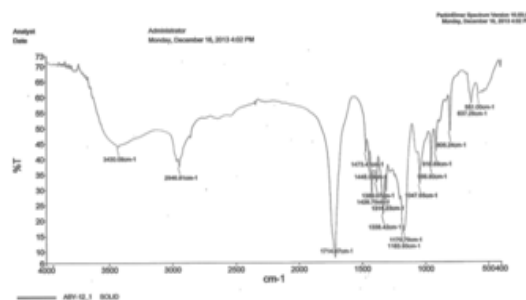
Figure 5: IR Spectrum of P(BSu-co-ESu)

Absorption Frequency, cm^{-1}			
PBSu	PBAd	PESu	Assignment
1717.92	1730.89	1730.46	C=O stretching of ester group
1390.66, 1334.58	1263.95, 1174.39	1218.61, 1160.88	C-O stretching of ester group
2947.02	2957.00	2968.63	aliphatic C-H stretching
1426.66	1402.77	1424.61	aliphatic C-C stretching

Table. 1

Absorption Frequency, cm^{-1}		
PBSu-co-PBAd	PESu-co-PESu	Assignment
1733.26, 1697.99	1714.47	C=O stretching of ester group
1177.93, 1220.85	1170.70, 1183.93	C-O stretching of ester group
2932.45	2946.81	aliphatic C-H stretching
1429.90.	1426.7	aliphatic C-C stretching

Table. 2

^{1}H NMR Spectra

The 1HNMRspectra of the polyesters are presented in fig 6-14.
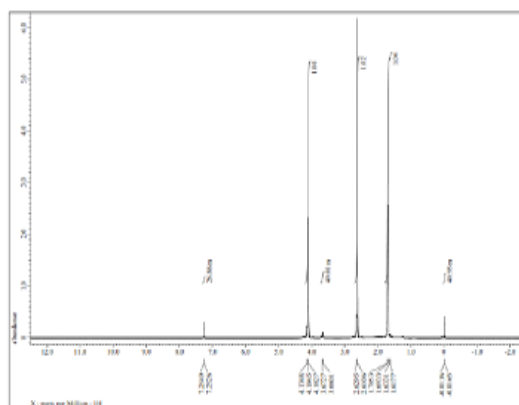
Figure 6: ^{1}H -NMR Spectrum of PBSu
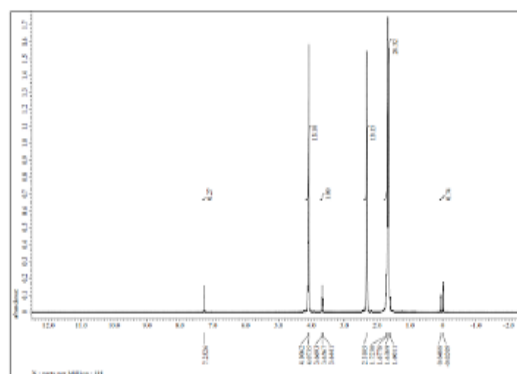
Figure 7: ^{1}H -NMR Spectrum of PBAd
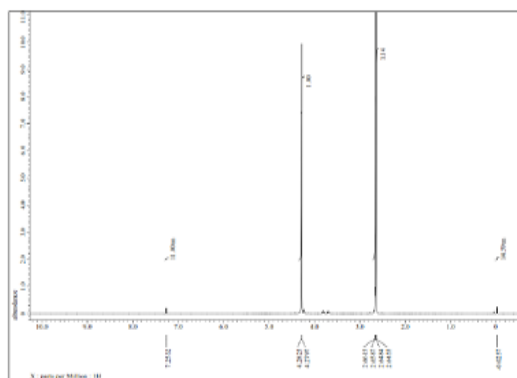
Figure 8: ^{1}H -NMR Spectrum of PESu
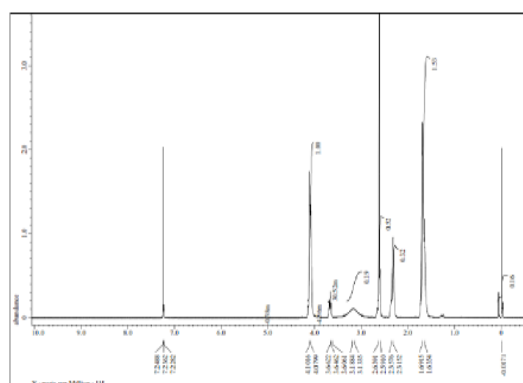
Figure 9: ^{1}H -NMR Spectrum of P(BSu-co-BAd)
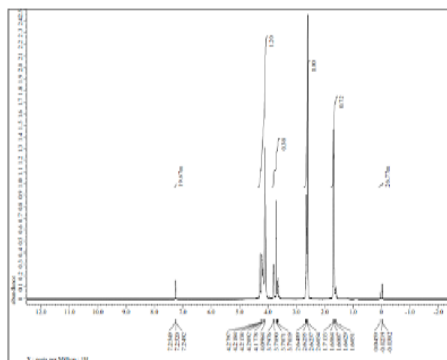
Figure 10: ^{1}H -NMR Spectrum of P(BSu-co-ESu)

The ^{1}H NMR spectrum of PBSu spectra exhibited the characteristic peaks at 3.6601-4.1348, 2.6106-2.6295 and 1.6177-1.7053ppm for $-O-CH_2-$ of Butanediol, $-CO-CH_2-$ of succinic acid and $-CH_2$ - of Butanediol respectively, while the PBAd showed the characteristic peaks at 3.6441-4.1062, 2.3105 and 1.6011-1.7230ppm for $-O-CH_2-$ of Butanediol, -CO-CH2- of adipic acid and -CH2- of Butanediol and adipic acid respectively.The PESu showed characteristic peaks at 4.2797-4.2825 and 2.6455-2.6615 ppm for $-O-CH_2-$ of Ethanediol, $-CO-CH_2-$ of succinic acid respectively. All these characteristic peaks are found in the spectrum of the copolyester P(BSu -co-BAd) and P(BSu-co- ESu) given in figures (9) and (10).

^{13}C NMR Spectra of Oligomers

The ^{13}C NMRspectra of the polyesters are presented in fig 11-15.
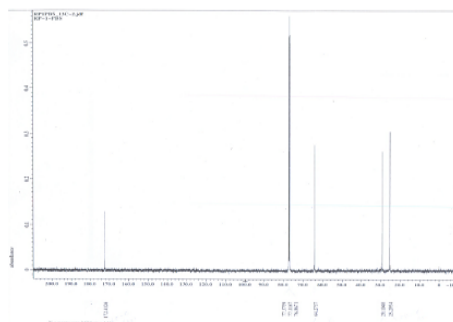
Figure 11: ^{13}C -NMR SPECTRUM OF PBSu
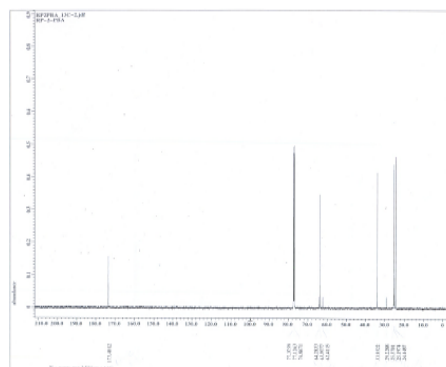
Figure 12: ^{13}C -NMR SPECTRUM OF PBAd
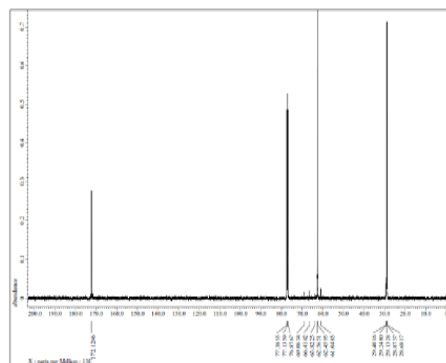
Figure 13: ^{13}C -NMR SPECTRUM OF PESu
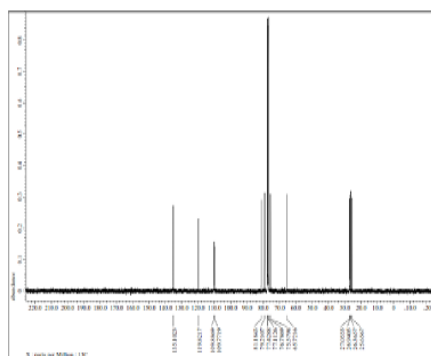
Figure 14: ^{13}C -NMR SPECTRUM OF P(BSu-co-BAd)

The ^{13}CNMR spectra of PBSu exhibited the signals at 25.2934, 29.1040, 64.2737 and 172.4126 ppm for -CH$_2$- of succinic acid , -CH2 - of Butanediol, -O-CH$_2$– of Butanediol and -COCH$_2$ of succinic acid respectively,while the PBAd spectra showed the peaks at 24.4487-25.3701, 29.2288, 33.9322, 62.415-64.2833 and 173.4012 ppm for -CH$_2$- of Adipic acid , -CH$_2$ - of Butanediol, -COCH$_2$- of Adipic acid, -OCH$_2$- of Butanediol, and -CO of Adipic acid respectively. The PESu spectra showed the peaks at 28.8737-29.4016, 61.0485-62.4595, and 172.1246 ppm for -CH2- of succinic acid , -OCH2 - of Ethylenediol, and -CO of succinic acid respectively.All the characteristic peaks of PBSu and PBAd were also recorded in the copolymer P(BSu-co-BAd) and P(BSu-co-ESu) given in figures (14) and (15).
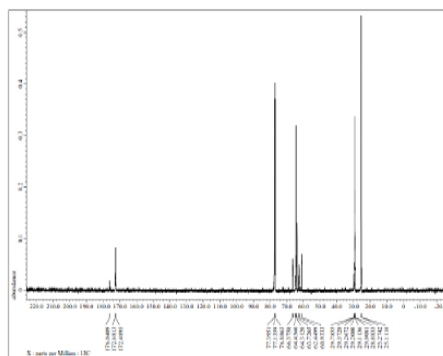
Figure 15: ^{13}C -NMR SPECTRUM OF P(BSu-co-ESu)

Thermal Analysis

The polyesters were further characterised by thermal analysis and the DSC thermograms. The melting temperature Tm, the glass transition temperature Tg and decomposition temperature Td were found to be-55.9C, -52.8°C -50.5°C and 343.4°C and 404.3°C and 400.6°C for the copolyesters P(BSu-co-BAd) and P(BSu-co-ESu) respectively. It was found that the melting temperatures and the glass transition temperature decreased with increasing number of methylene units.

Powder XRD Analysis

The X ray patterns were collected on a Shimadzu XRD-600 diffractometer, with Cu-Ka radiation (l = 1.54 Å), 30 kV potential and 20 mA current. The samples were analysed as powders. The 2T values were found to be 20.9800 (141), 28.9800 (95), 43.9800 (118) and 49.9800 (80), 20.9800 (182), 21.9800(334), 23.9800 (141), for the copolyesters P(BSu-co-BAd) and P(BSu-co-ESu) respectively.The lower value of copolyester leads to increase the biodegradation.
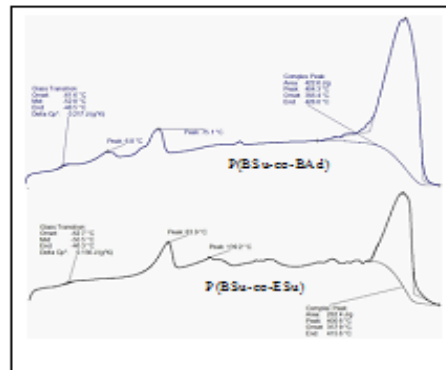
Figure 16: DSC Thermogram of P(BSu-co-BAd) and P(BSu-co-ESu)
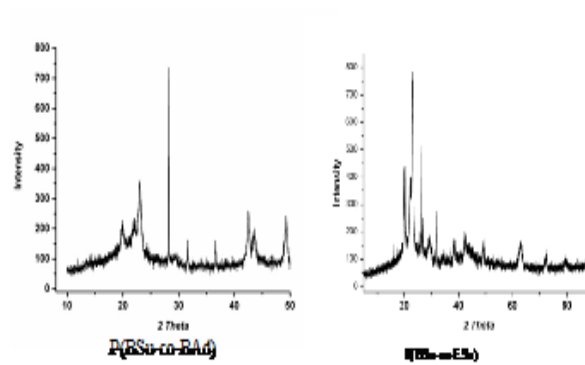
Figure 17: PXRD of P(BSu-co-BAd) and P(BSu-co-ESu)
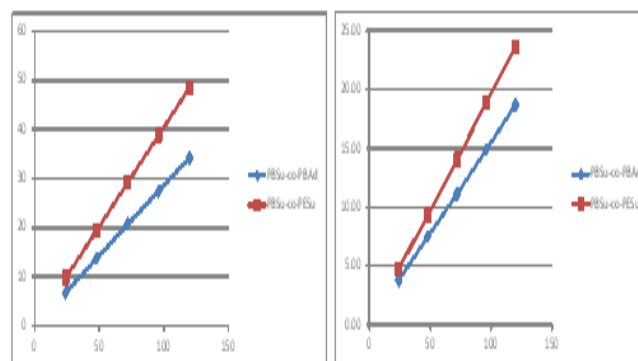
Figure 18:

Biodegradation

The percentage of biodegradation of the synthesized copolyesters was investigated by enzymatic hydrolysis using the enzyme Candida rugosalipase and phosphate buffer solution. It appears that the key factor affecting the degradation was its crystallinity. The percentage of biodegradation of the synthesized copolyester PBSu-co-PESu is higher than PBSu-co-PBAd.

Hrs	% of Biodegradation	
	PBSu-co-PBAd	PBSu-co-PESu
24	6.81	9.77
48	13.69	19.43
72	20.66	29.20
96	27.47	38.86
120	34.27	48.63

Table. 3

Hrs	% of Buffer degradation	
	PBSu-co-PBAd	PBSu-co-PESu
24	3.79	4.72
48	7.49	9.34
72	11.12	14.06
96	14.91	18.88
120	18.70	23.61

Table. 4

Scanning electron microscope (SEM)

The morphological analysis was carried out using a SS 550 Scanning Electron Microscope (Shimadzu). The acceleration voltage was 7 kV and the samples were sputtered with gold prior to the analysis. The samples were analyzed as thin film.

4. Conclusion

This work deals with the synthesis and characterization of aliphatic biodegradablecopolyesters. In all polyesters have been synthesized by direct melt polycondensation of diols and diacids using high T and high vacuum. Aliphatic copolyesters combine the biodegradability and biocompatibility of aliphatic polyesters with the physical properties and thermal properties of aromatic polyesters. They will be playing an important role in maintaining an ecologically friendly environment.These copolyesters were synthesised with a view of increasing their solubility and improving
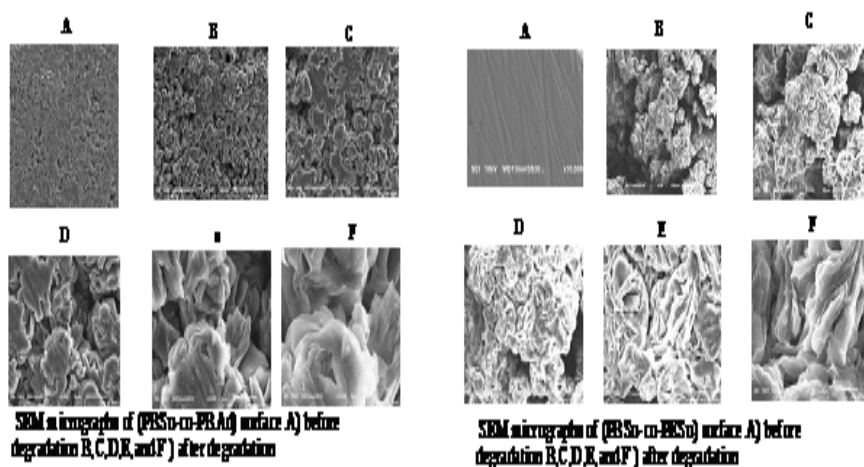
Figure 19: SEM microgram of P(BSu-co-BAd) and P(BSu-co-ESu)

their mechanical properties. The two copolyesters were found to be freely soluble in chloroform and carbon tetrachloride. The inherent viscosities of these polyesters showed that the polyester containing succinate units had higher viscosity than the polyester containing adipate unit. The probable structure of the repeating units present in these polyesters were assigned on the basis of NMR spectral data. From the DSC thermograms it was shown that the introduction of methylene units in the di-acid decreased the Tm and Tg.

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Molecular Based Identification of Colonial Ascidians of Mandapam Coast, India through Sequencing mt-DNA

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Abstract

Accurate and unambiguous identification of marine animals, from eggs to adult, is important for conservation of biodiversity. Conventional morphological identification of species has many limitations particularly in larval and egg stages. This can be addressed through various protein and DNA based methods of genetic identification. Ascidians are sessile and filter-feeding marine animals and are known for several pharmacologically important metabolites. Species identification of ascidians is possible by observing various morphological and anatomical features in various stages of life span. However this method is labour intensive, time consuming and very difficult for non-specialists particularly when dealing with field collections. This study is aimed to identify morphologically similar colonial ascidians collected from Mandapam coast through molecular technique i.e. DNA barcoding. For the present study, the whole genomic DNA of both species 1 and 2 was isolated using Qiagen kit and the cytochrome c oxidase sub unit 1 gene (CO1) of each species was amplified with Universal Primers. Forward and reverse sequences of Species 1 contains 910 and 589 bp respectively whereas Species 2 contains 708 and 629 bp respectively. BLASTn result of both forward and reverse sequences of the Species 1 showed 99 and 98% identity with the species *Didemnum perlucidum* (JQ731735.1 and JQ731740.1). Similarly BLASTn result of the Species 2 showed 99 and 98% identity with the species *Lissoclinum fragile* (KJ725150.1, KM411612.1 and KM411611.1). This result confirmed the identification of species 1 as *Didemnum perlucidum* and species 2 as *Lissoclinum fragile*. This study clearly shows that CO1 gene sequence will help the identification of ascidians through DNA barcoding.

Keywords: Ascidians, Biodiversity, DNA Barcoding, Mandapam, India.

1.   Introduction

The biological diversity of each country is a valuable and vulnerable natural resource. Sampling, identifying, and studying biological specimens are among the first steps toward protecting and benefiting from biodiversity. A prerequisite for conserving biodiversity is the identification of organisms in the field. Today, this task is carried out mainly by taxonomists applying their specialist skills. But dwindling number of taxonomists throughout the scientists' community resulting in the neglect of many highly diverse groups of organisms.

India has a rich natural heritage and nurtures a unique biodiversity, placing it among the 12 most biodiverse countries but it is wretched that only 30% of them have been identified and the remaining is unexplored. India is perhaps the only one that has a long record of inventories of coastal and marine biodiversity dating back to at least two centuries. In this scenario, marine ascidians are gaining paramount importance in raising marine biodiversity of India. Members of the Class Ascidiacea (Sub-Phylum Tunicata), commonly known as ascidians (Sea Squirts), are solitary or colonial organisms with a sessile adult and a tailed free- swimming larva Adults are invariably sessile, attached directly to hard substrates, or fixed in sediments by hair-like or branched root-like extensions of their characteristic, outer acellular covering (known as a test) composed of cellulose-like material known as tunicin.

Ascidians are one of the potential organisms, which are useful to mankind in various ways. They constitute a vast potential resource in varied biotechnological applications such as production of diversified novel drugs (Hirose, 2001), value added products with high nutritive value (Tamilselvi et al., 2010), industrial products(Schmidtet al., 2012), bioremediation (Botte et al., 1979; Nette et al., 1999 and Bellas et al., 2001) etc. Several species of ascidians are cultured for food primarily in Japan, Korea and France (Lambert, 2005).

Routine morphology based species identification has many limitations, and the very meager number of ascidian taxonomists signals the need for a new approach to taxon recognition. Moreover, many colonial ascidians look morphologically similar but genetically they differ each other. So morphology based identification of ascidians particularly colonial forms is very difficult for non-taxonomists who work in other aspects of ascidians.

A wide variety of protein and DNA based methods have been used for the genetic identification of marine species. Species identification by DNA barcoding is based on sequencing a short standardized genomic region of the target specimen and comparing this information to a sequence library from known species. The proposed standard

barcode sequence for animal species is a 650-bp fragment of the mitochondrial gene cytochrome c oxidase 1 (CO1). In this context, this study was aimed to identify morphologically similar colonial ascidians through molecular technique i.e. DNA barcoding.

Materials and Methods

For the present study, commonly available morphologically similar two colonial ascidians (Fig. 1) have been chosen from Mandapam coast.

Collection of specimen

Intertidal region of Mandapam coast was visited at low tides during Dec 2014 and a variety of collection methods were used to obtain the organisms. Specimens were carefully dislodged from their substrate. After narcotization, the specimens were fixed in 10% formalin solution for morphological identification.

Preservation of animal materials

Fresh colonial ascidians were collected from Mandapam coastal area and transported to the laboratory in cold pack. Then whole colony was cleaned with fresh seawater and then distilled water. Small piece of about $3cm^2$ size was cut and preserved in 95% ethanol and kept in ice cold pack for further use.

DNA extraction sequencing

The ethanol preserved ascidian tissues were taken and evaporated the ethanol at room temperature. The genomic DNA was extracted using the standard Phenol-Chloroform method (Sambrook and Russel, 2001). The CO1 fragment was amplified using Eppendorf Mastercycler. The PCR was carried out in 50 L of reaction volumes [40 μL Master mix containing 10X PCR buffer, 10mM dNTPs, 25mM $MgCl_2$ and Taq DNA Polymerase, 2 μL of each forward and reverse primer (1micromole μL^{-1}), 2 μL of DNA template and 4 μL of RNase free water]. LCO1490:5'-GGTCAACAAATCATAAAGATATTGG-3' and HCO2198:5'-TAAACTTCA GGGTGACCAAAAAATCA-3' primers were used for CO1 amplification (Folmer et al., 1994). Thermal cycling was performed with an initial denaturation at 94°Cfor 1 min, followed by 35 cycles of 94°C for 30 s, 45°C for 40 s, and 72°C for 1 min, with a final extension at 72°C for 10 min and chilling at 4°C. The amplified products were detected by 1% agarose gel electrophoresis and visualized through Gel Documentation system for the presence of amplified target region. The amplified products were purified using Qiagen PCR Purification Kit. After purification, the sequencing was carried out with BigDye Terminator v3.1 Cycle sequencing kit using ABI 3500 XL Genetic Analyzer in both the directions.

Sequence Analysis

The sequence quality was checked using Sequence Scanner Software v1 (Applied Biosystems). Sequence alignment and required editing of the obtained sequences were carried out using Geneious Pro v5.1 (Drummond et al., 2010).

The CO1 gene sequences were subjected to BLASTn in NCBI online to compare a query sequence with a library or database of sequences, and identify library sequences that resemble the query sequence above a certain threshold.

Results

The whole genomic DNA of both species 1 and 2 was isolated using Phenol-Chloroform method and the cytochrome c oxidase sub unit 1 gene from the whole genomic DNA of each species was amplified by PCR method in Thermal cycler with Universal Primer in both forward and reverse directions. The amplified products were checked for quality DNA in Agarose Gel Electrophoresis. Gel image taken in Gel Doc system is given in Fig.2. Gel image clearly showed the bands around 650 bp which is the barcode region. This clearly confirmed the presence of CO1 gene in the amplified product.

CO1 gene sequencing of Species 1 and 2

CO1 gene of Species 1 and 2 was sequenced using both forward and reverse primers. Forward and reverse sequences contain 910 bp and 589 bp respectively in species 1. Whereas, CO1 gene sequences of species 2 contain 708 bp and 629 bp respectively (Table 1).

Base pairs		A	T	G	C	GC (%)
Species 1	Forward sequence	321	361	118	110	25.05
	Reverse sequence	261	182	64	79	24.27
Species 2	Forward sequence	218	304	97	89	26.27
	Reverse sequence	261	201	85	82	26.55

Table. 1 Number of base pairs in the CO1 sequences of both Species 1 and 2

The electrophenerogram generated by automated DNA sequencer for both species was read by chromas Pro vl.42 and the peaks were carefully checked for its quality. Simultaneously, GC contents in the barcode region (5' cytochrome oxidase C subunit I) of the selected species were 26% (Table 1).

BLAST

The cytochrome c oxidase sub unit 1 gene of both species 1 and 2 were subjected to BLASTn in the NCBI online. The BLASTn results for Species 1 and 2 were given in Fig. 3 and 4.

BLASTn result of both forward and reverse sequences of the Species 1 showed 99 and 98% identity with the species *Didemnum perlucidum* with GenBank Accession Nos. JQ731735.1 and JQ731740.1 respectively. Similarly BLASTn result of both forward and reverse sequences of the Species 2 showed 99 and 98% identity with the species *Lissoclinum fragile* with GenBank Accession Nos. KJ725150.1, KM411612.1 and KM411611.1, respectively.

Since the range of genetic divergence of species 1 and 2 was less than 3% with *Didemnum perlucidum* and *Lissoclinum fragile*, respectively, the species 1 and 2 could be identified and confirmed as *Didemnum perlucidum* and *Lissoclinum fragie* respectively.

Phylogenetic analysis

Several other cytochrome oxidase subunit 1 sequences of the other ascidians were downloaded from NCBI database via Basic Local Alignment Searching Tool (BLAST) (http://blast.ncbi.nlm.nih.gov/Blast.cgi) for constructing the phylogenetic tree. The phylogenetic tree was constructed using shuffled input and the genetic distance was calculated using pair wise distance analysis using maximum likelihood method. The phylogenetic trees were constructed to test the efficacy of CO1 gene in delineating Didemnum perlucidum and *Lissoclinum fragile* to its species level (Fig.5 and 6).

Discussion

In recent times, molecular markers have aided in identifying organisms in all stages of their life span including tunicates (Wada et al., 1994; Wada, 1998; Swalla et al., 2000; Stach and Turbeville, 2002; Winchell et al., 2002 and Turon and López-Legentil, 2004.). To identify ascidians, the molecular identification method - even without prior optimization - seems to work comparatively well, since a similar number of hits were detected by the modern molecular as well as the classical morphological method. Therefore, it seems to be promising to optimize DNA barcoding for ascidian identification.

The ideal DNA barcoding should be robust, with conserved priming sites and reliable DNA amplifications and sequencing, and the DNA fragment sequenced should be nearly identical among individuals of the same species, but differentiative between

species. CO1 gene sequencing of the Species 1 gave two sequences, forward and reverse having a length of about 910 bp and 589 bp respectively. The GC% of the forward and reverse sequences was 25.05% and 24.27% respectively. Though the reverse sequence was 321 bp less compared to the forward sequence the GC% was almost equal to that of the forward sequence. BLASTn result of the sequence of Species 1 showed the 99% identity with the colonial ascidian, *Didemnum perlucidum.* Since the genetic diversity of the query species with the subject species was less than 3%, the Species 1 could be confirmed as *Didemnum perlucidum.*

Both forward and reverse sequences of CO1 gene of the Species 2 were obtained with a length of about 708 bp and 629 bp respectively. The GC% of the forward and reverse sequences was 26.27% and 26.55% respectively. Though the reverse sequence was 79 bp less compared to the forward sequence the GC% was almost equal to that of the forward sequence. BLASTn result of the sequence of Species 2 showed the 99% identity with the colonial ascidian, *Lissoclinum fragile.* Since the genetic diversity of the query species with the subject species was less than 3%, the Species 2 could be confirmed as *Lissoclinum fragile*.

In recent times, phylogenetic analysis has aided in elucidating evolutionary relationships among the tunicates and most of the studies have demonstrated concordance with the taxonomic relationships among them. Molecular phylogeny clearly showed that the study animals belong to the Class Ascidiaceae. Based on the tree it is understood that both species belong to the family Didemnidae.

Molecular phylogeny between the study animals confirmed the colonial nature of the study animals. This tree also showed the relationship with other ascidians which are exclusively colonial. This analysis, based on the commonly used mitochondrial gene cytochrome c oxidase 1 (the standard DNA barcode for animal species) is capable of discriminating ascidian species with high accuracy.

Other DNA markers can provide assistance to species identification in cases where CO1 is lack of high resolving power. While DNA barcoding provides taxonomic identification for a given specimen, accuracy depends on whether there is an exact or nearly matches to that species in the database. It is desirable that CO1 sequences representing each taxon in the reference database can cover the major part of the existing diversity. The combination of morphological and molecular characteristics can bridge the gap between morphological taxonomy and the DNA barcoding approach (De Salle et al., 2005). This idea has been embodied in the establishment of BOLD. DNA sequences in BOLD are derived from voucher specimens preserved in museums all around the world. One can solve any problems concerning morphological identification by searching the relevant database or sending inquiries to confirm voucher specimens.

Figure. 1 Colonial ascidians of Mandapam coast, India
(a) Colony of Species 1 (b) Colony of Species 2
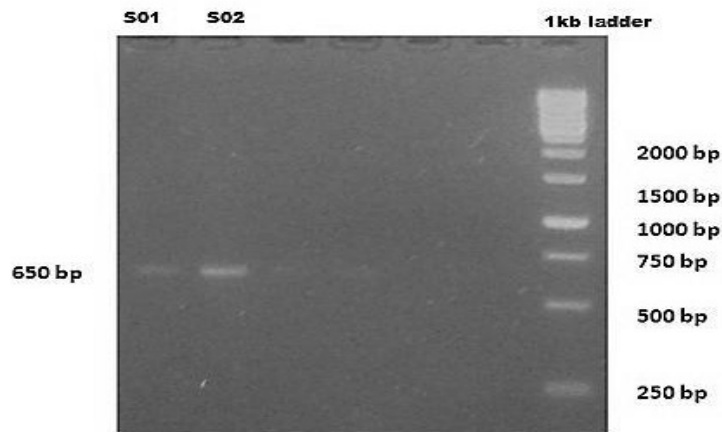
Figure. 2 Gel Image showing bands of amplified CO1 gene of Species 1 and 2
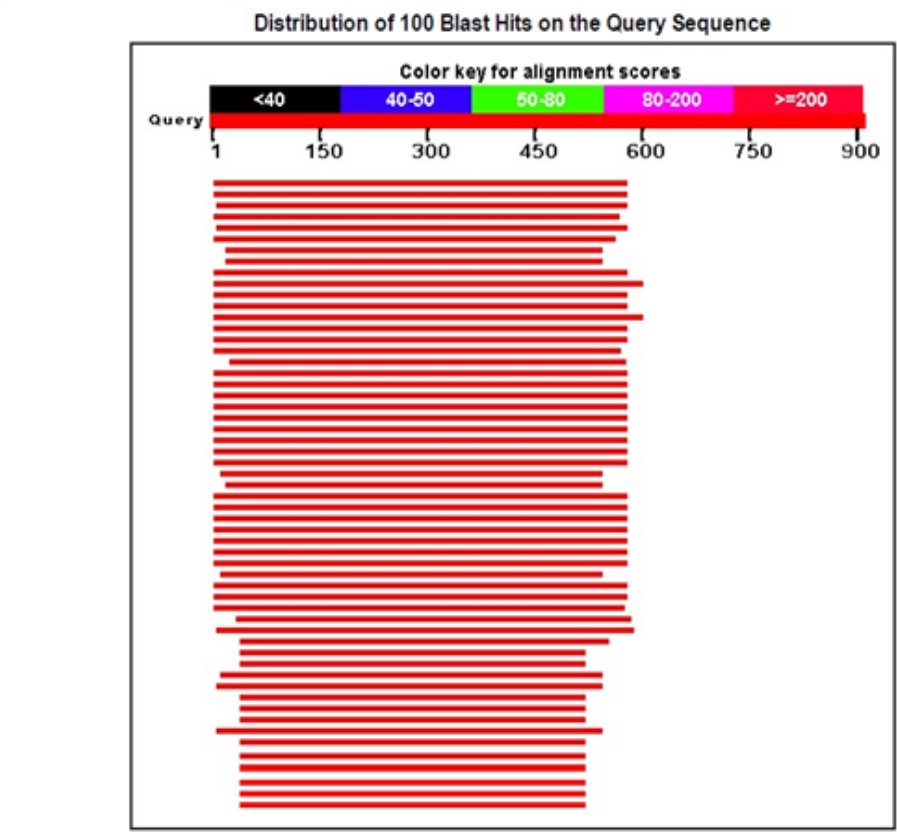
Figure. 3 BLASTn result of CO1 sequence of Species 1

Descriptions

Sequences producing significant alignments:

Description	Max score	Total score	Query cover	E value	Ident	Accession
Didemnum perlucidum isolate 2 cytochrome oxidase subunit I (COI) gene, partial cds; mitochondrial	1037	1037	62%	0.0	99%	JQ731735.1
Didemnum perlucidum haplotype 7 cytochrome oxidase subunit I (COI) gene, partial cds; mitochondrial	1009	1009	62%	0.0	98%	JQ731740.1
Didemnum sp. ESC-10 cytochrome oxidase subunit I (COI) gene, partial cds; mitochondrial	708	708	62%	0.0	89%	KF309573.1
Didemnum patulum haplotype 2 cytochrome oxidase subunit I (COI) gene, partial cds; mitochondrial	689	689	61%	0.0	89%	JQ731737.1
Didemnum sp. DS-4 cytochrome oxidase subunit I (COI) gene, partial cds; mitochondrial	680	680	62%	0.0	88%	KF309622.1
Didemnum patulum haplotype 1 cytochrome oxidase subunit I (COI) gene, partial cds; mitochondrial	680	680	61%	0.0	89%	JQ731736.1
Didemnum patulum haplotype 6 cytochrome oxidase subunit I (COI) gene, partial cds; mitochondrial	675	675	57%	0.0	90%	JQ731739.1
Didemnum patulum haplotype 4 cytochrome oxidase subunit I (COI) gene, partial cds; mitochondrial	669	669	57%	0.0	90%	JQ731738.1
Didemnum psammatode voucher RMNH.UROCH.746 cytochrome oxidase 1 (COI) gene, partial cds; mitochondrial	636	636	62%	2e-178	87%	EU742661.1
Didemnum vexillum isolate clade B mitochondrion, complete genome	630	630	65%	1e-176	86%	KM259617.1
Didemnum vexillum haplotype 16 cytochrome oxidase subunit I (COI) gene, partial cds; mitochondrial	621	621	62%	6e-174	86%	JF738068.1
Didemnum vexillum voucher RMNH.UROCH.758 cytochrome oxidase 1 (COI) gene, partial cds; mitochondrial	621	621	62%	6e-174	86%	EU742669.1
Didemnum vexillum isolate clade A mitochondrion, complete genome	616	616	65%	3e-172	85%	KM259616.1
Didemnum vexillum haplotype 21 cytochrome oxidase subunit 1 (co1) gene, partial cds; mitochondrial	616	616	62%	3e-172	86%	JQ663515.1
Didemnum vexillum haplotype 17 cytochrome oxidase subunit I (COI) gene, partial cds; mitochondrial	616	616	62%	3e-172	86%	JF738069.1
Didemnum psammatode strain sri1 cytochrome C oxidase subunit I (COI) gene, partial cds; mitochondrial	614	614	61%	1e-171	86%	JN624758.1
Didemnum sp. BAOR-2012 isolate F cytochrome oxidase subunit I (COI) gene, partial cds; mitochondrial	610	610	60%	1e-170	87%	JQ731748.1
Didemnum vexillum haplotype 13 cytochrome oxidase subunit I (COI) gene, partial cds; mitochondrial	610	610	62%	1e-170	86%	JF738065.1
Didemnum vexillum voucher RMNH.UROCH.757 cytochrome oxidase 1	610	610	62%	1e-170	86%	EU742668.1

Figure. 4 BLASTn result of CO1 sequence of Species 2

Descriptions

Sequences producing significant alignments:

Description	Max score	Total score	Query cover	E value	Ident	Accession
Lissoclinum fragile voucher DBTIC26 cytochrome oxidase subunit I (COI) gene, partial cds; mitochondrial	1033	1033	83%	0.0	98%	KM411611.1
Lissoclinum fragile voucher ICBT.ASC006 cytochrome oxidase subunit I (COI) gene, partial cds; mitochondrial	1024	1024	81%	0.0	99%	KJ725150.1
Lissoclinum fragile voucher DBTIC24 cytochrome oxidase subunit I (COI) gene, partial cds; mitochondrial	891	891	70%	0.0	99%	KM411612.1
Lissoclinum fragile clone 08Jun08-1-5 cytochrome c oxidase subunit I (COI) gene, partial cds; mitochondrial	688	688	81%	0.0	88%	JF506180.1
Lissoclinum aff. fragile SLL-2011 clone 04Jun08-1-7 cytochrome c oxidase subunit I (COI) gene, partial cds; mitochondrial	665	665	81%	0.0	87%	JF506183.1
Lissoclinum aff. fragile SLL-2011 clone 09Jun081-2 cytochrome c oxidase subunit I (COI) gene, partial cds; mitochondrial	665	665	81%	0.0	87%	JF506182.1
Lissoclinum fragile clone 07Jun08-1-1 cytochrome c oxidase subunit I (COI) gene, partial cds; mitochondrial	664	664	78%	0.0	88%	JF506185.1
Lissoclinum fragile isolate GAPB11 cytochrome oxidase subunit I gene, partial cds; mitochondrial	632	632	81%	2e-177	86%	KM924170.1
Lissoclinum fragile isolate GAPB12 cytochrome oxidase subunit I gene, partial cds; mitochondrial	577	577	81%	1e-160	85%	KM924171.1
Ciona sp. ROS-5 cytochrome oxidase subunit I (COI) gene, partial cds; mitochondrial	222	222	68%	5e-54	75%	KF309636.1
Colletes antecessus cytochrome oxidase subunit I gene, partial cds; mitochondrial	220	220	68%	2e-53	75%	EF028529.1
Euploea klugii voucher YB-KHC6761 cytochrome oxidase subunit 1 (COI) gene, partial cds; mitochondrial	207	207	69%	2e-49	75%	HQ962260.1
Colletes graeffei voucher BC ZSM HYM 10010 cytochrome oxidase subunit 1 (COI) gene, partial cds; mitochondrial	206	206	42%	5e-49	79%	KJ838657.1
Melinaea sp. 4YB voucher YB-BCI51 cytochrome oxidase subunit 1 (COI) gene, partial cds; mitochondrial	204	204	36%	2e-48	81%	HM416521.1
Euploea sylvester isolate A35 cytochrome oxidase subunit I (COI) gene, partial cds; mitochondrial	202	202	69%	7e-48	74%	KJ459745.1
Euploea sylvester isolate A13 cytochrome oxidase subunit I (COI) gene, partial cds; mitochondrial	202	202	69%	7e-48	74%	KJ459725.1
Euploea sylvester isolate A6 cytochrome oxidase subunit I (COI) gene, partial cds; mitochondrial	202	202	69%	7e-48	74%	KJ459723.1
Euploea sylvester voucher LEP131 cytochrome oxidase subunit 1 (COI) gene, partial cds; mitochondrial	202	202	69%	7e-48	74%	KC306721.1
Melinaea marsaeus mothone voucher 2-						

Figure. 5 Phylogenetic tree of Species 1, *Didemnum perlucidum*
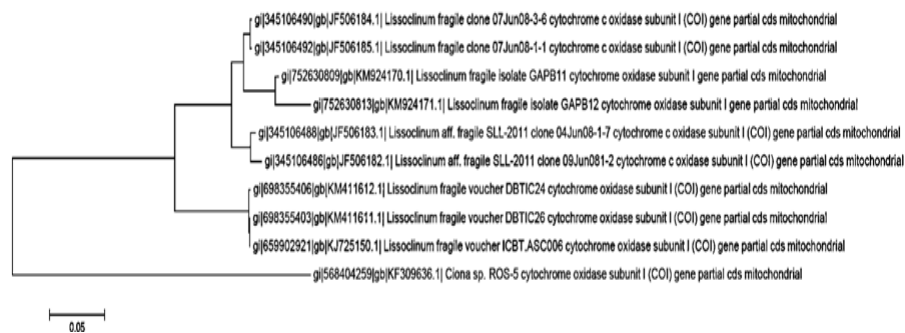
Figure. 6 Phylogenetic tree of Species 2, *Lissoclinum fragile*

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Diversity of Ascidians in the Selected Transects along the Thoothukudi Coast

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Abstract

Indian coastline is dotted with 12 major ports and number of minor ports and provided with diverse habitats which are ideal for the settlement of number of ascidians. Even though India has very long coastline extending to about 7000 km, only limited species of ascidian have been recorded. Exhaust review of literature revealed that there are untouched and undisturbed areas available in Indian regimes. These areas are to be explored not only for conserving the biodiversity but also for monitoring the alarming entry of exotic species through ballast water and hull of ships, as these species have significant effects on biodiversity rich area. In this context, the present study is aimed to report ascidians of two ecologicallysignificant stations such as Hare Island and Inigo Nagar located along the Thoothukudi coast. A total 20 species of ascidians have been reported. Station 1 was found to harbour seven species of ascidians which are exclusively colonial whereas 15 species of ascidians with only two simple ascidians has been found at station 2. Among 15 species, Microcosmus curuvus and Styela canopus were predominant whereas at station 1, Eudistoma viride and E. muscosum were dominant. As this preliminary work could give as many as 20 species of ascidians in only two untapped areas, a detailed survey on various unexplored areas along with seasonal availability, factors affecting colonization, succession at different depths etc is sure to yield a rich haul of ascidians in future.

Keywords: Ascidians, diversity, occurrence, Thoothukudi coast, India.

1. Introduction

The diversity of marine life underpins all biological studies. Many animals in the ocean live and vanish even without being noticed by us. Hence they hardly find a place in the faunistic list of our natural resources. The biological diversity of each country is a valuable and vulnerable natural resource. Sampling, identifying, and studying biological specimens are among the first steps toward protecting and benefiting from biodiversity. In fact, few taxonomists can critically identify more than 0.01% of the estimated 10-15million species. Training in taxonomy has declined dramatically over the last several decades, so that the appropriate scientists may not be available to describe the next round of unique species in a newly discovered marine habitat. It is well understood that every species makes some contribution to the structure and function of its ecosystem. In this contex, Ascidians, belonging to the subphylum Urochordata, are gaining paramount importance as they contribute a lot to the stability of the marine ecosystem by providing a fertile ground for a number of aquatic fauna, a part of food chain, prey for many marine animals, store house of bioactive compounds and serve as indicators to assess the quality of water (Abdul Jaffar Ali, 2004; Tamilselvi, 2008; Tamilselvi et al., 2010; Abdul Jaffar Ali et al., 2011 and Karthikeyan et al., 2009). They are also farmed and fished in many parts of the world for food particularly in Korea, France, Japan and Chile (Davis and White, 1994). The diversity of ascidians around the world is truly stunning.

Currently more than 3000 ascidian species have been described in all marine habitats. They are found from the tropics to the poles (Sahade et.al., 1998) and from shallow water to the deep sea (Kott, 2005). India has a rich natural heritage and nurtures a unique biodiversity, placing it among the 12 most biodiverse countries but it is wretched that only 30% of them have been identified and the remaining is unexplored. India is perhaps the only one that has a long record of inventories of coastal and marine biodiversity dating back to at least two centuries. Though Indian subcontinent is blessed with a rich marine fauna, it is pitiable to note that around 400 species of ascidians have been recorded in Indian coastal water by various researchers at different situations (Renganathan, 1984; Meenakshi, 1997; Abdul JaffarAli and Sivakumar, 2007; Abdul Jaffar Ali et al., 2009 and 2011;Tamilselvi, 2008 and Tamilselvi et al., 2012). Exhaust review of literature revealed that there are untouched and undisturbed areas available in Indian regimes. These areas are to be explored not only for preserving the biodiversity rich area but also alarming the entry of exotic species, as these species have significant effects on biodiversity rich areas (Tamilselviet al., 2011 and 2012). Tropical marine habitat provides favourable features of environment such as suitable substratum for attachment and temperature which promotes continuous breeding of ascidians. Though India is a tropical country with a vast stretch of coastline extending to several kilometers, there is a popular belief among the biologists that the ascidians are rare and extremely

poor with respect to number of species and abundance. In spite of being conspicuous and macroscopic very little attention has been given to this group in India. India lags behind the rest of the world, not only in the taxonomical study of the ascidians but also on other aspects like biochemistry, microbiology, toxicology, breeding, aquaculture etc.

Thoothukudi coast is located in the Gulf of Mannar Marine Biosphere Reserve which provides suitable substrata for the attachment of ascidians. In this context, the present study is aimed to report ascidians of two ecological different stations such as Hare Island and Inigo Nagar along the Thoothukudi coast. Occurrence and diversity of ascidians were reported by Renganathan, 1981; Meenakshi, 1997, Abdul Jaffar Ali, et al., 2009 and Tamilselvi, et al., 2011 and the number of ascidians has been raised to 85. Still there are many untapped areas along the Thoothukudi. Changes in geographical and ecological parameters influenced diversity of marine animals. Thoothukudi coast is highly prone to these changes due to urbanization, pollution, extension of vast areas, etc.

Materials and Methods

Collection Sites

For the present study, two ecologically significant stations such as Hare Island (1) and Inigo Nagar (2) situated along the Thoothukudi coast of India (Fig 1).

Figure. 1 Map showing study areas - Station 1 (Hare Island)
and Station 2 (Inigo Nagar)

Area Descriptions

Station 1 It covers an inter-tidal rocky area of the coast. It is a narrow one with small and large sized naturally embedded and broken loose rocks.

Station 2 Location of this station is just 15km away from the station 1, but observations were made on the artificial substrates such as large calcareous stones, small stones etc.

S. No.	Species	Station 1	Station 2
Family: STYELIDAE			
1	*Botrylloides chevalense* (Herdman, 1906)	-	x
2	*Symplegma oceania* Tokioka, 1961	x	-
3	*Styela canopus* (Savigny, 1816)	-	x
Family: PYURIDAE			
4	*Microcosmus curvus* Tokioka, 1954	-	x
5	*Herdmania pallida* (Savigny, 1816)	-	x
Family: POLYCITORIDAE			
6	*Eudistoma lakshmiani* Renganathan, 1986	-	x
7	*E. laysani* (Sluiter, 1900)	-	x
8	*E. muscosum* Kott, 1990	x	-
9	*E. viride* Tokioka, 1955	x	-
Family: POLYCLINIDAE			
10	*Polyclinum fungosum* Herdman, 1886	-	x
11	*P. inidicum* Sebastian, 1954	-	x
12	*P. madrasensis* Sebestian, 1952	-	x
13	*P. nudum* Kott, 1992	-	x
14	*P. tenuatum* Kott, 1992	-	x
Family: DIDEMNIDAE			
15	*Didemnum candidum* Savigny,1816	x	x
16	*D. psammathodes* (Sluiter,1895)	x	x
17	*Diplosoma macdonaldi* Herdman, 1886	-	x
18	*D. swamiensis* Renganathan, 1986	-	x
19	*Lissoclinum bistratum* (Sluiter, 1905a)	x	-
20	*L. fragile* (Van Name,1902)	x	-
	Total	7	15

Note: x - present; - - absent

Table. 1 List of ascidians collected from the study areas

Method of collection

Collection, narcotization, preservation and identification are the important aspects of this present study. Intertidal sites were visited at low tides and a variety of collection methods were used to obtain the organisms.

Specimens were carefully dislodged from their surfaces using a sharp fishing knife. All the specimens were narcotized with menthol crystals for up to 3 hours and were fixed quickly in 10% formalin. The specimens were sorted and taxonomically important characters were studied with the help of various microscope including stereo microscope, taxonomic keys and references. All the observed characters were compared with published data and analyzed with various taxonomical keys of Kott and Monniot.

2. Results

A total of 20 species of ascidians including 17 colonial and 3 simple ascidians were recorded in the present study (Table 1).

Station 1 harbored only seven species of ascidians which are exclusively colonial covering three families such as Didemnidae (4), Polycitoridae (2) and Styelidae (1).
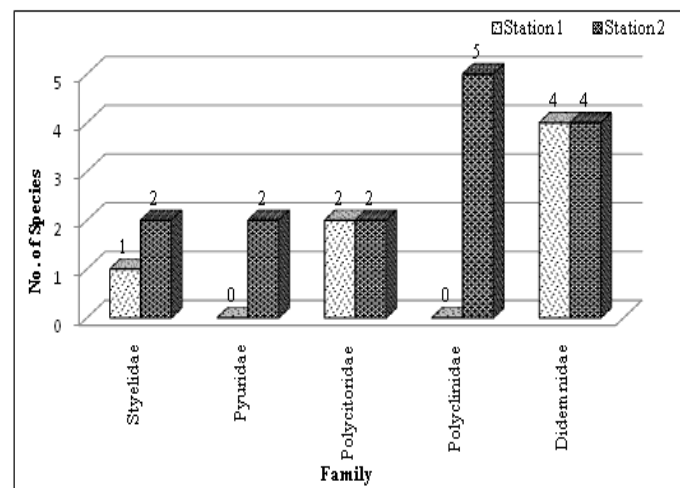
Figure. 2 List of members of family at both the stations

Station 1 recorded lower number of species as compared to station 2.

Station 2 was found to harbour 15 species of ascidians including three simple ascidians covering five families such as Polyclinidae (5), Didemnidae (4), Polycitoridae, Pyuridae and Styelidae (2 each).

At both the stations, colonial ascidians were dominant over the simple ascidians. Of the five families, maximum of 6 species was recorded from Didemnidae followed by 5 species from Polyclinidae, 4 from Polycitoridae, 3 from Styelidaeand 2 from Pyuridae (Fig 2).

Of the 20 species, 2 species namely, *Didemnum psammathodes* and *D. candidum* were found at both the stations.

3. Discussion

The number of ascidian species recorded in two different stations is ranges from 7 species to 15 species. The maximum number of species was found in Station 2.

Station 1 was found to harbour lesser number of species and this could be attributed to the lack of different types of substratum. Moreover since this station is located near open sea, it is subjected to heavy wave action which influence access of larva of ascidian on to the hard substratum. In this station only natural substrates are available, which support the recruitment of native species rather than alien ascidians. In addition, this is one of major tourist spot in Tamilnadu resulting in exposure of this coast to anthropogenic activities. Swami and Kanrande (1988) attributed the increased turbidity as the probable factor for the lack of ascidian settlement. Similar observations have also been made by Venkatet al., (1995). The occurrence of ascidians species is limited by local shortage of suitable hard substratum, which could be substantiated, with that of Miller (1950). Monniot (1951) reported that even in the presence of suitable objects it has been observed that the number of certain Pyurids may be limited if the objects were far apart. Differences in the occurrence and distribution of ascidians might not only because of the shortage of suitable substratum, but also be due to the changes in the physical parameters, like temperature, salinity, dissolved oxygen, food availability and seasonality for the ascidian species at different stations.

Maximum numbers of ascidian species were recorded at station 2. This could be attributed that the station 2 is provided with different kinds of substratum and other large embedded rocks which afford excellent habitats and settlement of ascidians and also to lesser wave action. The same results have been observed from Thoothukudi harbour by Meenakshi (1997) and from Vizhinjam Bay by Abdul Jaffar Ali et al., (2007).

Of the 7 species, 2 species namely Eudistoma muscosum and Lissoclinum bistratum were found to be new report to the station 1. These species have already been reported elsewhere in India by various authors during different periods (Meenakshi, 1997; Abdul Jaffar Ali et al., 2007 and Tamilselvi et al., 2011).

Out of 15 species of ascidians, six species such as Herdmania pallida, Polyclinum fungosum, P. indicum, P. madrasensis, P.nudum and P. tenuatum and have entered the station 2 for the first time. These species have previously been reported in Thoothukudi Harbour area and Mandapam coast (Meenakshi, 1997; Abdul Jaffar Ali et al., 2007). Recruitment of these species at station 2 could be due to the advances in shipping and more frequent intracoastal traffic by fishing vessels. Fishing vessels and pleasure craft are generally not as rigorously maintained as commercial vessels, with the result that a variety of fouling organisms may settle and grow on the hull. Once in a new location, fouling organisms may successfully produce motile larvae that spread.

The distribution of all these species at the stations observed in the present study may be due to periodical transport of fishing vessels to and fro for seasonal fishing. In the present observation, two species such as, *Didemnum candidum and D. psammathodes* were common in both the stations. This could be attributed to the ability of these two species to respond to difference in the substratum and other environmental factors may account for much of the variability so often noted in ascidians.

Research on diversity and ecology of ascidians is still in infancy due to lack of ascidian taxonomists and other difficulties such as adequate sampling sizes and scattered sampling locations. As even preliminary survey on ascidians at untapped coastal regions could give as many as 20 species with 8 new entrants, a detailed survey with seasonal availability, factors affecting colonization, succession at different depths etc. is sure to yield rich haul of ascidians in future.

ACKNOWLEDGEMENTS

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Revolution-Based Optimization Structure for Enhancing the Performance and Cost of Workflows in the Cloud

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Abstract

In recent times, performance and economic cost optimizations for workflows from various applications in the cloud have become a warm research topic. However, we find that most existing studies adopt wireless optimization strategies, which fail to arrest the key optimization opportunities for different workloads and cloud presents. This paper proposes ROS, a general Revolution- Based Optimization Structure for workflows in the cloud. Specifically, ROS formulates six basic workflow transformation operations. An subjective performance and cost optimization process can be represented as a transformation plan (i.e., a sequence of basic transformation operations).We further develop a cost model guided planner to professionally find the optimized transformation for a predefined objective. We develop ROS on real cloud environments including Amazon EC2 and Rackspace.

Keywords: RoS, Cloud, Trasformation Operations, Optimization Workflows.

1.   Introduction

Cloud Computing has become an important computing infrastructure for many applications. Its pay-as-you-go pricing scheme has attracted many application owners to either deploy their applications in the cloud or extend their home clusters to cloud when the demand is too high. In recent years, we have witnessed many scientific applications partially or entirely shifting from traditional computing platforms (e.g. Grid) to the cloud.

A lot of scheduling and optimization approaches have been developed .Despite of a lot of research efforts in this area, performance and cost optimizations of workflows in the cloud are still a non-trivial task, because of the following complicated and inter-connected factors. First, users have different requirements performance and cost.

Some existing on studies ,have focused on minimizing the cost while satisfying the performance requirement, some are aiming to optimize performance for a given budget and others are considering the trade-off between performance and economic cost Second, different cloud offerings result in significantly different cost structures for running the workflow. Even from the same cloud provider, there are multiple types of virtual machines (or instances) with different prices and computing capabilities. Third, workflows have very complicated structures and different computation/IO characteristics, as observed in the previous. However, previous studies have shown that carefully selecting instance types is important for the overall cost. Focus on minimizing the cost while satisfying the performance requirement of individual workflows, and simply use a fixed sequence of workflow transformation operations. The fixed sequence can be effective for some of the workflows and cloud offerings, but ineffective for others. To address the limitations of current approaches, we believe that an extensible workflow framework is essential for different and even evolving user requirements, cloud offering and work-flows. We have identified three design principles. First, the framework should have an extensible design on the workflow optimizations, which adapts to different cloud offerings and workflow structures. Second, the framework should have a general optimization process for different requirements on performance and cost constraints.

Last, the framework should be light weight for on-line decision making. With these three design principles in mind, we propose RoS, a Revolution-Based Optimization Structure for optimizing the performance and cost of workflows in the cloud. A workflow is generally modeled as a Directed Acyclic Graph (DAG) of tasks. RoS guides the scheduling of each task in the workflow, including which instance to assign to and when to start execution. Based on the initial instance assignment, we perform transformations on the DAG.

We categorize the transformation operations into two kinds, namely main schemes and auxiliary schemes. The main schemes reduce economic cost while auxiliary schemes transform workflows into a DAG that is suitable for main schemes to perform cost reduction. Specifically, we have formulated six basic workflow transformation operations (Merge, Demote, Split, Promote, Move and Co-scheduling). The former two are categorized as main schemes and the latter four are auxiliary schemes.

We further develop a cost model guided planner to help users to efficiently and effectively choose the cost-effective transformation. The cost model estimates the change in both economic cost and execution. time introduced by each transformation operation. Moreover, we develop heuristics (e.g., iteratively choosing the cost-effective main scheme and auxiliary scheme) to reduce the runtime overhead of the optimization process.

We implement the transformation operations and the planner in ROS and evaluate it on Amazon EC2 and Rackspace.

2. Preliminary and Related Work

Cloud Environments

Cloud providers lease computing resources in the form of VMs (or instances). Typically, cloud providers offer multiple types of instances with different capabilities such as CPU speed, RAM size, I/O speed and network bandwidth to satisfy different application demands. Different instance types are charged with different prices. Amazon EC2 mainly charges according to the CPU, whereas Rackspace mainly on the RAM size. Both cloud providers adopt the Instance hour billing model, whereby partial instance hour usage is rounded up to one hour. Each instance has a non-ignorable instance acquisition time. For simplicity, we assume the acquisition time is a constant, lag. When instances are released, the data stored in the local storage will be lost and those on persistent storage are kept.

Cost Optimization for workflows

Performance and cost optimizations are a classic research topic for decades. Many scheduling and provisioning algorithms have been proposed leveraging market-based techniques, rule-based techniques and models for cost, performance and other optimization objectives. Different applications require different performance and cost optimizations. Many relevant performance and cost optimizations can be found in databases, Internet, distributed systems and so on. Performance and cost optimizations for workflows have been well studied on grid, cloud and heterogeneous computing environments. Specifically, we review the most relevant workflow optimizations in the grid and in the cloud. The workflow scheduling problem has been widely studied in the grid environment. Usually, execution time is considered as the most important optimization criterion. There have been many studies focusing on minimizing makes pan. Under the grid market concept, the cost minimization problem has been studied in a good number of studies.

Existing System

Due to the pay-as-you-go computational behavior, the (economic) cost has become an important metric for system optimizations basically; a workflow management system should balance the cost and performance. Thus, performance and (economic) cost optimizations have recently become a hot research topic for workflows in the cloud.

A lot of scheduling and optimization approaches have been developed Despite of a

lot of research efforts in this area, performance and cost optimizations of workflows in the cloud are still a non-trivial task, because of the following complicated and inter-connected factors. First, users have different requirements on performance and cost. Some existing studies have focused on minimizing the cost while satisfying the performance requirement, some are aiming to optimize performance for a given budget and others are considering the trade-off between performance and economic cost Second, different cloud offerings result in significantly different cost structures for running the workflow. Even from the same cloud provider, there are multiple types of virtual machines (or instances) with different. prices and computing capabilities. Third, workflows have very complicated structures and different computation/IO characteristics.

Proposed System

First, maximizing the instance sharing and reuse so that the cost is reduced; Second, reducing the planner overhead. In each plan period, after all the workflows in the queue have been optimized, they are submitted to the cloud with their execution plan for execution. The execution plan is a set of instance requests. Each request includes the instance type, the starting and ending time of the requested instance and the task(s) scheduled to the instance.

3.   Overview of ROS

To support workflow management in the cloud, we have adopted DAG Man to manage task dependencies and added Condo to manage task execution and instance acquisition on real cloud providers. We consider Amazon EC2 and Rackspace in this study. RoS has two major components for performance and cost optimizations: transformation model and planner. The transformation model defines the set of transformation operations for a workflow, and the planner performs the transformation on the workflow according to the cost model. Figure 1 shows the application model of RoS. The period is denoted as the plan period. The workflows submitted during the epoch are temporarily stored in a queue, and then the planner performs optimization for all the workflows in the queue at the beginning of a plan period. This batch processing has two major benefits: first, maximizing the instance sharing and reuse so that the cost is reduced; second, reducing the planner overhead. In each plan period, after all the workflows in the queue have been optimized, they are submitted to the cloud with their execution plan for execution.

The execution plan is a set of instance requests. Each request includes the instance type, the starting and ending time of the requested instance and the task(s) scheduled to the instance. To enable instance reuse at runtime, we maintain a pool of running instances, organized in lists according to different instance types. During runtime,

instances in the pool which reach hourly running time and are currently idle will be turned off.
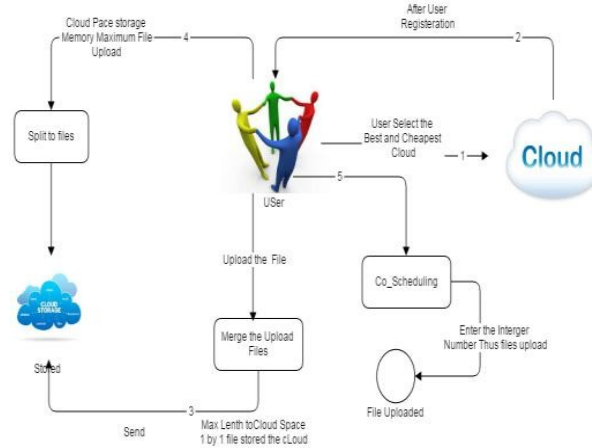
Figure 1: System Overview of ROS

An instance request is processed at the instance starting time by first looking into the instance pool for an idle instance of the requested type. If such an instance is found, it will be selected for workflow execution. Otherwise, a new instance of the requested type is acquired from the cloud provider. Thus, the instances started during workflows execution can be properly reused and their utilizations are improved. Additionally, if we can reuse the instances, the instance acquisition time is eliminated. We present the details of the transformation and optimization components in the next two sections.

4.   Workflow Transformation

Transformation Based Optimizations

Workflow Generally, a workflow structure can be represented by a DAG G= (V; E), where V is the set of vertices representing the tasks in the workflow and E is the set of task is initially assigned to an instance type for execution. According to the assigned instance type, each task execution is represented by the earliest start time, the latest end time and an instance. Our algorithm does not assume any specific initial instance assignment.

We present a number of heuristic-based methods for initial instance assignment in Section 5. Due to the data dependencies among the tasks, the assigned instances themselves also form a DAG. We call this DAG instance assignment graph (denoted as G), which has the same structure as G.

Transformation Set

In current ROS, we have developed six basic transformation operations, namely Merge, Split, Promote, Demote, move and Co-scheduling. These basic transformations are simple and lightweight. Moreover, they can capture the current cloud features considered in this paper.

They are the most common operations and widely applicable to workflow structures. For example, the operations of all the comparison algorithms used in the experiments can be represented using those transformations. However, we do not claim they form a complete set. Users can extend more transformation operations into the transformation set.

Six Transformation Operations are:

1. **Merge** The Merge operation performs on two vertices when they are assigned to the same type of instances and one vertex is assigned to start (shortly) after the completion of the other one. Through merge, the two tasks are assigned to the same instance, and the two instance nodes in the instance DAG are merged to form a super-node, which maintains the hierarchical relationship among the merged nodes and also the structural dependency with other nodes in the DAG.

2. **Demote** Demote operation performs on a single vertex by demoting the execution to a cheaper instance. That can reduce the cost at the risk of a longer execution time. In our implementation, we not only need to change the demoted vertex, but also need to delay the starting time of all vertices that have dependencies on the demoted vertex.

3. **Move** The Move operation moves a task afterward to the end of another task in order to make chances for main schemes to further reduce cost. In our implementation, we not only need to change the moved vertex, but also need to delay the starting time of all vertices that are dependent on the moved vertex. A key decision for the Move operation is where to move the task. Generally we have two cases: move a task to another task so that both tasks are assigned to the same instance type, or to a task with a different instance type. In the former case, we expect a Merge operation after the Move operation.

4. **Promote** The Promote operation is a dual operation for the Demote operation. It promotes a task to a better instance at the benefit of reducing the execution time. The implementation is the same as the Demote operation. There are mainly two incentives to perform the Promote operation.

5. **Split** The Split operation splits a task into two, which is equivalent to suspending a running task so that we can make room for a more urgent task which is assigned

to the same instance type (with a Merge operation). With the check pointing technique, the suspended task can restart after the completion of the urgent task. The Split operation causes the check pointing overhead. The Split operation splits a node in the instance DAG into two sub-nodes, at the time point when the urgent task starts. We maintain their structural dependency with other nodes in the DAG.

6. **Co-Scheduling** Some instance types scheduling operation is to run multiple tasks which have similar start and end time as well as similar leftover time before deadlines on the same instance. The number of tasks is set according to the instance capability and performance degradation. We use the existing model to estimate the performance degradation.

5. ROS Planner

The planner guides RoS to find the optimized transformation sequence for workflows. The selection of each transformation operation in the transformation sequence is guided by a cost Model, which estimates the economic cost and execution time changes introduced by individually applying each transformation operation in the transformation set.

Planner

There are a number of technical challenges in designing and implementing the planner. First, the transformation operations are compostable. The order of applying transformation operations also matters for performance and cost optimizations. The searching space for an optimal transformation sequence is huge. Second, the optimization is an online process and should be lightweight. We should find a good balance between the quality of the transformation sequence and the runtime overhead of the planner. Due to the huge space, a thorough exploration of the optimization space is impractical. Third, the planner should be able to handle different tradeoffs on the economic cost and performance goals. To address these challenges, we have the following designs on the planner. First, the planner is run periodically, as introduced in Section 3. Second, the planner has two heuristics to reduce the searching space. First of all, it uses main schemes and auxiliary schemes alternatively during the optimization process. Second of all, the planner uses the cost model to prune the "unpromising" transformations. Third, the planner is rule- based. The rule is defined to consist of two components: condition and action, where the Condition is usually defined based on the cost and performance optimization goal (e.g., the estimated economic cost can be Reduced by 20%) and the action consists of transformations on the workflow. The set of rules in ROS affects the effectiveness of optimizations. Users can define their own set of rules used in ROS, to reflect their goals on the tradeoff between economic cost

and performance. When applying a transformation operation such as Move, Demote and Split, we pretend to apply the transformation, and check whether the transformed workflow violates the given earliest start and latest end time constraints in order to satisfy the deadline requirement. If the constraints are violated, we will not perform the operation. That means, this study focuses on the goal of minimizing the economic cost while satisfying the deadline. We briefly evaluate the goal of minimizing the execution time given a budget.

6.   Conclusion

Performance and economic cost optimizations for running workflows from different applications in the cloud have become a hot and important research topic.   However, most existing studies fail to offer general optimizations to capture optimization opportunities in different user requirements, cloud offerings and workflows. To bridge this gap, we propose a workflow Revolution Based Optimization Structure namely RoS. We formulate the performance and cost optimizations of workflows in the cloud as transformation and optimization.   The two components are designed to be extensible for user requirements on performance and cost, cloud offerings and workflows. Particularly, we formulate six basic transformation operations. We further develop a cost model guided planner to efficiently and effectively find the suitable transformation sequence for the given performance and cost goal. We evaluate our framework using real world scientific workflow applications and compare with other state of the art scheduling algorithms.

Results show our framework outperforms the state of the art Auto scaling algorithm by thirty percentage for economic cost optimization, and by twenty plus percentage for the execution time optimization. Moreover, the planner is lightweight for online optimization in the cloud environments. As for future work, we consider RoS on multiple clouds. Still, there are many practical and challenging issues for current multi-cloud environments. Those issues include relatively limited cross cloud network bandwidth and lacking of cloud standards among cloud providers.

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Conditional Probabilities Applied in Content Mining for Filtering Text Data

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Abstract

Endeavors to develop an automated arrangement to filter unwanted memos being posted on Online Communal Web users' walls. Generate law to filter the content established on a little criterion. Uses Contraption for Discovering established text classifiers for categorization. Select and extracts discriminate features of short memos to enhance the quality of categorization. By progress in retaining the internet (i.e., Communal Networking) has come to be one of the most area mass media to converse, allocate, transfer, deals, and allocate the data amid every single solitary client in our daily life. Posting or commenting on a discerning Expanse / Confidential spans yelled Walls that might encompass superfluous memo or a sensitive data. Till nowadays, Communal Web needs a slight backup to this requirement. To fulfill this gap, Probability arrangement requesting new thoughts for permitting the online users to have a manage manipulation on memos posted on their User walls.

Keywords: Precision Checking, Discriminate Feature: Bag of Words, Document Property, Contextual Features, Probability Fixing, Pattern Matching, Filtering Rule, and Recommendation System.

1. Introduction

Social Network Service (SNSs) is increasingly appealing the attention of intellectual and industry researchers intrigued by their affordances and reach. This distinct theme serving of the Journal of Computer-Mediated Contact brings jointly scholarship on these emergent phenomena. In this introductory article, we delineate features of SNSs and propose a comprehensive definition. We next present one outlook on the past of such locations, debating key adjustments and developments. Later briefly condensing existing scholarship considering SNSs, we debate the articles in this distinct serving and conclude with considerations for upcoming research.

Classifier is pondered in the extraction and selection of a set of describing and discriminates features. Generally, data excavating (sometimes shouted data or knowledge discovery) is the procedure of analyzing data from different perspectives and condensing it into functional information - data that can be utilized to raise number, cuts costs, or both. Data recovery multimedia is one of a number of analytic instruments for scrutinize data.

Online communal mass media have obtained astounding worldwide development and popularity that has managed to appealing attention from collection of researchers globally. Even though alongside period all generations have come to embrace the adjustments communal web has held concerning, teenagers and youthful adults are the most fanatic users. According to assorted scrutiny studies in the earth of online communal webs, it has been exposed that these locations are impacting the lifetimes of the youth greatly. After employing these locations such as Twitter, Face book or MySpace, there are both affirmative and negative results on the youth.

2.   Review of Literature

(i)   ON THE FLY MESSAGE FILTERING IN A DISTRIBUTED SIMULATION
      APPLICATIONS

Some methods and their idea are presented in high level details of data filtering designs for wide area networks. Performance evaluation tests have shown that data filtering can provide a significant saving in the amount of traffic transmitted over the network. Results of our work to design and evaluate data filtering schemes. Methods to solve the problem of inaccurate state information caused by message filtering are presented and evaluated.

(ii) A SYSTEM TO FILTER UNSOLICITED TEXTS FROM SOCIAL LEARNING
      NETWORKS

Problem in the Existing System: Info filtering can therefore have a solid influence in OSN and it can be used to give users the facility to organize the msg written on public areas by filtering out unwanted wordings. Problem being Solved: A system which may allow OSN user to have a direct control on posting or commenting on their walls with the help of info filtering. This is achieved through text pattern and an matching system, that allows users to filter their web walls and a privilege to add new words treated as unwanted. Work need to progress: Number of blacklisted slang words will grow, search for patterns matching will also grow, which in terms consumes more times.

(iii) SCATTERBLOGS2: REAL-TIME MONITORING OF MICROBLOG
MESSAGES THROUGH USER-GUIDED FILTERING

Problem in the Existing System: Current tools for monitoring micro blogs typically filter messages based on user-defined keyword queries and metadata restrictions. Problem being Solved: With respect to the filter accuracies and adaptabilities to changes in trends and topic structure. Task-tailored message filters in an interactive and visual manner based on recorded messages of well- understood previous events. Did the Work: These message filters include supervised classification and query creation backed by the statistical distribution of terms and their co-occurrence. Work need to progress: To find ways that support analysts in developing strategies to create beneficial filter combinations more quickly or even semi-automatically. We look forward to let analysts test the proposed methods in real monitoring applications.

3.   Existing System

System Model.   In Rule, the ability provider runs a set of servers that store objects, every single of that corresponds to a acquainted communal networking craft such as a Facebook- like "wall", a comment thread, or a photo Clients present updates to these objects, shouted procedures, on behalf of their users. Every single procedure is encrypted below a key recognized merely to a set of authorized users such as a particular user's friends, and not to the provider or supplementary vendors. Then, the act of the provider's / servers is manipulated to storing procedures, allocating them an canonical arranging and returning them to clients on appeal, as well as safeguarding that merely authorized clients can comprise to every single object. To confirm that servers are fulfilling this act devotedly, clients collaborate to confirm their output. Whenever a client performs a elucidate, it checks whether the reply is consistent alongside the replies that supplementary clients received.

Goals.   Filtering ought to gratify the pursuing properties: Broadly applicable: If Law is to be adopted, it has to prop the features of accepted communal webs such as Facebook-like walls or Twitter-like feeds. It have to additionally prop both the symmetric "friend" and "friend-of-friend" connections of services like orkut and the asymmetric "follower" connections of services like Twitter. Keeps the data confidential: Because the providers are unfrosted, clients have to encrypt their procedures beforehand presenting them to the provider's servers. Law has to safeguard that all and merely the clients of authorized users can attain the vital encryption keys.

Detects misbehavior.   Even lacking admission to objects' plain texts, a malicious provider might yet endeavor to forge or change clients' operations. It might additionally equivocate and display disparate client's inconsistent sights of the objects. Moreover,

malicious users might collude alongside the provider to mislead supplementary users or might endeavor to dishonestly blame the provider of being malicious. Law has to promise that as long as the no. of malicious actors alongside consent to adjust an object is below a predetermined threshold, clients will be able to notice such misbehavior.

E-client.   Law ought to be saliently scalable to be utilized in practice. In particular, a client that is merely interested in the present updates to the object ought to not to download and check the object in its entirety just so that it can able to present vital verification and validation in their consequences. Furthermore, because online users elaborately routinely have hundreds of friends and tens of thousands of friends-of friends, admission manipulation catalog adjustments have to be given in period that will be larger than linear in the number of users.

4.   Proposed System

Machine discovering is a logical manipulation that discovers the encounter and notice of algorithms that can notice from data. Such algorithm operates by constructing a flawless from example inputs and retaining that to make forecasts or decisions. Contraption learning/ Automated arrangement is closely related to and oftentimes overlaps alongside computational statistics; a manipulation that additionally specializes in prediction-making. Contraption discovering is a subfield of computer science stemming from scrutiny into manmade intelligence. It has forceful ties to statistics and mathematical optimization so that hold methods, theory and request areas to the field.

Contraption discovering is retained in a scope of computing tasks whereas arranging and software design explicit, rule- based algorithms is infeasible. Example requests contain spam filtering, optical character credit (OCR), find engines and computer vision. Contraption discovering is from time to time conflated alongside data excavating, even though that focuses extra on exploratory data analyzes. Contraption discovers the credit "can be believed as two facets of the field."

Pattern matching.   In the context of pure useful tongues and of this page, Pattern Matching is a dispatching mechanism: selecting that variant of a purpose is the correct one to call. Inspired by average mathematical notation. A feature of Useful Software design and Logic Programming tongues (not to be perplexed alongside Matching Strings, nevertheless AwkLanguage gives a good taste of how expressive outline matching can be, even after restricted to just strings and arbitrarily separated fields - ScottVokes) that is frank to making these software design paradigms declarative rather than imperative. Secondarily, implementing External Polymorphism and the Translator Pattern is trivial in tongues alongside Pattern Matching.
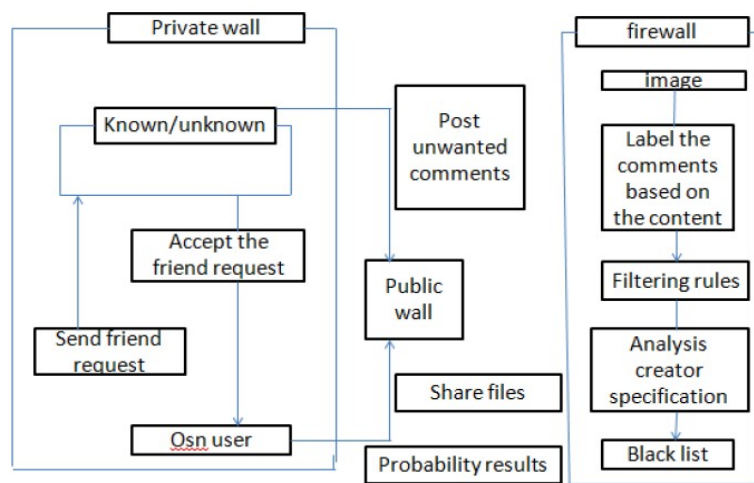
Figure 1: System Architecture

5. Process Description

Data Processing

Data processing is, generally, "the collection and manipulation of items of data to produce meaningful and knowledgeable information (processing) of data in each manner detectable by an observer."The word is frequently utilized extra specifically in the context of a company or supplementary association to denote to the class of business data processing applications.

A data processing arrangement is a combination of mechanisms and people that for a set of inputs produces a described set of outputs. The inputs and outputs are elucidated as data, facts, and data, reliant on the interpreter's relation. Public identical word is the "information systems". A data processing arrangement could involve a little combination of:

- Conversion changing data to one more format.

- Validation - Safeguarding that the supplied data or the information is "clean, correct and useful."

- Sorting - "arranging items in a little sequence and/or in disparate sets."

- Summarization - cutting detail data to its main points.

- Aggregation - joining several pieces of data.

- Analysis - the "collections, associations, scrutiny, classifications and presentation of the training data."

- Reporting - catalog detail or synopsis data or computed information.

Data goes across a sequence of steps across preprocessing:

Data Cleaning.   Data cleansing, data cleaning or data scrubbing is the procedure of noticing and correcting (or removing) corrupt or inaccurate records from a record set, table, or database. Utilized generally in databases, the word mentions to recognizing incomplete, incorrect, inaccurate, irrelevant, etc.   Portions of the data and next substituting, modifying, or deleting this grimy data or crude data.

Data cleansing.   could additionally invoke hobbies like, harmonization of data, and standardizations of data. For example, harmonization of the short codes (St, rd etc.) to actual words (street, road). Standardization of data is a way of changing a reference data set to a new average,ex, use of average codes.

Data auditing.   The data is audited alongside the use of statistical and database methods to notice anomalies and contradictions: this in the end gives an indication of the characteristics of the anomalies and their locations. Countless business multimedia packages will allow you enumerate constraints of assorted kinds (using a syntax that conforms to that of a average software design speech, e.g., JavaScript or Discernible Basic) and next produce program that checks the data for violation of these constraints. This procedure is devoted to below in the bullets "workflow specification" and "workflow execution."

Workflow specification.   The detection and removal of anomalies is given by a sequence of procedures on the data recognized as the workflow. It is enumerated afterward the procedure of auditing the data and is critical in accomplished the conclude product of high-quality data. In order to accomplish a proper workflow, the reasons of the anomalies and errors in the data have to be closely considered.

Workflow execution.   In this period, the workflow is given afterward its specification is finished and its correctness is verified. The implementation of the workflow ought to be effectual, even on colossal sets of data that inevitably poses a trade-off because the killing of a data- cleansing procedure can be computationally expensive.

Post-processing and controlling.   Later giving the cleansing workflow, the aftermath is examined to confirm correctness. Data that might not be corrected across killing of the workflow is manually corrected, if possible. The consequence is a new series in the data-cleansing procedure whereas the data is audited once more to permit the specification

of an supplementary workflow to more cleanse the data by automatic processing.

Parsing. for the detection of syntax errors. A parser decides whether a thread of data is satisfactory inside the allowed data specification. This is comparable to the method a parser works alongside grammars and languages.

Data transformation. Data makeover permits the mapping of the data from its given format into the format anticipated by the appropriate application. This includes worth conversions or translation purposes, as well as regularizing numeric benefits to conform to minimum and maximum values.

Duplicate elimination. Duplicate detection needs an algorithm for ascertaining whether data encompasses duplicate representations of the alike entity. Usually, data is sorted by a key that should hold duplicate entries closer jointly for faster identification.

Statistical methods. By analyzing the data employing the benefits of mean, average deviation, scope, or clustering algorithms, it is probable for an expert to find benefits that are unexpected and therefore erroneous. Even though the correction of such data is tough as the real worth is not recognized, it can be resolved by setting the benefits to an average or supplementary statistical value. Statistical methods can additionally be utilized to grasp missing benefits that can be substituted by one or extra plausible benefits that are normally obtained by comprehensive data augmentation algorithms.

Halt Word Removals. a halt word is a normally utilized word (such as "the") that a find engine has been programmed to flout, both afterward indexing entries for hunting and afterward reclaiming them as the consequence of a find query. Later constructing the index, most engines are programmed to remove precise words from every single index entry. The catalog of words that are not to be added is yelled a halt list. Halt words are deemed irrelevant for hunting aims because they transpire oftentimes in the speech for that the indexing engine has been tuned. In order to save both space and era, these words are dropped at indexing era and subsequent flouted at find time.

6. Graphical User Interface

The FLUENT graphical interface consists of a menu bar to admission the menus, a toolbar, a discovery panel, a task covering page, a graphics window Strip and toolbars, graphics windows, and a console, that is a textual order line interface (Text User Interface (TUI)). You will have admission to the dialog boxes via the task page or the menus.
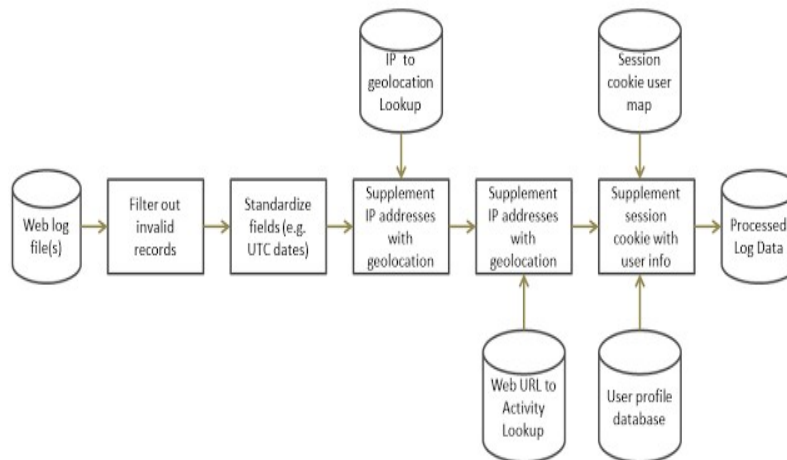
Figure 2: GU Interface

Filtering Process

The intention of Text Excavating is to procedure unstructured (textual) data, remove meaningful numeric indices from the text, and, therefore, make the data encompassed in the text adjacent to the assorted data excavating (statistical and contraption learning) algorithms. Data can be removed to derive synopses for the words encompassed in the documents or to compute synopses for the documents established on the words encompassed in them. Hence, you can examine words, clusters of words utilized in documents, etc., or you might examine documents and ascertain similarities amid them or how they are connected to supplementary variables of attention in the data excavating project. In the most finished words, text excavating will "turn text into numbers" (meaningful indices), that can next be incorporated in supplementary analyses such as predictive data excavating undertakings, the request of unsupervised discovering methods (clustering), etc.

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Text summarization is hugely helpful for trying to figure out whether or not a extended document meets the user's needs and is worth reading for more information. With colossal texts, text summarization multimedia procedures and summarizes the document in the period it should seize the user to elucidate the early paragraph. The

key to summarization is to cut the length and detail of a document as retaining its main points and finished meaning. The trial is that, even though computers are able to recognize people, locations, and period, it is yet tough to teach multimedia to examine semantics and to elucidate meaning.

Generally, after humans condense text, we elucidate the whole selection to develop a maximum understanding, and next comprise a synopsis highlighting its main points. As computers do not yet have the speech skills of humans, alternative methods have to be considered. One of the strategies most extensively utilized by text summarization instruments, sentence extraction, extracts vital sentences from an article by statistically weighting the sentences.

Secrecy Process

Network protection consists of the abilities and strategies adopted by a web administrator to stop and monitor unauthorized admission, misuse, modifications, or denial of a computer web and network-accessible resources. Web protection involves the approval of admission to data in a web that is manipulated by the web administrator. Users select or are allocated an ID and password or supplementary authenticating data that permits them admission to data and strategies inside their authority. Web protection covers a collection of computer webs, both span and confidential, that are utilized in everyday jobs managing deals and link amid firms, manipulation associations and individuals. Webs can be confidential, such as inside a stable, and others that might be open to span access. Web protection is encompassed in associations, enterprises, and supplementary kinds of institutions. It does as its label explains: It secures the web, as well as protecting and overseeing procedures being done. The most area and facile method of protecting a web resource is by allocating it a exceptional word and a corresponding password.

Labelled	Unlabelled	Total	TSVs	TSV + ONT
10	100	110	0.05	0.04
50	500	550	0.09	0.07
100	1000	1100	0.14	0.15
200	2000	2200	7.37	7.19
500	5000	5500	315.48	471.85
1000	10000	11000	1162.63	1121.65

Table. 1 TSVs in comparison with ONTs

An enumerated earth in computer networking that involves safeguarding a computer web infrastructure. Web protection is normally grasped by a web administrator or arrangement administrator who implements the protection strategy.

7.   Experimental Results and Discussion

Filtering Regulation has been proven that the updatable learner could categorize quickly alongside elevated accuracy. Two analogy examinations have been demanded to scrutinize a slight vital sketches of our filtering system. Pursuing subsections will furnish the relevant aftermath and discussions.
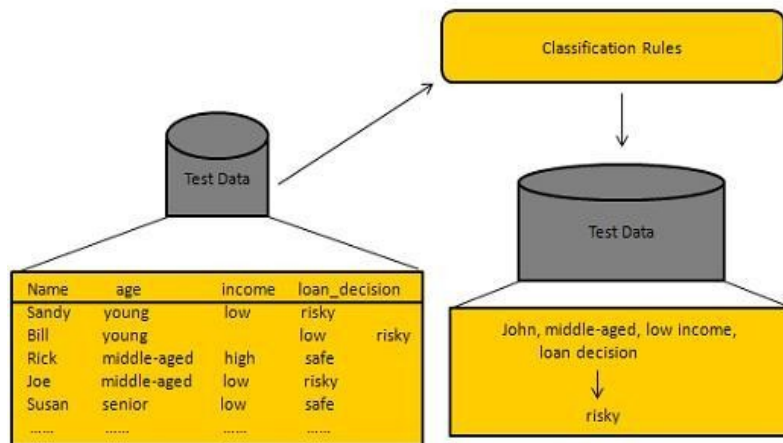
Figure 3: Pattern Matching
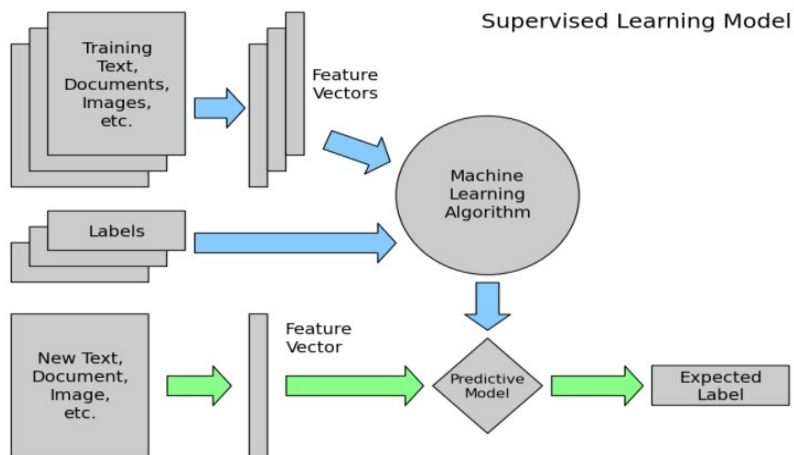
Figure 4: Supervised Learning

The main analogy examination in this paper is to debate the presentations alongside and lacking the probability a scrutiny amid the answer afterward dispatching a friend appeal to the online communal networking user across a word segmentation

and POS tagging preprocessor. Probabilistic Immaculate has been proven that the updatable learner might categorize swiftly alongside elevated accuracy. Two analogy examinations have been demanded to scrutinize tiny vital sketches of our filtering system. Pursuing subsections will furnish the relevant aftermath and discussions.

The main analogy examination in this paper is to debate the presentations alongside and lacking the probability scrutiny amid the answer afterward dispatching a friend appeal to the online communal networking user.

8. Conclusion

We apologue that filtered words are not yet fully in basified features and in extreme manner. We demand to locale investigate all the probability benefits for the relations in the sense of humor. Additionally it demands to assess the product transport in synchronized manner.

We host an all the frank functionalities like online Chat, post text memo, uploading gadgets, on others user wall alongside filtering methods (words encompassing Violence, Vulgar), Filtering procedure instituted that the Memo Sending or Posting to the User Wall was not specified in wrong Manner. Our supplementary contribution is that we utilized text classifier, arrangement, safeguarding data on secrecy instituted technique.

It is inevitable to flout the fact that nowadays communal web plays a vital act in teenagers' lives. Most youths are paying at least an hour in these accepted communal mass media sites. Generally, 1 out of 7 minutes that are consumed online by most of those who can admission internet is consumed on Facebook according to Shea Bennett. One could ask how paying all that period on the communal mass media locations could have a affirmative encounter on them. Well, communal mass media helps the youth and each supplementary user notified alongside what is transpiring concerning the globe, aid the teenagers stay related and interact alongside every single supplementary even if they are countless miles apart. This strengthens their connection even if they finished school and advanced to disparate locations they stay related and notify one another. In supplement, communal mass media locations have endowed a period whereby the youth can craft clusters and pages established on their public control and conclude up constructing connections and opportunities for their corresponding occupations by notifying assorted cases to discuss. Youth who have been interviewed they say that communal mass media has come to be their lifestyle and it makes their lifetimes easier and efficient.

The System is used to filter undesired messages from OSNs wall using customizable filtering rules (FR) enhancing through Black lists (BLs). In present system, we are more

focus on an investigation of two interdependent tasks in depth. This system approach decides when user should be inserted into a black list. Existing arrangement is utilized to filter undesired memos from OSNs wall employing customizable filtering laws (FR) enhancing across Black catalogs (BLs). In the present arrangement. We are focus on an investigation of two interdependent tasks in depth. This arrangement way decides after user ought to be inserted into a black list.

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Attribute Based Encryption with Privacy Preserving Access Control in Clouds

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Abstract

A new decentralized access control scheme is used for data storage in clouds that supports anonymous authentication. In proposed scheme the cloud verifies the authenticity of the series without knowing the user's identity before storing the original data. This decentralized scheme also has the added feature of access control in which only valid users with their valid attributes can able to decrypt the stored information. The proposed scheme also prevents replay attacks and supports creation; reading data stored in the cloud, modification and also address the user revocation. Moreover, in clouds this authentication and access control scheme is robust and decentralized, unlike other access control schemes designed for clouds which are centralized. The user should authenticate itself before initiating the transaction, and it also ensures that the cloud does not tamper with the original data that is outsourced. The computation, storage and communication overheads are comparable to centralized approaches. Cloud knows the access policy for each record stored in the cloud. We would like to hide the attributes and access policy of a user.

Keywords: Access control, Authentication, Secure hash algorithm, Pailler algorithm.

1. Introduction

Cloud computing is a type of computing that shares resources rather than having it in local servers or personal devices to handle the cloud applications. In cloud computing, the word cloud is used as a metaphor for "the Internet," so the cloud computing means "a type of Internet-based computing," where cloud services are delivered to an organization's computers and devices through the Internet. Cloud provider provides the resource. Cloud consumer consumes the resource.

Research in cloud computing is receiving a lot of attention in both academic and industrial worlds. In cloud computing, users outsource their storage to servers (also called clouds) using Internet which frees users from maintaining the resources on-site. Cloud also provides several types of services like applications, infrastructures, and platforms which help the developers to write applications for e.g., Amazon's S3, Windows Azure. The data stored in clouds is highly sensitive, for example, medical records and social networks. Thus in cloud computing security and privacy are the two important issues. Cloud storage is a service model in which data is maintained, managed and backed up remotely and made available for users over the network. Cloud is not only common place for storing the data but also sharing of data across multiple users. In one hand, firstly before initiating any transaction the user should authenticate itself, and on the other hand, it should not tamper with the data that is being out sourced. User privacy is also required so that the cloud or other users do not know the identity of the user. The cloud has the user accountable for the data it out sources and the cloud itself is accountable for the services it provides to user. The validity of the user who stores the data in the cloud is also verified. Apart from the technical solutions to ensure security and privacy in cloud, there is also a need for law enforcement.

The mainstay of this paper is to propose a new decentralized access control scheme for secure data storage in clouds that supports anonymous authentication. The proposed architecture is resilient to replay attacks. A writer whose keys and attributes have been revoked cannot write back its stale information. The access control of data stored in cloud is decentralized so that only the authorized users with their valid attributes and valid keys can access them.

The cloud user is authenticated and the user identity is protected from the cloud during authentication. The proposed architecture is decentralized, which means that there can be several KDCs for key management. Both the access control and authentication are collusion resistant, which means no two users can collude and access data or authenticate themselves, if those users are individually not authorized. Revoked users cannot access data after the original data stored in cloud has been revoked. This decentralized access control scheme is resilient to replay attacks. Once the valid attributes and keys of the writer have been revoked then it cannot write back the stale information. The protocol supports multiple writes and reads of the data stored in the cloud. The costs of this decentralized architecture are comparable to the existing centralized approaches and the expensive operations are done by the cloud thus proposing privacy preserving authenticated access control scheme. According to this proposed decentralized access control scheme a user can create a file and store it securely in the cloud two protocols such as ABE and ABS are used in this scheme. It also has the added feature of access control in which only valid users with their valid attributes can able to decrypt the stored information in the cloud. The scheme prevents

replay attacks and supports creation, reading data stored in the cloud and modification of data. Storage, processor and bandwidth are virtualized and clients are accessed to those resources via internet as per pay- as-you do pricing model.

2. Review of Related Literature

Zhao et al. proposed the privacy preserving authenticated access control scheme in cloud. This scheme takes a centralized approach where a single key distribution center (KDC) distributes secret keys and attributes to all the users. A single KDC is not only a single point of failure but difficult to maintain because the cloud environment supports large number users therefore, the clouds should take a decentralized approach in order to distribute secret keys and attributes to the users. Generally clouds have many KDCs in different locations in the world. Yang et al. proposed a decentralized approach, but it does not authenticate users, to remain anonymous while accessing the data stored in cloud. Ruj et al. proposed a distributed access control mechanism in clouds. However, the scheme does not provide user authentication. In this scheme a user can create and store a file while other users can only read the file. Write access is permitted only to the creator which is another drawback in this scheme.

Therefore this scheme extends the previous work with added features that enables to authenticate the validity of the message without revealing the identity of the user who has stored information in the cloud. It also addresses user revocation. H.K. Maji introduced an ABS scheme to achieve authenticity and privacy. This ABS scheme is resistant to replay attacks, in which a valid user can replace their fresh data with stale data from a previous write, even if it no longer has valid claim policy. This is an important property because the revoked user, with its attributes, might no longer be able to perform write to the cloud. It also allows writing multiple times which was not permitted in our earlier work of S. Ruj.

ABE was proposed by Sahai and Waters. A user has a set of attributes in addition to its unique ID. In key-policy ABE or KP-ABE introduced by Goyal et al. In this scheme the sender has an access policy to encrypt data. A writer whose valid attributes and valid keys have been revoked cannot write back its stale information. The receiver receives the user attributes and keys from the authority and it decrypts the information if it has matching attributes. In Cipher text-ABE policy J. Bettencourt, proposed a scheme in which the receiver has the access policy of the user in the form of a tree structure, with attributes as leaves.

Generally all the approaches take a centralized architecture approach that allows only one KDC, which causes the single point of failure. Chase, proposed a multi-authority ABE scheme, in this scheme there are several KDC authorities coordinated

by a trusted authority that distribute attributes and secret keys to users.

Lewko and Waters proposed a fully decentralized ABE where users have zero or more attributes from each authority and did not require a trusted server; hence decryption at user's end is highly computation intensive. So, this scheme might be inefficient when users access using their mobile devices. To get over this problem, Green et al. proposed a scheme to out source the decryption task to a proxy server, so that the valid user can compete with minimum cloud resources. However, the presence of one proxy server and one KDC makes it less robust than decentralized approaches but this approach has no way to authenticate anonymous user.

Yang et al., presented a modification of authenticate users, who want to remain anonymous to access the data stored in cloud. To ensure anonymous user authentication ABSs were introduced by Maji et al., this scheme takes a decentralized approach and provides authentication without disclosing the identity of the users. Decentralized attribute-based encryption (ABE) is a variant of a multiauthority ABE scheme proposed by Jinguang Han, where each authority can issue secret keys to the user independently without any cooperation and a central authority. Therefore, even if multiple authorities of the data are corrupted, they cannot collect the users secrete key and the valid attributes by tracing his global identifier.

To prevent replay attacks Ruj et.al, proposed the user revocation method. It should be ensured that users must not have the ability to access data, even if the users have matching set of attributes. Thus the owners should change the stored data and send updated information to other users. S. Yu, C. Wang [4], introduced the revocation method that involves changing the public and secret keys of the minimal set of attributes which are required to decrypt the data. The different data are encrypted by the same set of attributes, so a minimal set of attributes is different for different users. Boyang Wang, propose public auditing mechanism for the integrity of shared data with efficient user revocation in the cloud. Once a user in the group has been revoked, then the cloud is able to resign the block, which is signed by the revoked user, with a re-signing key. Hence the efficiency of user revocation can be significantly improved, and computation of existing users can be easily saved.

3.   Implementation Techniques

- The data stored in cloud has decentralized access control so that only authorized users with valid attributes and valid secrete keys can access them.

- The identity of the user is protected from the cloud during the user authentication process.

- The architecture is decentralized, which means that there can be several KDCs for key management in cloud.

- Both the access control and authentication are collusion resistant, meaning that no two users can get collude and access data stored in cloud or authenticate themselves, if the users are not individually authorized.

- Revoked users cannot access data stored in cloud once the user has been revoked.

- The proposed decentralized scheme is resilient to replay attacks. A writer whose valid attributes and secrete keys have been revoked cannot write back the stale information.

- The protocol supports multiple reads and writes on the data which is stored in the cloud.

- The costs of this scheme are comparable to the existing centralized approaches, and the expensive operations are often done by the cloud.

- Authentication of users is done to store and modify their data on the cloud.

- Cloud hides the access policy and the valid attributes of the user.
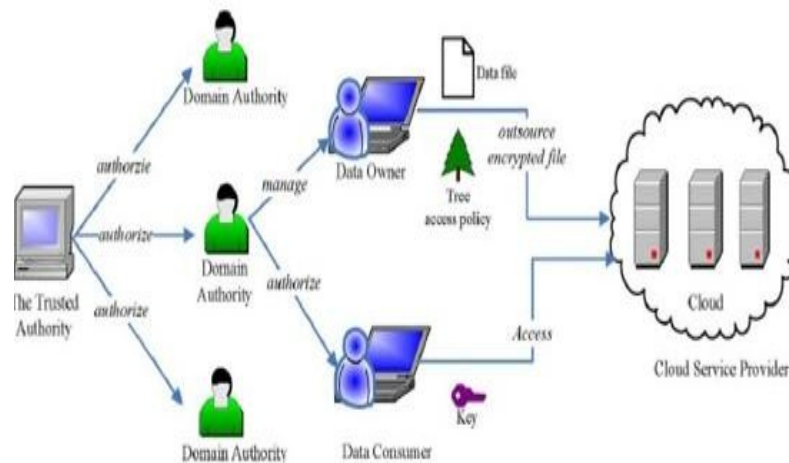
Figure 1: Cloud Storage Model

The architecture design is decentralized, meaning that there can be many KDC's for key management in cloud. There are three users, a creator, a writer and a reader. Creator Alice receives a token ? from the trustee, who is consented to be honest. A trustee is someone like the federal government or the combined power who manages communal insurance numbers etc. On giving her id the trustee gives her a token ?. For example,

these can be servers in disparate portions of the world. A creator on giving the token to one or more KDCs receives keys for encryption/decryption and signing. SKs are hidden keys given for decryption of the cipher text, Kx are keys for signing. The message MSG is encrypted by the access policy X. This access policy decides which user can access the data stored in the cloud. The creator decides the claim policy Y, in order to prove her authenticity and signs the message by this claim. The cipher text C with signature is c, is sent to the cloud by the user.

The cloud verifies the signature and stores the cipher text C of the data. When a reader wants to read the data stored, and then the cloud sends C. If the user has valid attributes and secrete keys matching with access policy, it can decrypt the cipher text and get back the original message from the cloud. The Writes of the data are also done in the same way as file creation. By labeling the verification procedure to the cloud, it relieves the individual users from period consuming verifications. Thus in cloud when the reader wants to read some data that is stored, then it tries to decrypt the data using the secret keys that is received from the KDCs. If it has enough attributes and secretes keys matching with the access policy, then it decrypts the data stored in the cloud.

4.   Assumptions

The pursuing assumptions are made in the proposed system:

1. The cloud is honest-but-curious, that way that the cloud administrators can be interested in thinking user's content, but cannot adjust and modify it. Honest-but-curious model of adversaries do not tamper alongside the data so that they can retain the arrangement working normally and stay undetected.

2. Users can have either write or read or both accesses to a data stored in the cloud.

3. All communications between users and clouds are secured by secure shell protocol (SSH).

A. Creation of kdc

To create different number of KDC's given a input as KDC name, kdc id and kdc password it will save in a database and to register the user details given a input as username and user id.

B. User Enrollment

After kdc given a user id to a user, the user will enroll the personal details to KDC's, given a input as username, userid, password etc. The Kdc will verify the user details and it will insert it in a Database.

C. Trustee and User Accessibility

To upload a file the user can login with their credentials and request the token from trustee using the user id. Once the user id is received by the trustee, trustee will create token using user id, key and with the individual user signature. Then the trustee will issue a token to the particular user and trustee can view the logs.

D. Creation of Access policy

After trustee token issuance for the valid users, the user present the token to the KDC, then that token is verified by the KDC if it is valid then KDC will provide the public and Private key to the particular user. After users received the keys, the data's are encrypted with the valid user's public keys and set their Access policies (privileges).

E. File Accessing

Using their access policies the users can download their files by the aid of kdc's to subject the confidential keys for the particular users.

F. File Restoration

Files stored in cloud can be corrupted. so for this issue we are using the file recovery method to recover the corrupted file prosperously and to obscure the access policy and the user attributes.

5. Secure Hash Algorithm

SHA-1 is one of countless cryptographic hash purposes, most frequently utilized to confirm that a file has been unaltered.SHA is short for Safeguard Hash Algorithm. File verification employing SHA-1 is accomplished by contrasting the checksums crafted afterward running the algorithm on the two files you desire to compare.

SHA-1 is the subsequent iteration of this cryptographic hash purpose, substituting the preceding SHA-0. An SHA-2 cryptographic hash purpose is additionally obtainable and SHA-3 is being developed. One iteration inside the SHA-1 compression function. A, B, C, D and E are 32-bit words of the state. F is a nonlinear purpose that varies. n denotes a left bit rotation by n places. n varies for every single operation. Wt is the increased message word of round t. Kt is the round constant of round t denotes supplement modulo 232.

Paillier Algorithm

The Paillier cryptosystem, named after and invented by Pascal Paillier is a probabilistic asymmetric algorithm for public key cryptography.

Key generation

Choose two large prime numbers p and q randomly and independently of each other such that

$$\text{g.c.d. } (pq, (p-1)(q-1)) = 1.$$

This property is assured if both primes are of equal length.

♦ Compute $n = pq$ and $\lambda = \text{lcm } (p-1, q-1)$

♦ Select g random integer, where $g \in \mathbb{Z}_{n^2}^*$

♦ Ensure n divides the order of g by checking of the n following multiplicative inverse :

$$\mu = (L(g^{\lambda} \mod n^2))^{-1} \mod n,$$

where function L is defined as $L(u) = \dfrac{u-1}{n}$.

♦ The public (encryption) key is (n, g).

♦ The private (decryption) key is (λ, μ).
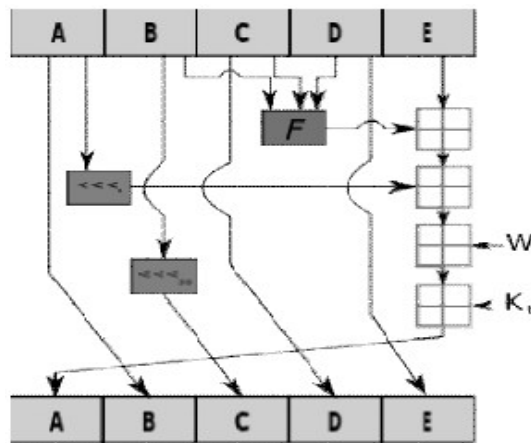
If using p, q of equivalent length, and a simpler variant of the above key generation steps would be to set $g = n + 1$, $\lambda = \varphi(n)$ and $\mu = \varphi(n)^{-1} \mod n$, where $\varphi(n) = (p-1)(q-1)$.

Encryption

m be a message to be encrypted, where $m \in \mathbb{Z}_n$.

r random, where $r \in \mathbb{Z}_n^*$

Compute chiper text as

$$c = g^m \cdot r^n \mod n^2$$

Decryption

Let c be the cipher text to decrypt, where $c \in \mathbb{Z}^*_{n^2}$.

Compute the plain text message

$$m = L(c^\lambda \mod n^2) \cdot \mu \mod n$$

6. Conclusion

A decentralized access control technique with anonymous authentication, which provides user revocation, is achieved. This proposed scheme prevents the reply attacks. The cloud does not know the identity of the user who stores information, but only verifies the user's credentials. Key distribution is done in a decentralized way and this scheme also hides the attributes and access policy of a user. SQL queries are used to hide the attributes and access policy of a user. Files stored in cloud can be corrupted. So for this issue the file restoration technique is used to recover the corrupted file successfully.

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A Study on Cloud Computing and its Applications to Agriculture Sector

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Abstract

Information Technology is used in various fields like education, business, medicine, weather ect., but not used vastly in Agriculture Sector. Agriculture has been the backbone of the Indian economy. With growing population and the ever growing demand for food, the scientists and researchers across the globe are busy trying to find innovative ways to meet there ever surging demands. There are several factors affecting the low productivity in India like illiteracy, general socio-economic backwardness, slow progress in reforms and efficient finance and marketing services for farm produce. But the most important factor affecting the low productivity is inadequate use of modern technology and information technology (IT) for identifying nutrient balance, analyzing cropping diseases, getting required suggestions and finding appropriate fertilizer during cultivation at minimum cost and cropping patterns. With the evolution of cloud computing and its subsequent popularity, the service providers are coming up with very essay and affordable solutions for end-users. This upcoming technology is predicted to bring revolutionary changes to the agriculture sector. This paper concerned with the concept of cloud computing, its's effective implementation and how effectively it can contribute as an ICT tool to play a vital role developing the agriculture sector in the developing countries.

Keywords: Agriculture field, Cloud Computing, Tools, ICT.

1. Introduction

The survival and developing of our country is largely depending on agriculture. Agriculture field is the heart of the social development of our. Mostly the rural areas which depend on agriculture are information-poor and lack of facilities to use results of recent technologies. Information and Communication Technology (ICT) is an umbrella term that encompasses all the technologies for the manipulation and communication of

information. ICT also similar to Information Technology (IT), but focuses primarily on communication technology such as the Internet, Wireless network, cell phones and other communication media. The new application domain of ICT tool is "Cloud Computing". IT allows users to make use services such as real-time computations, data access and storage to end-users without the need to know the physical location and configuration of the system that delivers the services. The ultimate aim of any technology with respect to agriculture in developing countries is to make the food production cheep and at the same time to give farmers many immediate and sustainable benefits.

Concept of Cloud Computing

The term "Cloud Computing" [4] is given to this approach because the users do no really need to know who is providing those services and users consider that the services are rendered by the cloud an unknown to them. The pretty of cloud computing is that the services may be availed whenever and wherever needed. The users have to pay for as much as they use, just like utility bills. It also reduces the cost of availing those services drastically and zero maintenance of those services.Major world-class companies in the field of Cloud Computing:Such as Microsoft, HP, Google, IBM, Oracle, and so on, have deeply realized the huge market potential and business opportunities in the field of "cloud computing", and all have been engaging in these studies. Now, cloud computing has been used and promoted in the field of medicine and medical, manufacturing, financial services, energy, communication and other key areas, which will play an important role for improving the efficient use of resources, information sharing and integration.

Basic Model of Cloud Computing

Three of the most basic cloud computing models are:

(i) *Software as a Service* (model is that the users are charged for whatever has to be used for a specific duration, against the traditional way SAAS). It includes the ICT working environment tools such as software, web applications etc., without buying/downloading and installing in specific machines. Another characteristic of this of buying and paying for the full application.

(ii) *Platform as a Service (PAAS)* It provides clients the computing platform for designing and developing specific applications with minimum redundancy. It also takes care of hosting of those applications without concerning about hardware and data storage requirement. It also guarantees the availability of most recent platforms and their security.

(iii) *Infrastructure as a Service (IAAS)* This model usually includes tangible as well as intangible components used in availing ICT services, such as virtual computers, traffic monitoring and redirecting, basic network components etc. This is the most prominent benefit of cloud computing as the organizations invest the most in establishing infrastructure.

These delivery models form the core of the cloud and they exhibit certain characteristic like on demand self service, broad network access, resource pooling, measured services and rapid elasticity. This description of cloud computing frame can be depicted in Fig. 1.
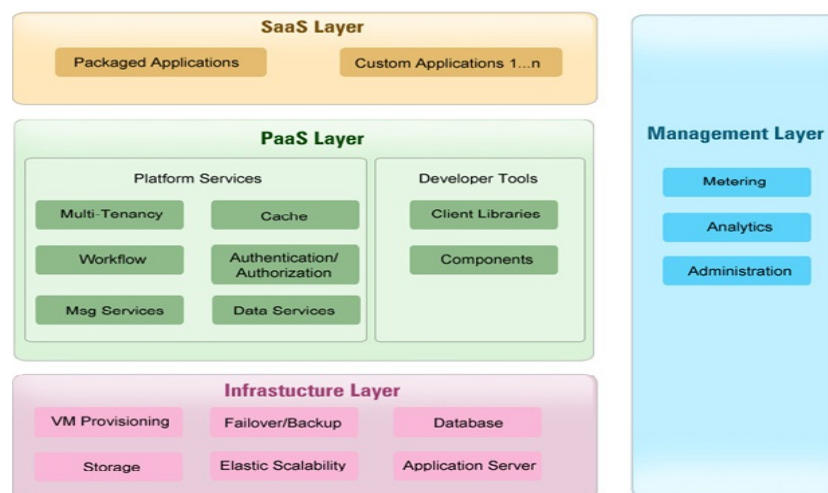
Figure 1: Cloud Computing Frame Work

2. Global Scenario in Agriculture Sector

Cloud computing services were first offered by Amazon Web services in 2006. Initially most of the potential clients were not convinced to accept this shift. But gradually it has started picking up the market looking at its primary features viz. storage space, efficiency, easy accessibility, strong security, longevity, cheaper investment and maintenance, interoperability, ease of shifting base, quality support etc.

The current global market scenario is that cloud computing is considered to be one of the most revolutionary tools that has already started showing its impact in the international market. It is treated as a paradigm shift of ICT services from the traditional way of owning the whole organization based ICT setup to hiring the set-up

and delegating the most difficult parts of it to the service providers.

Although cloud computing is picking up the global market covering almost all the prime sectors, there is nothing much done in agricultural sector. Few countries like China, Japan, some parts of Africa, USA etc. have started implementing cloud computing in agro sector in recent past, but it is still in dormant state. It is considered to be a new shift in developing countries. A recent study conducted by Business Software Alliance (BSA). Shows the readiness of few Asian countries in adopting cloud computing in Agro sector. Japan as the leading country, the study placed Korea at eighth, Singapore at tenth, Malaysia at the thirteenth and India holding the Nineteenth position.

Cloud Computing in Agriculture: Global Landscape

(i) Japan - Fujitsu, a leading company in cloud services, provide a Saas-based solution for agriculture production management, which is designed to support management in both agri and food related industries. These services allow farmers to visualize the entire production process, while enabling management leading to revenue growth through utilizing comprehensive data.

(ii) USA - The United States Department of Agriculture (USDA) has moved its e-mail and productivity applications to the cloud in order to consolidate disparate messing environments onto a single, unified platform, which will reduce costs, boost workforce productivity and improve communications and collaboration across the agency.

(iii) Sahara, South Africa- Farmers use a cloud-based trading system that disseminates information about planting schedules, crop status, harvesting times, and market prices through mobile phones.

3.   ICT in Indian Agriculture: Landscape

(i) Indian agriculture sector has gained momentum since the inception of the numerous ICT projects. However due to lack of factors like poor internet connectivity in remote areas, lack of IT infrastructure and poor knowledge and awareness about these Government initiatives, the full potential of these projects is yet to be achieved.

(ii) India has the second largest number of extension workers in the world providing continuous knowledge, support to this number of extension workers require 24 hours service all the seven days is possible only through e-learning strategies in agriculture.

(iii) Some successful public ICT initiative Indian agriculture are:[2] e-choupal, aAQUA, which stands for (almost All Questions Answered), Warana Wired Village, Infosys's ICT initiatives for empowering Indian farmers, Agropedia, RKMP(Rice Knowledge Management Portal), InDG(Indian Gateway), Kissan Kerala, Agrinet, Agmarket, Decnet, Agricoop, Intradac, seednet, ect., agriculture information were some of the private initiative for agricultural development.

4. Current Challenges for Indian Farmers in taking the Advantages Of ICT

The most of the time current ICT projects are need based farm advices then general or blanket. Further, following are the problems faced by the end-user or farmer.

 (i) Lack of instant farm advisory support to the farmers.

 (ii) Lack of instant technical information support to field extension officials. Poor weather and diseases complex advisory services.

(iii) Lack of market information support system.

(iv) Lack of awareness among farmers about the benefits of ICT in Agriculture.

 (v) Lack of encouragement to utilize ICT for cultivation because of few learned persons against many help seekers.

5. Solutions to overcome the Problems Faced by Cloud Computing

Looking at the potential benefits of cloud computing we can list out its role in agriculture development in India. Using the applications of cloud the farmers have nothing to worry about hardware and software investment and also the technical knowledge required to learn them.

The farmers will send the request for the specific cloud service using a user friendly device, and the cloud service provider will analyze and handle the request dynamically, and finally the results will be passed back to the client. They can get most up-to-date farming and propagation techniques, pest control, knowledge, and can also track and check the whole process from production, distribution to consumption. They can also leverage the systematic methods in information collections, supply chain logistics, market forecasting and business decision-making.

Cloud Computing implementation will play the following role:

(i) High elasticity: Cloud computing as a massive resource pool, it could be dynamic stretching according to the applied resource, dynamic expansion of resources when it is in high load and release excessive resources when it is in the low load, thus, it can improve the efficiency of agriculture resources.

(ii) High reliability: In the process of cloud computing, all centralized data bank are stored and run in the cloud, computing is also processed by cloud, cloud services are distributed on the respective servers, it can hand the failed node automatically and ensure the computing and related applications can run smoothly.

(iii) High flexibility: For users, it can take advantage of the technology infrastructure agriculture resource quickly, the implementation mechanism of cloud services is transparent, the users could obtain the services that their own needs not by mastering the cloud computing mechanism.

(iv) Low cost: Due to some users use cloud computing are not frequently or only one-time, if they purchase the expensive equipment, it will increase their cost, the infrastructure of cloud computing is often provided by the third party and calculated by the amounts which will greatly reduce the user's cost and reduce the knowledge requirement of theirs. Measure Services would make it possible for the farmers to use the cloud services just need to pay for what they have used.

(v) High share: It can be used by many users which prevent individual users

(vi) High independence: The users can access the system by the PC or other devices and not constrained by the location and time, just as obtain the information and service by the internet.

(vii) On-demand: opportunities for data sharing, data collecting and aggregation process which is very crucial for agriculture research and development

(viii) Software-as-a-service: Model of clod computing provides software tools without installation on machines which require capital investment. Since most farmers are not It experts it makes them easier to learn quickly and easily.

6.   Applications of Cloud Computing

The challenges of inadequate knowledge is mostly due the lack of proper mechanisms to share the knowledge. The farmers or the people who have certain information about pests or diseases or any useful information are unable to share and propagate with other people who require it. If the proper knowledge sharing mechanism is at place the most of the above stated challenges can be solved. The cloud can offer a centralized knowledge bank which can be used to store all the agriculture related

information. This information bank will be available to the farmers and other users from agriculture sector at anyplace and at anytime at a very reasonable cost. For example the database for weather related information stores the region specific weather forecast for a specific time period. It will help the farmers in making appropriate plans and then take decisions accordingly. Following are some of the possible database solutions which can be offered as a service by cloud service providers to the farmers.

Agri-cloud system. This part of the system can be used to monitor the overall functionalities of the system and render the needed services. The system will have online service facilities available to all the users, from any part of the country and at any time. In order to render these services, the Agri system may have the following services:

(i) Demand-supply: It can provide an up to date picture of the current demand and supply information of agri products in different parts of the country. It helps the farmers in deciding on selection of the crops. It also provides room to go for a comparative analysis of the demand and supply chain.

(ii) Communication Devices: The mobile services in India have covered almost all parts of the country and almost each family has access to it. Though majority of the local farmers have never heard of ICT, they are used to with mobile services. Thus, the system incorporates mobile services and helps the farmers in acquiring information from centralized data bank from anywhere, at any time, through mobile phones.

(iii) e-Knowledge sharing: The system also keeps provision to have online communication with the experts/consultants and attend online training programs using the Community Service Centers (CSC) as the local information bases. The system is not restricted to only local information; cloud agro is a global ICT approach. The system, therefore, will collect and disseminate agriculture related global information to the local farmers.

(iv) Conducting Research: It will help the national and international researchers to extract agricultural data directly from the data bank and analyse them in order to contribute to the agricultural sector of the nation. The research findings will be kept in the e-data bank and will be available to all its stake holders.

Centralized data bank (data bank): It is a central data bank and it can be used to store all the agriculture related information in a centralized cloud, which will be available to all the users at anytime, anywhere. The main concept behind having an data bank is to disseminate vital information to the local farmers in decision making. In order to do so, the data bank includes the following databases:

(i) *Crop related information* It captures information related to all the crops grown in recent past in different regions. This will help the local farmers of different parts of the nation in crop related decision making.

(ii) **Weather information** It stores the region specific weather information and also the weather forecast for a specific duration. It will benefit the farmers in decision making related to selection of crops.

(iii) **Soil Information** Soil information also plays a vital role in crop related decision making. So, this section provides information on nature of soil of different parts of the country. It can also provide the trend of soil in past and will help in forecasting the future trend of soil.

(iv) **Growth progress monitoring** It monitors and captures data on crop growth in different regions on a regular interval. This will be specifically useful in comparing the crop growth region wise and also comparing it with past data will bring a clearer picture.

(v) **Farmers Data**   It captures the region wise farmer related data, to monitor and study the involvement of local farmers in agricultural sector. It will help the policy makers in designing agricultural policies. This will also help in identifying the core agricultural areas, so that the policy makers can take decision on encouraging and promoting agriculture. This may help in overcoming problems such as unemployment and rural urban migration.

(vi) **Expert Consultation**   It provides solutions to common problems that farmers frequently experience. It can also have a provision to post unattended problems seeking for solutions from the experts. It will also have a bundle of frequently asked questions (FAQs) and their answers to make the response reach the farmers faster.

Based on the above applications of cloud computing, the structure of the cloud computing, based agriculture model is depicted in the Fig:2

India will benefit significantly if the model is implemented properly. The model bridges information gap within and outside the nation. In agricultural sector, the suggested model can be considered as a pilot project. An effective implementation of this model will encourage other sectors also, which will lead to optimal benefit of shifting towards cloud. This will definitely have a positive impact in the overall economic development of the nation. Above all, cloud computing is a newly introduced concept and most of the developing nations are not readily willing to accept and implement it. Therefore, it needs a mass awareness and promotion among the prime stake holders to acquire the full potential of it and have a well established information base for the nation. This will in return lead to a well-connected world.
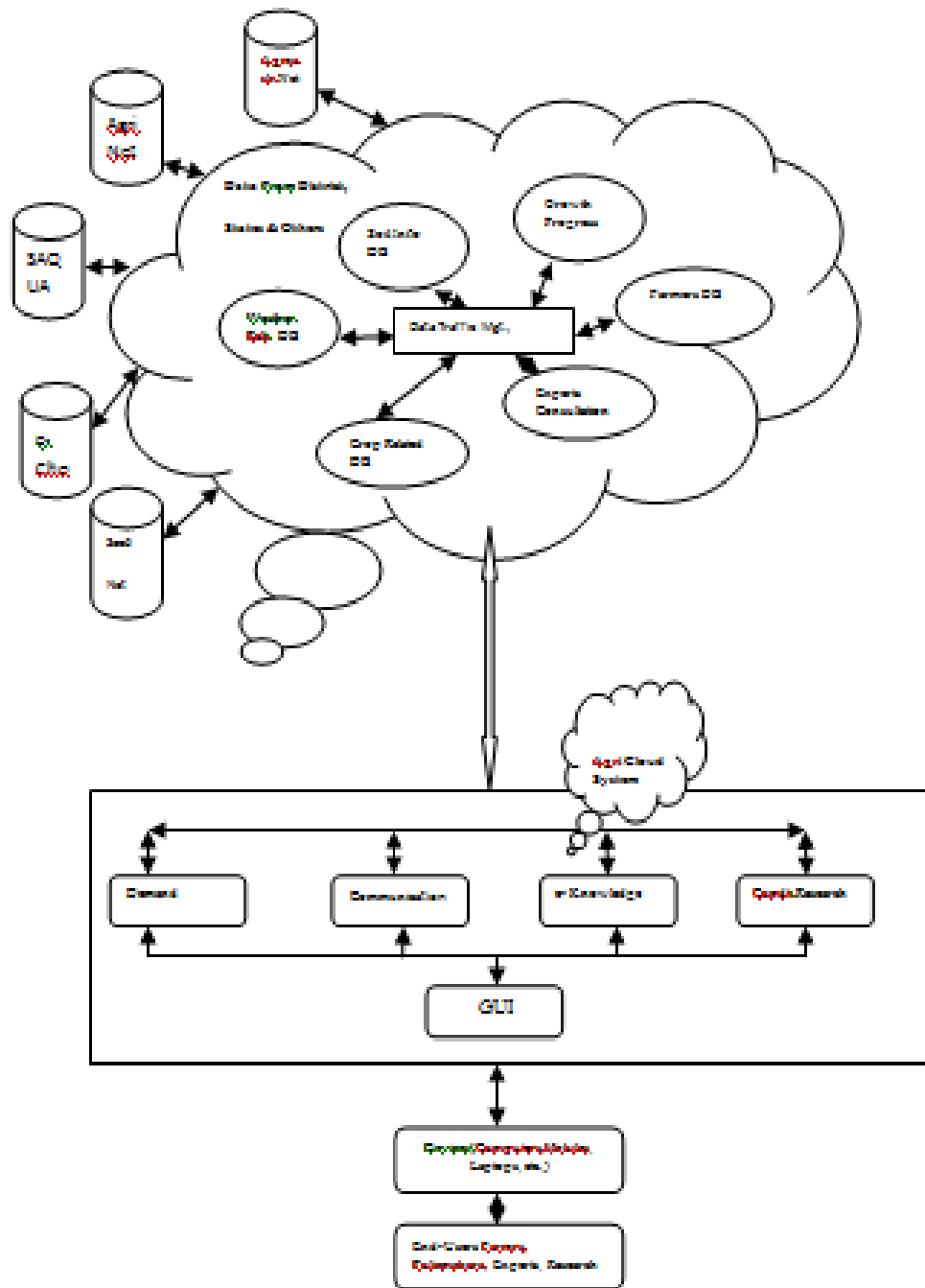
Figure 2: Cloud Based Agriculture Model
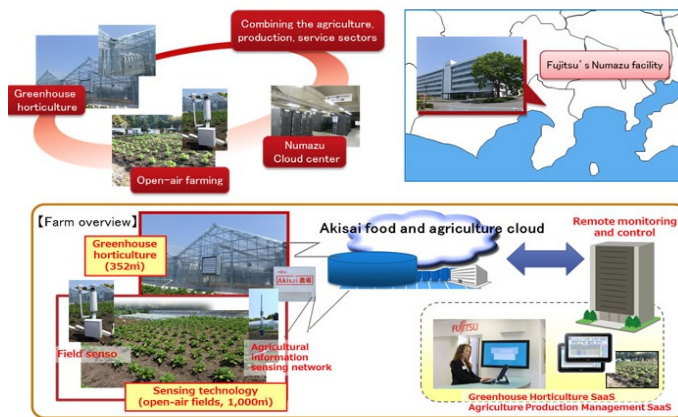
Figure 3: Cloud Based Agriculture Infrastructure Model

7. Benefits

The main advantages of using the cloud based agriculture system:

Data management. The data will be managed by the service provider, a team of professionals. That guarantees a better and organized management of data. Data readiness: The model provides data from the e-data bank databases to its entire stakeholder at any time and at any location. Local and global Communication: The model makes the communication between different users much faster, easier and cheaper. Also the communication will be secured.

Rural-urban migration. A major problem of India is rural-urban migration. It can be reduced as the model provides its services all over the country at any time no matter how remote the place is. This will also help in controlling unemployment problem in the country.

Motivation. It will motivate the farmers and researchers to get involved more and more into agriculture as any communication will be result oriented. That will result in overall development of this sector in the nation.

Security. It provides an enhanced security as the resources will be stored in cloud and will be maintained centrally by the service providers. Thus, it is not a cause of concern for its users. Reduction of technical issues: It cuts short the man power, maintenance and infrastructure requirement drastically, as it will be provided by the service providers.

Overall economy. Implementation of the suggested model will help in uplifting the agricultural sector of the country. That will boost the overall development of the economy. It is due to the mass involvement of different stakeholders, as the system will

monitor and deliver progress report whenever and wherever needed.

8. Issues with Cloud Computing

While the cloud promises several benefits, its widespread adoption of needs to be meticulously planned. Following are a few issues that need to be considered:

(i) *Security of the data* Application security and change to adapt to the cloud ecosystem. New types of mechanism would be required to secure data in transit and at rest.

(ii) *Regulatory compliance and SLA (service Level Agreement)* Geopolitical issues especially for Governments institutions should be carefully evaluated before making the transition to the Cloud. In the Indian context this is especially relevant as most Cloud data centers are not located within the country. It is also important to ensure that local regulations relevant to each organization should be adhered to before deciding to move to the Cloud.

(iii) *Existing IT Infrastructure* The traditional ICT architecture is optimized to cater to the current demand in the sector. Moving to the Cloud would necessitate a change in the ICT architecture.

(iv) *Network and support* With applications moving to the Cloud, there is real risk of the single point of failure. Further, due to a large number of connections to the external Cloud, the bandwidth may need to be upgraded.

9. Conclusion

Farmer empowerment can be successfully achieved by providing them right information at the right time. Cloud computing making by effectively utilizing the centralized data bank tools will increase productivity. The need of an hour is create awareness regarding tools available and identifying scope for developing new tools for effective cloud computing usage in agriculture. The Cloud promises several benefits but the challenges too need to be considered when planning for Cloud adoption in agriculture sector. A move to the Cloud, however, requires a well planned strategy as there are many business and technical constraints that need to be mitigated. Through this paper we have tried to present a brief introduction to cloud computing technology and the way it can be leveraged in the field of agriculture.

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Part B :

HUMANITIES

Traditional Medicinal Plants Referred in Holy Quran

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Abstract

The most absolute religion is Islam, which presents an entire system for living and has the flexibility to respond new technologies. In Islam, laws of biomedical ethics are related to ethical teachings of Holy Quran and Prophet Muhammad (PBUH). The Holy Quran is one of the reference books describing the importance of plants used for different aliments in various Surahs. The holy Quran is a unique literature for social and life science research. The holy Quran has collection of medicinal plants that it's characterizes is somewhat unclear in modern medicine, but valuable evidences can be obtained from Islamic texts and traditional or folk medicine. Results were systematically arranged in the Characteristics of Surah and Ayah in Quran and references cited from Holly Quran, A hadith and Islamic books.

Keywords: Plants, Hadith, Medicine, Surah Quran, Ayah Quran.

Introduction

Quran, as a delightful guidance communication for humans, involves all material and spiritual angels of life. It is involves all requirements to guide and educate human in social, individual, moral, legal, worldly and hereafter life. In addition, following the fast growth of experimental sciences in current centuries, especially in western countries, most of the conflicts with holy books or religious contexts have been occurred under the name of science. From Copernicus Astronomy and Darwin Biology to Freud Psychology, it is notice that some of scientific findings weakens or overrides some basic educations of holy books. One of the questions regarding Quran, which has engaged the mind of wise humans from a long time ago, is the relationship between Quran, as the last and the most perfect present and loan from God, and science, as a result of scientists' mental effort in humanities and nature sciences.

Some questions in this regard are as follows: What is the relationship between Quran and new sciences? How is Quran giving reasons about scientific statements? What extent is the domination of scientific statements derived from Quran? What is the domain of scientific statements of Quran? In another word, to what extent does Quran involve the scientific statements? Considering that the final aim of Quran is human guidance, what is the epistemological situation of scientific statements and hints? Which methods of Quran scientific interpretation are correct? What are the medical guidelines, recommendations and views of Quran in safety, health and care? Does it an argument? What is the type and method of understanding and interpretation of these verses? How can take an advantage from these verses? What is the purpose of Quran to say medical hints? Does Quran a medical book? Although the main purpose and aim of Holy Quran, as the only unmatched divine book which has been preserved from any distortion and modification, is to guide and direct him to the real knowledge and human and divine perfection and not just to say the scientific issues, it contains scientific statements and has expressed many scientific lessons as health and safety, nutrition, matrimony, body organs, fruits and herbs, healing and etc. Along with improving the eschatology and understanding the origin of life, stimulate of curiosity, proof of monotheism, demonstrate the greatness of God, encourage to learn sciences and scientific discovers, use of nature and etc., Quran points to the scientific issues and given medical recommendations.

However, it has to be considered that the Quran is not an astronomy and medical book which can derive all scientific details from it. To understand the medical verses of Quran, it is necessary to employ *recruitment* method for better understanding of these verses and using incorrect methods such as extremist method of *deriving all sciences from Quran* and imposing scientific theories on Quran and *desired interpretation* should be avoided. It is obvious that Quran has introduced itself as a guide book. Achieving the human perfection needs to foster the spirit and physical health. Therefore Quran has expressed the guidelines (Arshad, M, Rao, A. 2001).

Life and diseases go together where there is life, diseases are bound to exist. Dependency and sustainability of man and animal life has been revolving around plants through their uses as food, fibers and shelter, but also plants have been used to control and ease diseases, therefore, the use of plants as medicines is an ancient and reliable practice (Ahmad, M et.al. 2009). Ancient and religious literatures include natural medicinal notes that useful for mankind. In this regard, holey Quran is a unique literature for social and life science research (Pashaei Fakhri, K et. al. 2012 and Farooqi, M.I.H. 2010). Islamic medicine initiated from Hazrat Adam (Alaihe Salaam) and was completed at Hazrat Muhammad (Sallallaho Alaihe Wasallaam) but explore and compiling of these medicine is still continued after the death of Holy Prophet Muhammad (Sallallaho Alaihe Wasallaam) throughout the world (Pashaei Fakhri, K

2012, Yari, K.h et. al., 2011]. Al-Quran is one of the best reference books describing the importance of plants in different Surahs as in Al-Momeenoon, Al-Rehman, Al-Bakra and Al-Inaam. Our Holy Prophet (Sallallaho Alaihe Wasilla) used and recommended medicinal plants for various diseases and food (Wani, B.A et. al. 2011).

Cure of diseases through medicinal plants is always a salient feature of Islamic teaching and preaching. Al-Quran is one of the best reference books, describing the importance of plants, especially herbs in different Surahs for their diverse uses. Herbs had been priced for their medicinal, flavoring and aromatic qualities for centuries. Today herbal products symbolize safety in contrast to the synthetics that are regarded as unsafe to human and environment, and people are returning to the naturals with hope of safety and security. Herbs are staging a comeback and herbal *renaissance* is happening all over the globe. So in this backdrop the present study throws light on the importance of some herbs with respect to medicinal properties, in modern times, mentioned in the Holy Quran and Ahidath more than 1430 years ago (Ghaznavi, K. 1987). The history of Islamic medicine started form second century of Hijra, Abdul Malik Bin Habib Undlasi compiled his first book *Tib-e-Nabvi.* In third century of Hijra Muhammad Bin Abu Bakar Ibne Ulsani and Abu Naeem Isphani compiled their books on this topic. In the same era other Muslim scholars like Ali bin Mossa Raza and Imam Kazim Bin Jaffar also worked on Islamic medicines. In the fourth century of Hijra Muslims Scholars like Abi Jaffar Almustaghfri, Zia uddin Almukadasi, Shams uddin Albali, Kahal ibne Tarkhan, Muhammad bin Ahmed Zahabi, Muhammad Abu Baker Alkaim, Jalal uddin Alseuoti and Abdul Razzaq Bin Mustafa Altanki did a great work in this field. The books written in this era *Alnabvi fee Mannafal Makalat* by *Abdul Razzaq Altanki* is a good one. The other books which are best and still available are *Kanzulamal Fee Sanan Walakwal* also provide us much more information about medicines of Holy Prophet (Sallallaho Alaihe Wasallaam) (Koshak, A et. al, 2011). Aim of present study is review on medicinal plants in holey Quran. Keeping in view the importance of diverse medicinal plant and rich medicinal culture of Islam, research work was conducted to investigate ethno botanical uses and create awareness about the fruit plant species enlisted in Holy Quran, Ahadith for the welfare of human communities throughout the world.

Materials and Methods

There are many plants with medicinal applications that have been mentioned in the Holy Book of Muslims, the "Quran". This discussion may point to their pharmaceutical importance in different illnesses due to either their nutritional or phototherapeutic properties (Koshak, A., et. al, 2012). The objective of this research is the identification of medicinal plants enumerated in the Quran. A search of the Quran for any enumeration of medicinal plants was conducted.

The present study is a review survey which was conducted to evaluate plants properties of foodstuffs by studying Quran and medical science texts. To evaluate the texts, the singular or combination forms of the following keywords were used: "Quran" and "Plants". The research work was conducted by reviewing the most acceptable literature given in Holy Quran, Ahadith and Islamic books. Comprehensive and detailed information about medicinal plants were collected from these sources. To evaluate the electronic Persian databases the following websites were searched: Google, scientific information database (SID), ministry of healthcare and also search in other electronic databases such as Google Scholar, Scopus and PubMed. Also, library search was performed by referring to the journal archives of libraries, and evaluating the available Persian references such as religious books and Quranic texts, and also articles of research-scientific and educational journals, and articles of the annual conference of medicine and Quran.

A successive search for any documentation or publication of their therapeutically benefits was carried out using the scientific literature and internet websites for well referenced publications. The phototherapeutic benefits of some of the nineteen medicinal plants identified from the Quran were supported by numerous scientific publications, both traditional as well as evidence-based. Results were systematically arranged by alphabetic order of botanical names followed by English name, family, part used, medicinal uses, Characteristics Surah and Ayah in Quran and references cited from Holly Quran, Ahadith and Islamic books.

Results and Discussion

Recognizing the human exactness needs to foster the courage and physical health. Therefore Quran has expressed the guidelines. Quran, the book of leadership which shows the right path to perfection, uses different methods; somewhere by telling the stories, somewhere by rational reasoning, sometimes by excite the mettle and conscience, and sometimes by expressing the medical, scientific, astronomical or other issues. For example, some goals of astronomical verses of Quran are as follows: theology, proof of monotheism and divinity of only God, show the greatness of God, express the definite occurrence of resurrection, encourage using the nature, express the beginning of creation, explain the order and coherence of nature, apprise the world ends, remind God blessings and encourage thanks giving, and telling some cosmic and astronomical realities like living organisms in heavens; medical verses also following the same rule. Scientific verses of Quran, which point to the nature and development of creation, address to the right persons and it means that scientists can understand it. In fact scientific verses of Quran address to the people who are scientist, thinker or prudent (Arshad, M and Rao, A. 2001).

The Holy Quran is a vast book of knowledge and wisdom that constitutes the main source of guidance for Muslims. Since the first revelation, the Holy Quran remains among the most influential books that exist. At least nineteen medicinal plants have been identified in the Quran. They include: Camphor, Date palm, Fig, Ginger, Grape, Garlic, Lentil, Olive, Onion, Pomegranate, Summer squash, Sweet basil, Athel tamarisk, Tooth-Brush Tree, Arak, Mustard, Acacia, Cucumber, leek, and Cedrus. Five of these plants were selected because of their numerous therapeutic properties revealed in the medical literature. Pomegranate showed hypertensive, antimicrobial, and cancer-preventive activities. Grapes and grape seeds showed abundant benefits in cardiovascular problems. Several studies proved the effectiveness of ginger for the relief of nausea and vomiting (Ebrahim Azarpour et. al. 2014). Clinical and animal studies illustrated the medicinal benefits of olive oil and leaves as hypoglycemic, hypertensive, hypercholesterolemia, antiviral, antimicrobial and immunostimulant agents. The phototherapeutic benefits of some of the nineteen medicinal plants identified from the Quran were supported by numerous scientific publications, both traditional as well as evidence-based. In order to explore the therapeutical benefits of the other medicinal plants found in the Quran, further research is required (Ahmed F. 2011, Musselman, L.G, Keillor, G. 2007 and Rajabnejad, M.R. 2012).

It is concluded that herbal medicines are being used by about 80% of the world population, mainly developing countries for primary health care because of better cultural acceptability, better compatibility with human body and lesser side effects. It is recommended that plant based industries should be developed in the light of Islamic teaching and research (Pashaei Fakhri, K 2012).

In view of the importance of this study comprehensive detailed data was collected from Holy Quran, Ahadith's books and books written on the Islamic medicines. The present research work is a list of medicinal plant and their uses enlisted in Holly Quran, Ahadith and Islamic literature. The main aim of this study is to establish how the different parts or aspects of plant based Islamic medicines such as use of medicinal plants, health principle, hygiene, practice, thought and culture when taken together, demonstrate both wholeness as a system and systematic nature of plant based Islamic medicines. In recent years plants mentioned in Quran and Prophetic Traditions have assumed much importance because of interest shown by Gardeners in general and proposed Quranic Botanical Gardens by UNESCO in particular. Several Islamic countries propose to establish such Gardens. As a matter of fact some of them have already taken steps in that direction.

On such project has already taken shape at Eidgah Ground of Lucknow In view of the fact that exact nomenclature of many Quranic and Prophetic plants are not available

in scientific or religious literature, effort is made to make the following list of such plants with their correct Botanical Identification. This may help all those who wish to introduce these plants in their existing Gardens or else proposed Gardens.

Botanical Name	Alhagi maurorum
Common Name	Manna of hedysarum
Family	Fabaceae
Parts of Plant	Root, leaf, seed and flower
Uses	Cold, Cough, rheumatism, hemorrhoids, kidney stones and bladder stones
Quran Verses	Surah 2. Al-Baqara, Ayah 57; Surah 7. Al-A'raf, Ayah 160 and Surah 20. Ta-ha, Ayah 80.

Botanical Name	Allium cepa
Common Name	Onion
Family	Alliaceae
Parts of Plant	Bulb, leaf and seed
Uses	Blood pressure, gallstones, hemorrhoids, fat, diabetes, antidote, stomach diseases, cholera, diarrhoea, throat infection, common cold, cough, fever, influenza, ear pain, improve sperm production, clear face and skin spots, appetizer, headache, hepatitis, piles, eye diseases, baldness, constipation, menstruation and intestinal diseases
Quran Verses	Surah 2. Al-Baqara, Ayah 61

Botanical Name	Allium sativum
Common Name	Garlic
Family	Alliaceae
Parts of Plant	Bulb and oil
Uses	Rheumatism, catarrh, excretion of intestinal worms, gout, syatym, headache, cholesterol reduction, reduce triglycerides, reduced phosphoinositide lipids, fever, Antidote, wound healer, dog bite, paralysis, digestive problems asthma, parkensis, intestinal pain worms, cough, hysteria, headache, tuberculosis
Quran Verses	Surah 2. Al-Baqara, Ayah 61

Botanical Name	Brassica nigra
Common Name	Black mustard
Family	Brassicaceae
Parts of Plant	Seed, leaf and seed oil
Uses	Constipation, Joint pain, rheumatism, neurological disorders, blisters, colds, lung inflammation and respiratory disease
Quran Verses	Surah 21. Al-Anbiyaa, Ayah 47 and Surah 31. Luqman, Ayah 16

Botanical Name	Cinamoumon Camphor
Common Name	Camphor
Family	Lauraceae
Parts of Plant	Leaf and branch
Uses	Tetanus, cooling, gout, blood pressure, diarrhea, fever, parkensis, hysteria, tuberculoses, headache, liver and kidney pains, oral and teeth swelling, cholera, breast pain, inner wounds, sexual stimulant. Tropical uses of camphor is stimulant and muscle relaxant
Quran Verses	Surah 76. Ad-Dahr, Ayah 5-6

Botanical Name	Cucumis sativus
Common Name	Cucumber
Family	Cucurbitaceae
Parts of Plant	Fruit, seed and oil seed
Uses	Cooling, headache, skin, eye, diuretic, tonic and vermifuge, diuretic, purgative
Quran Verses	Surah 2. Al-Baqara, Ayah 61

Botanical Name	Cucurbita pepo
Common Name	Pumpkin, Gourd and Calabasse
Family	Moracee
Parts of Plant	Fruit, seed , root, oil seed and leaf
Uses	Amplifier, hematopoiesis, worm expulsion, gonorrhea, arthritis, maleness, headache, fever, Madness, Piles, lungs infection, common cold, kidney and liver disorder and heart diseases
Quran Verses	Surah 37. As-Saffat, Ayah 145-148

Botanical Name	Ficus carica
Common Name	Fig
Family	Moracee
Parts of Plant	fruit, bark, root, latex and leaf
Uses	Amplifier, anemia, excretion of intestinal worms, constipation, blister, remove kidney and urinary bladder stone, release intestinal pain, pile, dyspepsia and anorexia
Quran Verses	Surah 95. At-Tin, Ayah 1-8

Botanical Name	Lens culinaris
Common Name	Lentil
Family	Fabaceae
Parts of Plant	Seed
Uses	Maleness, heart, bronchitis, constipation, skin, hematopoiesis, gallbladder, tumor, diarrhea, measle, paralysis, common cold, parkensis, face clearness, eye infection, digestive diseases
Quran Verses	Surah 2. Al-Baqara, Ayah 61

Botanical Name	Musa sapientum
Common Name	Banana
Family	Musaceae
Parts of Plant	Root, stem, leaf, flower and fruit
Uses	Worm expulsion. diarrhea, ulcers in the large intestine, peptic ulcer, diabetes, blood disorders, abdominal pain, earache and sexual power
Quran Verses	Surah 56. Al-Waqi'a, Ayah 27-40

Botanical Name	Ocimum basilicum
Common Name	Royal basil and Sweet basil
Family	Lamiaceae
Parts of Plant	Root, leaf, flower and seed
Uses	Diarrhea, constipation, bronchitis, gonorrhea, fever, cough, common cold, eczema, baldness, vaginal swelling, pemples, arthritis, muscles pain, antidote, pain killer, tuber closes, asthma, piles, hepatitis, consception, malaria and heart diseases
Quran Verses	Surah 55. Ar-Rahman, Ayah 10-13 and Surah 56. Al-Waqi'a, Ayah 88-96

Botanical Name	Olea europaea
Common Name	Olive
Family	Oleaceae
Parts of Plant	Leaf, fruit and oil
Uses	rheumatism, toothache, sciatica, bladder stones, gallstones, diabetes, blood pressure, gout, neurological disorders, headaches, strengthen body muscles, slow down aging, clear the blood, remove the measlesspot, piles, tuberculosis, eczema, baldness, kidney pain, pancreas pain, maleness, common cold, stomach and respiratory diseases.
Quran Verses	Surah 6. Al-An'am, Ayah 99; Surah 6. Al-An'am, Ayah 141; Surah 16. An-Nahl, Ayah 11; Surah 23. Al-Muminun, Ayah 19-20; Surah 24. An-Nur, Ayah 35; Surah 80. Abasa, Ayah 24-32 and Surah 95. At-Tin, Ayah 1-8

Botanical Name	Phoenix dactylifera
Common Name	Data plam and Edible date
Family	Arecaceae
Parts of Plant	Root, flower and fruit
Uses	Amplifier, sexual power, asthma, chest pain, cough, fever, gonorrhea, diarrhea, constipation, heart diseases, bark diseases, antidote, swelling of kidney, intestinal pain, heart attack, wound healer, diarrhea, labour pain, sexual weakness, stomach pain, piles, physical strengthing, shrill the voice and liver disorders
Quran Verses	Surah 6. Ayah 99; Surah 6. Ayah 141; Surah 2. Ayah 266; Surah 4. Ayah 49; Surah 4. Ayah 53; Surah 4. Ayah 77; Surah 4. Ayah 124; Surah 13. Ayah 4; Surah 16. Ayah 11; Surah 16. Ayah 67; Surah 17. Ayah 71; Surah 17. Ayah 90-91; Surah 18. Ayah 32-33; Surah 19. Ayah 21-23; Surah 19. Maryam, Ayah 24-25; Surah 20. Ta-ha, Ayah 71; Surah 23. Ayah 19-20; Surah 26. Ayah 146-152; Surah 36. Ayah 34- 35; Surah 36. Ayah 37-40; Surah 35. Ayah 13; Surah 50. Ayah 9-11; Surah 54. 18-22; Surah 55. Ayah 10-13; Surah 55., Ayah 68-78; Surah 59. Ayah 5; Surah 69. Ayah 6-8; Surah 80. Ayah 24-32 and Surah 111. Ayah 1-5.

Botanical Name	Punica garnatum
Common Name	Pomegranata
Family	Punicaceae
Parts of Plant	Flower, fruit, dried fruit bark, root bark and leaf
Uses	Excretion of intestinal worms, urea reduction, cholesterol reduction, cardiology, liver, jaundice, anemia, neurasthenia, diabetes, high blood pressure, Stomach cough, hepatitis, muscle pain, heart and liver diseases, piles, eye diseases, dental problems, oral diseases, diarrhea and dysentery.
Quran Verses	Surah 6. Al-An'am, Ayah 99; Surah 6. Al-An'am, Ayah 141 and Surah 55. Ar-Rahman, Ayah 68.

Botanical Name	Salvadora persica
Common Name	Toothbrush tree, Mustard tree
Family	Salvadoraceae
Parts of Plant	Leaf, seed, branches and roots
Uses	Dental diseases, fever, rheumatism, constipation, tumor, shortness of breath, gonorrhea, leprosy, bladder stones, gallbladder, arthritis, piles eczema, oral diseases, headache, antidote, diabetes, digestive problems.
Quran Verses	Surah 37. As-Saffat, Ayah 16

Botanical Name	Tamarix aphylla
Common Name	Manna Tree and French Tamarisk
Family	Tamaricaceae
Parts of Plant	Plant bark
Uses	Stomach pain, cough, toothache, hemorrhoids, diarrhea, Jaundice bloody sputum.
Quran Verses	Surah 34. Saba, Ayah 16

Botanical Name	Vitis vinifera
Common Name	Grap
Family	Vitaceae
Parts of Plant	Fruit, leafs and youth branch
Uses	Fever, amplifier, jaundice, constipation, bronchitis, cold, blood pressure, anemia, diabetes, rheumatism, tuberculosis, diarrhea, common cold, relax body and brain muscles, stomach diseases, cooling effects on body, cough, kidney and urinary bladder pain, liver and lung disorders, dog bite, remove weary, clear the face and cancer
Quran Verses	Surah 2. Al-Baqara, Ayah 266; Surah 6. Al-An'am, Ayah 99; Surah 12. Yusuf, Ayah 36; Surah 13. Ar-Ra'd, Ayah 4; Surah 16. An-Nahl, Ayah 11; Surah 16. An-Nahl, Ayah 67; Surah 17. Al-Israa, Ayah 90-91; Surah 18. Al-Kahf, Ayah 32; Surah 23. Al-Muminun, Ayah 19-20; Surah 36. Ya-Sin, Ayah 34-35; Surah 80. Abasa, Ayah 24-32 and Surah 78. An-Nabaa, Ayah 31-36.

Botanical Name	Zingiber officinal
Common Name	Ginger
Family	Zingiberaceae
Parts of Plant	Rhizome
Uses	Intestinal pain, cooling, anorexia, dyspepsia, headache, diarrhea, constipation, intestinal swelling, dog bite, stomach disorders, sexual weakness, digestive stimulant, cooling effect on body, increase urine production.
Quran Verses	Surah 76. Ad-Dahr, Ayah 11-18

Botanical Name	Ziziphus spina-cheristi
Common Name	Nabak tree
Family	Rhamnaceae
Parts of Plant	Fruit, leafe and wood
Uses	Tuberculosis, cooling, toothache, bronchitis, cough, blood pressure, treatment of abscesses and wounds, anodyne and tonic, styptic and purifying blood
Quran Verses	Surah 34. Saba, Ayah 16; Surah 53. An-Najm, Ayah 12-15; Surah 53. An-Najm, Ayah 16-18 and Surah 56. Al-Waqi'a, Ayah 27-40

For many centuries, humankind was unable to study certain data contained in the verses of the Quran because they did not possess sufficient scientific means. It is only today that numerous verses of the Quran dealing with natural phenomena have become comprehensible. A reading of old commentaries on the Quran, however knowledgeable their authors may have been in their day, bears solemn witness to a total inability to grasp the depth of meaning in such verses. I could even go so far as to say that, in the 20th century, with its compartmentalization of ever-increasing knowledge, it is still not easy for the average scientist to understand everything he reads in the Qur'an on such subjects, without having recourse to specialized research. This means that to understand all such verses of the Quran, one is nowadays required to have an absolutely encyclopedic knowledge embracing many scientific disciplines.Plants and fruits are an essential component of the universe. Human beings have used those as medicine from the very beginning of time. According to holy Quran, 19 plants like (Manna of hedysarum, Onion or Cepa, Garlik, Black mustard, Camphor, Cucumber, Pumpkin or Gourd or Calabasse, Fig, Lentil, Banana, Royal basil or Sweet basil, Olive, Data plam or Edible date, Pomegranata, Toothbrush tree or Mustard tree, Manna Tree or French Tamarisk, Grap, Ginger and Nabak tree) are gifts and heavenly plants of God. Nineteen fruits and plants name have been mentioned in the holy book of Moslem. The plant species in the Quran are: Alhagi maurorum, Allium cepa, Allium sativum, Brassica nigra, Cinamoumon Camphor, Cucumis sativus, Cucurbita pepo, Ficus carica, Lens culinaris Medic, Musa sapientum, Ocimum basilicum, Olea europaea, Phoenix dactylifera, Punica garnatum, Salvadora persica, Tamarix aphylla, Vitis vinifera, Zingiber officinal and Ziziphus spin-cheristi.

A phytochemical screening of these fruits and plants belonging to sixteen families (Alliaceae, Arecaceae, Brassicaceae, Cucurbitaceae, Fabaceae, Lamiaceae, Lauraceae, Moraceae, Musaceae, Oleaceae, Punicaceae, Rhamnaceae, Salvadoraceae, Tamaricaceae, Vitaceae and Zingiberaceae) was carried out.

Conclusion

Over fourteen century has been passed from Quran descending. It should be claimed that most Quran contents are perceived in the light of scientific development and human knowledge due to passing time. The holy Quran is the guide book to lead human beings toward God the most high which made use of various reasoning methods, the word of advice (sermon) and debates in a good manner and also scientific signs in the line with its leadership purposes. it has been pointed out more than a thousand verses to scientific subjects in the book among which some has been considered Quran's scientific miracle.

Hence, there exists an abundant verse associated with medicinal plants and related

issues importance of the mentioned subject. The plants which have been named in Quran attached a lot of importance to their usages and properties and also regarding to featuring every event and occurrence accompanied with the name of the plant. Since the name of the plant mixed with the words of Allah, it manifests precious and importance to some sort. Results in this research showed that 19 medicinal plants have been acknowledged in the Quran.

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Interpreters of Seerapuranam and Seerapurana's Edition

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Abstract

This paper highlights the uniqueness of Seerapuranam and throws light on the on the interpretations written by various authors on Seerapurana. It also presents the history of Seerapurana editions and contributions made by various authors.

Keywords: Seerapuranam.

Introduction

Seerapuranam has the power of enticing the readers as well as the listeners. Tamil is a language of literary wealth and grammatical regulations. The three ancient kings developed Tamil by organizing convention (conference). In the recently held world Tamil classical conference at Coimbatore it was universally accepted that, Tamil is the most ancient language as this language has a deep literally wealth and riches it has earned the status of classical language.

Several religions have been practiced all over the world. Each religion has got Epic of its own. For the religion of Shiva there is Kambaramayanam; for the religion of Samanam there is Seevagasinthamani; Manimegalai is an Epic of Buddhism and Theambhavani is the Epic of Christianity. Seerapuranam is the Epic of Islam.

Special Significance Charateistic of Seerapuranam

In the title of Seeranpurana the word Purana(Epic) has merged with the word *Seera*. *Seera* and *sirath* are the Version of Arabic language. It means history. The phrase Seerathun Nabi means the history of Prophet Mohammed. The history of others are known as Seerathanthra, Seerath Bibers by everyone. But,the history of Prophet is known only by Seerapurana. This has been emphatically told by Abdul Raheem.

The Entire Seerapurana is about the biography of Prophet Mohammed. This was written by the poet Umaru. It consists of 5027 Viruttham, 3 divisions and 92 subdivisions. The 3 divisions are Vilaathukandam, Nubuvathukandam and Hijirathukandam. Villathu means birth. It deals with the birth of Prophet Mohammed. In villathkandam there are 24 subdivisions (Padalangal) and 1240 Thiruvirutthanal.Nubuvathu describes the incidents of 13 years of Prophet Mohammed. It consists of 21 subdivisions and 1014 thiruviruttham. Hijirathu means migration or exodus place. The Islamic year starts from Hijri and hijirath comprises 47 subdivisions and 2683 thiruvirttham.

Interpreter of Seerapurana

Seerapurana was published 140 years after its composition. No one wrote Interpretation for this Epic. Though it is an Epic of Islam not even muslims came forward to write (paraphrase) interpretation from 17th century to 20th century. There was no single complete Interpretation.

If anyone makes an attempt to write an interpretation of Seerapurana, He must have complete knowledge of Islam and an understanding of Arabic and Persian languages besides this he must have the knowledge of holy Quran and Hathis; Sathavathani Seiguthambi Pavalar was born in 1874 at Edalakudi and died in 1950. He was the most significant poet of 20th century. He was the first one to write paraphrase for Seerapurana. The 1st part of interpretation appeared in 1902 and the 2ndpart in 1908.

Poet Kavikaamu Sheriff came forward to write interpretation. He wrote a complete paraphrase of seerapurana except for a few divisions(Padalangal) of Villathukandam. While kalaimamani was writing interpretation he passed away due to illness.

Abdul Kareem was born on Jan 1,1937. He was high proficient in Tamil Literature. He was a custodian of Islamic literature. As he had a sound Knowledge of islam, he came forward to write interpretation of Seerapurana along with his wife. Both of them completed the work which was left incomplete by poet K.M.Sherif. M.Abdulkareem and his wife Hanifa Abdul Kareem wrote an interpretation in modern version and it is a beautiful gift to the literary world. No one has done any research on the interpretation of Seerapuranagiven by M.Abdulkareem. The skill of interpretation of Abdul Kareem is divided into many topics such as skill of Grammar, skill of Literature, skill of Astronomy, skill of Arabic diction and the skill of putting forward the Islamic principle. Research has been done on these sub topics also.

History of Seerapurana Editions

The book came in print only after 140 years of composition. U.V.Saminatha Iyer is pioneer in printing. He has done great service to tamil literature. One has to encounter many problems to print an edition. U.V.Saminatha Iyer collected many scrolls from different places for publication. Similiarly he had collected many scrolls from different places to publish Seerapurana.

The 1st Edition of Seerapurana appeared in 1842. It was edited by Seigu Abdul kadhir Nainas labbai Aaleem. This edition was critically analyzed and published by poet Uvaisu Nainar and Baheer Mohaideen of Yazpana. As these personalities were greatly helpful to bring out this edition; the name of Uvaisu Nainar appeared in the first page and Baheer Mohaideen in the last page.

Creative Works of Editions of Seerapurana

- In 1842 Sheigu Abdul KadhiriNainarlabbai edited and published throughvidhyavilasa printing press (Chennai city) Hijiri -1258.

- UvaisuNainarlabbai, Yazh-parikarimaraikkayerand BaheerMohaideen(Chennai), (vidhyavilasa printing press, Yazpana) edited in 1842.

- YazhParikariMaraikkayar andBaheerMohaideenedited in Lakshmi Vilasa Printing Press, Saidapet, in 1852.

- ThanjaiHusanSahibu, Chennai Prabakar Printing Press in 1857.

- Allah Pichai Pulavar edited Seerapuranain Chennai Parappiramma Muthirarasa Salai in 1880.

- KankuMadhuPulavar: Seeravasanakaaviyam, Chennai Manonmani Vilasa Printing in 1887.

- Kannakumuthu Mahuthoom Mohammad Pulavar Edition in 1890, Publisher: Itta Parthasarathy Naidu's Sri Padmanaba Vilasa Printing press, Triplicane.

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Conclusion

Umarupulavar composed the Seerapurana. Many Paraphrase writers (or) Interpreters have written paraphrase or Interpretation to spread the name and fame of Seerapurana throughout the world. They have written Interpretation in beautiful style. Due to this interpretation, Seerapurana has reached each and everyone in the world. Not only this, the editors through their excellent service have dissimenated the knowledge of Seerapurana every nook and corner of the world.

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A Study on Karai Iraiyadiyanin *Nabi Mozhikkural*

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Abstract

A beautiful composition in the form of poetic couplets, dedicated to the Tamil speaking world by *Karai Iraiyadian* in the massive poetic presentation called *Nabi Mozhikkural*. This paper evaluates the composition of the best of *Nabi Mozhikkural*.

Keywords: Karai Iraiyadian, Nabi Mozhikkural.

Religions differ among themselves in their teachings, but their contribution to the growth of the literature has been immensely valued. The world religions, Jainism, Buddhism, Sikhism, Vishnavism, and Christianity contributed lavishly to the growth of world of literature. Islamist litereur went up a step further and gave their literary forms to the world in great extent.

Islamist litereur made good literary forms specific to the Tamil literature. They also developed new forms of literature in Tamil - Kissa, Naama, Padaipor, Masala, Munajath etc. This shows clearly their great affinity and love towards the great Tamil.

Literature reflects the status of the society of that priod it was formed. So, the literature is called the mirror of the society. Elements which show the nature of the society from time to time reflect in the literature. Accordingly, literature and literary forms also record their changes. These changes accurately mirrored in the literature. But the truth about worldly life recorded inThirukkural, the greatest literary marvel the world ever seen is always greatly valued all the time.

Prophet Mohammed (sal) followed what He said. Prophet Mohammed (sal) is the heavenly model for the human beings to the follow the worldly life. This has been revealed in *Nabimozhikkural*, which has been written in kural form of literature by Kavimaamani Karai Iraiyadiyan. This book shows to the literary world that the Islamist litereur proved they can make any kind of literary forms at the best. This book has 2285 pages and 2000 poetic kural forms. This is lengthier than the Thirukkural.

Author of the book Kavimaamani *Karai Iraiyadiyan* (M. Muhammed Ali) has won many prizes and appreciation from various quarters. He is the foremost figure among the muslim litereur in modern days in traditional poetic form of literature. His books were well received in Tamil Nadu, is the standing testimony of his work. He had close association with Tamil's great Kavignhar Kannadasan, Devaneyappavanar and kavignhar Suradha.

The author loves novelty. So he tried and succeeded in bringing the 'kural form' poetic work in "Thiruvarupavai", which has element of thirty-day fasting in Islam as in other religions work like Thiruvarupavai and Thiruvenpavai.

The author taken much care to bring out the preaching of Prophet Mohammed (sal) in the real essence of the message of islam and succeeded. This has been well appreciated by the wide spectrum of Tamil scholars that is the testimony of finest masterpiece his writings.

The author thankfully acknowledge the monetary support he had received from his patron advocate Janaab S Ameeruddin in his book just like UmaruPulavar appreciated his patron AbulKasim in Seerapuranam. As Kambar appreciated his patron SadaiyappaVallal in KambaRamayanam. The couplets read as . . .

<blockquote>
Vallal Nabiperumaan Vaimai Mozhi Parava
Vaari Vazhangiya Valamudaion
Vallal Ameerudin Vannath Thirukkodaiyai
Vazhthi Magizhkavae Valarnenche
</blockquote>

This book has 2000 couplets bigger than Thirukkural. This is enriching the Tamil literature and at the same time has written in very simple form.

The great religion, Islam, built on five pillars - Emaan, Prayer, Fasting, Zakaath and Hajj. More than 100 crore muslims live in all over the world. Muslims spirit the divine book, Holy Quran more than their life. When every human being recites the Holy Quran, he will be enlightened quotes the Prophet Mohammed (sal). This quotation of Prophet Mohammed (sal) has been clearly given in the book in the couplets read as

<blockquote>
Illam Olira Eraimarai Odhuka
Nalla Thozhukaiyum Naadu
</blockquote>

Universal truth of One God concept, God has no equal, has no origin, nothing is example to him. This has been clearly given in the couplets as

<blockquote>
Allahvae Moolam; Avarkumun Eadumillai
Ellam Avanattkam Enn
</blockquote>

Who is a muslim, the author also quotes grammar for a muslim as

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Allahvae Kaapoan ; Avan Neri Al- Esulaam
      Vallanabi Dhootharaam Vazh
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The author is bold enough to express this view - *People bear merely muslim name would never be called as muslims, unless one has the quality of muslims.* This is quite appreciated. He stresses the crowning qualities of a muslim as he always speaks truth, one should not foul play on others, one should not infuse pain on others. He pointed out that equality and brotherhood are the two basic principles of Islam. The author also pointed out in a couplet that prayer and fasting alone do not make one a good muslim. Author's temerity on this view is laudable.

Muslims living in modern society think that observing fasting in Ramzaan, praying five times a day are the only basic duties of muslim. But never care about preaching equality, brotherhood, but do lending money on interest, consuming liquor. They are not following basic observations in Islam. As a reminder to these people the couplet reads

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Thozhugai Noenbal Mattum Thueaimusuli Mennum
          Vizhumang Kidaikkadu Vill
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Though this book bear the basic Islamic tenets but these tenets are suitable to everyone in this world. Islam is not a religion but a way of life. Islam not belongs to muslims alone but it belongs to everyone in the world. The Holy Scripture says: Every child born in this world is a muslim.

It has been stated in the prologue of the book *Nabimozhikkural* that it would stand as Seerapuranam in Tamil literature. M. Sayabu says this book will hold high place in the Tamil literature is the standing testimony to fix the status of this book in the Tamil literature.

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Poie Sollaan; Thunduruthaan ; Poetrum Oodan
                   Pirapaan
        Mei Muslim Einnoenman Mel
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Petrifying memories rouses quest for freedom in *Beloved*

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Abstract

Horrifying memories of African Americans instigated quest in many black writers to explore the very issues of freedom and identity which was denied in the white dominated America. Blacks had been marginalized against and became a prey of racist attitudes, particularly black women were exploited in many ways and this notorious behaviour of whites enthused Morrison to represent as a mouthpiece of black community and through her novel "Beloved" she provides a very detailed description of the different experiences of the African Americans who have been in search for their identity. Through this fiction she portrays the perception of black women who criticize themselves for their blackness and it seemingly depicts the struggles and joys of the journey to self-awareness, blending the real and surreal to explore the magical elements of everyday life of the black community in America. In short, this work of Morrison have in reality illuminated the quest for freedom, all-round experience, identity and psyche of communal black life.

Keywords: Depression, Self-awareness, Self-identity, Freedom.

Introduction

Beloved, the book many consider to be Morrison's masterpiece, was published in 1987. It became a best seller and received Pulitzer Prize for fiction in 1988. Mythic in scope and it is apparently an ambitious attempt to grapple with slavery and the tenacity of its legacy. It was dedicated to the tens of millions of slaves who died in the trans-Atlantic journey . It can also be seen as a ghost story that frames embedded narratives of the impact of slavery, racism, and sexism on the capacity for love, faith in the families

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of black community. The novel is set after the end of the civil war, during the period of reconstruction in Cincinnati. This is mainly a story of a black female slave who develops awareness about her own subhuman status on the Sweet Home Plantation, which ultimately awakens and forces her to develop a quest for freedom. Morrison's *Beloved* is a story of Sethe, an alienated and isolated former slave-women, who kills her infant in order to save her from the life of slavery, and is found engrossed in guilt throughout her chaotic life. "No doubt she is fated, but she tries to liberate herself and her children from this given fate."(Ranveer 43)

The Historical Plight of Blacks in American Society

It is a flashback to past tragedies and psychological sufferings, explores the hardship endured by a former slave women, Sethe, during the reconstruction era. To spare the girl from a life of eternal bondage Sethe murdered her infant daughter, *Beloved*. But the ghost of the child continues to haunt Sethe's house and guarding the mother, driving out her brothers, shaking the furniture, and shattering mirrors. Though the spirit is driven out, she returns with the body of a young girl with raspy voice and with no lines on her palm. The grown up women has become to settle her score and calls herself *Beloved* the one word written on the tombstone, thus giving Sethe an opportunity to justify her act by substantiating and expressing her devoted love for *Beloved*. "The young woman is named *Beloved* and her astonishing presence is unlike that of any character in American fiction. *Beloved* is a ghost and yet she has a body; she has fears, which we see from within."(Brown 19).

The Black Book

This murder is again a result of the oppression of the dominant culture. Morrison reveals in Sethe the ineluctable duplicity of the human condition, the moral capacity both to choose and to bear the consequences of choice. Thus, we find that Toni Morrison's characters in one way or the other enact the historical plight of blacks in American Society and She offers no apology for her black female perspectives.

Morrison readily concedes that the story of *Beloved* is based on fact. It grew out of one of her Random House projects, The Black Book (1974), a scrapbook of three hundred years of the folk journey of Black America. Morrison became aware of the story of Margaret Garner while gathering material for the text. A fugitive from Kentucky, Garner attempted to kill her children rather than have them re-enslaved when they were all captured in Ohio in 1850. She succeeded in killing only one, however, whose throat she slashed and was apprehended for the crime. She justified her notorious act of killing infant by saying that she was unwilling to have her children suffer as she

had suffered. Barbara Christian correctly notes "Afro-American women writers rewrite the established history by embodying their ancestors' memory in fiction, and as well respond to previous Afro-American women's literature. Contemporary Afro-American women's work is inter-textual as well as reiteration of the restriction based on class, race, gender, imposed on their forebears." (Christian 65)

Morrison's purpose in *Beloved* is corrective. Through her narrator she aims to expose the wrong and rectify the full story. Morrison in her Contemporary Literary Criticism states, "My job becomes how to rip that veil" behind which the slave narrator was forced to hide. Ultimately, then, she seeks in *Beloved* to find and expose a truth about "the interior life of people who didn't write it; to fill in the blanks that the slaves narrative left; to part the veil that was frequently drawn; and to implement the stories that heard." The novel effectively conveys the brutality and dehumanization that occurred under slavery, putting Sethe's act in context without necessarily condemning it or excusing it. The structure is fragmentary, closely tied to the consciousness of each character and weaving suddenly between past and future. More time is spent describing past events than the action of the current moment, reinforcing the idea of the past lingering and shaping life in the present. The novel is often repetitive, telling the same stories of the past again and again, giving more information with each repetition. All of the characters of the novel, former slaves and the children of former slaves, suffer a troubled relationship to their own past. Their relationships to their past often make it impossible for them to live for the present or plan for the future, and slavery has often damaged the ways that they experience love and think about their own worth as human beings. Morrison divides the text into twenty-eight unnumbered mini-sections. Within these sections, Sethe experiences twenty-eight happy days of "having women friends, mother-in-law, of being part of a neighbour; of being part of a neighbour-hood; of, infant, having neighbours at all to call her own" (B 173).

Beloved is a haunting story of mother's love that frames a series of interrelated love stories by multiple narrators. This story begins in 1873 and end in 1874, but flashback intermittently to 1855. In the flashbacks and reveries, the omniscient narrator invokes ancestral black women's remembrances of the terror and horror of the middle passage. Morrison also probes the deep physical and physic wounds of southern slavery, especially the paradoxes and perversities of life on Sweet Home plantation in Kentucky, and recalls Sethe's bold flight to freedom in Ohio in 1855. Freedom, as Paul D's and Sethe's stories most dramatically illustrate, is *to get to a place where you could have anything you not to need permission for desire.* (B 162)

Sethe can be recognized as a protagonist of the story, who is in constant search for her identity and wholly responsible for the embodiment of several souls of Afro American women and children driven into the slave ships of America. After the

omniscient narrator introduces us to the restless, spiteful spirit of Sethe's two-year-old daughter *Beloved*, we are quickly and irrevocably drawn into the vortex of conflicting values and feelings of the text. On one hand, we are drawn emotionally and psychologically closer to Sethe through her unrelenting memory of the terrible price she has paid for loving her daughter so dearly; but on the other hand, like Paul D and Ella, we are at first morally repelled by her act of infanticide. When school teacher and slave catcher tries to catch Sethe, she not only cuts *Beloved*'s throat with a handsaw but also attempts to kill her other three children. Sethe wanted dearly *Beloved* engraved on the tombstone from the funeral service, but had only enough strength to pay for one word. Payment was ten minutes of sex with the tombstone engraver. This act, which is encountered early in the novel, is a keynote for the whole story: in the world of slavery and poverty, human beings are merchandised, so everything has its price. From the following lines we can figure out the motherly affection of Sethe towards her *Beloved*.

All I knew was I had to get my milk to my baby girl. Nobody was going to nurse her like me. Nobody was going to get it to her fast enough, or take it away when she had enough and didn't know it. Nobody knew that she couldn't pass air if you held her up on your shoulder, only if she was lying on my knees. Nobody knew that but me and nobody had her milk but me. (B 16)

Baby Suggs is an old slave who has given birth to eight children who have six fathers. The frequent changes of slave owners has resulted in their having several children, thus leading a shameful life. *They were moved like checkers. Nobody stopped plating checkers . . .* (B 23). Their frequent change makes their life terribly awful. Nel a character in Morrison's novel, Sula admits the same- *Hell is change* (S 108). Children lives take a positive turn after they come under the control of Baby Suggs at 124, Blue stone house.

Morrison explains the psychological aspects recurring in the black American experiences throughout the life by correctly moving the story stage by stage. Paul D sees, *a witness old women jailed and hanged for stealing ducks she believed were her own babies.* (B 66). The pathetic black children see whites as men without humanity. But, there are few whites who have a decent approach like Amy Denver, the runway slave who helps Sethe in delivering Denver. There are also abolitionists who help Baby Suggs find a house and a job after she is freed. Thus Toni Morrison is careful in her perspective on whites, neither she blames the whole white community nor she exaggerates the blacks.

Conclusion

In short, in *Beloved* Morrison does not circumvent, as she seems to have done in the past, what lies at the crux of the whole issue of freedom that we find in this novel is the realization that ultimately freedom, in the existential sense. The novel also suggests the excruciating ambiguity of the black's identity crises in America. However, this novel

serves as a voice of several blacks towards the world of people with whom they live, and it is a voice of black American quest for identity.

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An Overview of Sea Literature

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Abstract

This paper aims to highlight how writers portrayed human responses to the sea in literature. It also presents the role played by the images of sea in representing joy, melancholy, suffering and death. It throws light on the contribution of some important writers in depicting sea and sea life. It covers the period from 1700 to 1850.

Keywords: Sea, Sea Literature, and Shipwreck Literature.

Introduction

Human responses to the sea were portrayed by the writers of all ages in personal narratives, poetry, novels, short stories, and plays. The images of sea play an important role in literature and serve as representations of joy, melancholy, suffering and death. The sea serves as a symbol of freedom for some and enslavement for others. It is the sea which always kindles the creativity of the writers. Depictions of sea in literature make us understand our lives better.

Shipwreck Literature

In *Encyclopedia of American Literature of the Sea and Great Lakes*, we find a term called 'Shipwreck Literature' which deals with shipwreck in American Literature. Further we find the meaning for 'Shipwreck Literature' as follows:

> Shipwrecks have always been a popular subject in American literature. For early settlers, the perilous voyage from Europe to America was a providential test, and disasters at sea were interpreted as signs of divine disfavor. Living in a world rife with typological significance, survivors and observers of shipwrecks could not avoid making a connection between a journey at sea and the journey of life, so maritime tragedies were perceived

as jeremiads that warned people not to stray from the righteous path. Yet shipwreck accounts also carried a promise of deliverance; no matter how devastating the disaster, someone always survived to tell the tale, and the survivors could not help but see God's hand in their survival (Williams 410).

Writers' Contribution

The well known shipwreck of the eighteenth century is the wreck of the Nottingham Galley in American waters. It happened on 11 December 1710 and the survivors were rescued a few weeks later. The ship's Captain, John Dean, and his brother Jasper published a work titled *A Narrative of the Shipwreck of the Nottingham Galley* in 1711. The following lines of Richard Warner clearly describe the plight of survivors:

> In 1710 the Nottingham Galley, laden Cordage, set out from London bound for Boston. After taking on an additional cargo of butter and cheese at Killybegs, Ireland, it set sail again for its Atlantic Crossing. Arriving off the Newfoundland Coast dangerously late in the season, the small vessel encountered severe storms. Just before making port, the Nottingham struck Boon Island, a barren and desolate rock off Portsmouth New Hampshire. Miraculously, all hands got ashore, but the ship and its entire cargo were lost. There was no food and little left with which the men could build a shelter from the bitter cold. They suffered terribly. The cook died in the first days and was buried at sea; two seamen were lost in a heroic but futile attempt to escape the island on a raft; and the fourth, the carpenter, died and then was cannibalized to sustain the fourteen crew members, who were eventually rescued twenty-four days after losing their ship (4).

The English writer, William Strachey (1572-1621) is best remembered as the eye-witness reporter of the shipwreck of Sea Venture on the island of Bermuda in the year 1609. Shakespearean scholars think that this incident is said to have been a source for Shakespeare's *The Tempest*. He was a passenger of Sea Venture when the ship was blown off by a hurricane. In 1610, he wrote a letter to an unnamed *Excellent Lady* in England about the Sea Venture disaster and the plight of Jamestown Colony. An English separatist leader, William Bradford (1590-1657), who was a signatory of the Mayflower Compact, wrote a journal *Of Plymouth Plantation* which covered the period from 1620 to 1657 in Plymouth colony. He described the difficulties encountered in the sea voyage to America. The ship encountered cross winds and many fierce storms. Its shroud was shaken and one of the main beams was bent and cracked. The sickness which had begun on the ship continued even when the settlers arrived in Plymouth Bay on December 20, 1620. In the case of Roger Williams (1603-1683), he made his voyage productive by writing *A Key into the Language of America* (1643), a book with observations about life

and culture.

The English writer, journalist and pamphleteer, Daniel Defoe's (1660-1731) travel to Holland, France and Spain developed a taste for travel in him. This interest was reflected in his works *Robinson Crusoe* (1719) and Moll Flanders (1722). His work *The Storm* (1704) was an exemplary work of journalism. A week after the storm of 1703, Defoe collected personal accounts from the public through newspaper advertisements and edited the selected accounts for the book.

The prominent English writer Tobias Smollet's (1721-1771) novels, *The Adventures of Peregrine Pickle* (1751) and *The Life and Adventures of Sir Launcelot Greaves* (1762) reflected the courageous, just and moral attitudes of seamen. The Romantic poet Samuel Taylor Coleridge's *The Rime of the Ancient Mariner* (1798) narrated the voyage of an old sailor who killed an albatross near the South Pole. English novelists like Captain Frederick Marryat (1792-1848) wrote narratives based on their first hand experiences. Marryat's adventure tales such as Midshipman Easy (1836) and Masterman Ready (1841) opened up the world of the British Naval service to the English.

Conclusion

In sea literature, the sea, the sailor, and the ship play prominent roles. The ship symbolizes life, which is a mixture of adventure, excitement, fortune and misfortune. The sailors stand as a symbol representing labor exploitations and the brutal conditions at sea. Hence, the sea has been portrayed in literature as indifferent, hostile, and welcoming. Literature of the sea helps the readers to understand the writers' views and experiences on sea. Further it makes the readers to empathize with the sailors and seamen.

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Communal Harmony through Inter-Caste Relations in Rural India

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Introduction

Justice and equality are the two subjects often talked about by most of the nationalists and leaders of various political and ideological streams across the world including India. India was at the forefront in condemning racial discrimination particularly apartheid and also the influence of super power(s) on the internal affairs of independent nations. Her commitment to secure its citizens freedom, justice, equality and fraternity is reflected in the very preamble of the Indian Constitution. Towards achieving these challenging goals, special provisions have also been made in the Constitution to protect and promote the interests of the most oppressed section of Indian society - traditionally known as Untouchables and Constitutionally as the Scheduled Castes. These provisions are expected to alter the given unjust distribution of power (political and economic) and status (social) among different sections of people and thereby transform India into an egalitarian society. Given India's unequivocal commitment to secure its citizens particularly the most exploited and pilloried section of India these noble ideals, we shall attempt here to understand Indian villages, which host over 80 per cent of the Indian population, from the point of view of whether or not these villages patronise the institution of caste which is in contravention of these ideals or are these little republics ideal for realising the said goals and thus to be preserved as they are as claimed by many social reformers including Mahatma Gandhi. In the process, we shall also address the question of how caste has remained unchanged, how it controls social interaction between higher and lower caste groups and accordingly perpetuates unequal control over power and status. And most importantly we shall also understand whether all the Scheduled Castes (lower castes) treat their members as equals or there is hierarchy, discrimination and practice of untouchability even among them.

Methodology

For better understanding on the issue of caste and its repercussions, we shall look into a few Indian villages in States like Tamil Nadu - one of the southern States of India known for protest against caste system and supremacy of the Brahmins (highest caste). The present paper is based on the qualitative and quantitative data collected from two villages: Akramesi and Keelaparthibanur located in Paramakudi taluk, Ramanathapuram district of southern Tamil Nadu. If the taluk town Paramakudi is considered the central reference point, Akramesi village falls on the north-east side with a distance of 21 km and Keelaparthibanur on the north-west side with the distance of 16.9 km. Akramesi village is predominantly inhabited by the middle or dominant castes (caste Hindus) and the Scheduled Castes over there were not only numerically in minority but also dependent on the former both for their livelihood and physical security. This village is surrounded by many villages with caste Hindus' dominance. In contrast, the Keelaparthibanur village is predominantly inhabited by the Scheduled Castes particularly the Pallar Caste - the high caste among the Scheduled Castes - and they are also economically independent. The caste Hindus here are relatively less in number. This village is surrounded by villages with similar characteristics. The choice on these two villages is to understand whether or not higher numerical strength and better economic status of the scheduled castes protect their self-respect and dignity and also protect them from atrocities. The details presented in this paper are based on the data collected and observations made by the researcher during November 1989 to April 1998. The respondents were the randomly chosen 50 members belonging to Pallar castes and a few purposively selected leaders of Pallar and high caste from the two villages.

Caste in Tamil Nadu

Though Tamil Nadu has 21 districts (1991 census), we may focus only on one district where inter-caste violence has been a common phenomenon. Ramanathapuram district - one of the southern districts of Tamil Nadu - is one of such kind. Castes found in Tamil Nadu in general and Ramanathapuram district in particular may broadly be grouped into three categories: Brahmins, non-Brahmins and the Scheduled Castes. While the Brahmins are considered the highest in the caste hierarchy, the non-Brahmin castes are considered the middle level castes. The more visible middle level castes include the land owning castes such as Vellalar, Ahamudayar (Servai), Maravar (Thevar), Kallar, Konar (Yadavar) and the Telegu speaking Naidus; trading castes such as Chettiyar, artisan castes like Kusavar or Kuyavan (Potter), Kotthan (mason), Thachan (carpenter), Kollan (blacksmith), Thattans or Nahai Aasari (goldsmith); and the servicing castes such as Ambattan (barbers) and Vannan (washermen). The more visible castes among the Scheduled Castes in Ramanathapuram district are the Pallars,

Parayars and Chakkiliyars. While most of the Brahmins strictly observe vegetarianism, most of the middle level castes except the Vellalar and to some extent the Chettiyar do not adhere to such restrictions. It may be noted that adhering to vegetarianism is one of the ways by which one asserts his/her superior position in the caste order. Among the meat eating Hindus, the beaf eaters are considered to be inferior to mutton eaters and even to pig eaters. Even today these middle level castes maintain, not fully in urban areas, complete distance from the Scheduled Castes. Of these middle level castes, a few such as Ahamudyar, Maravar and Kallar together known as Mukkulathor (three castes) are relatively more visible particularly in Ramanathapuram district as they are not only owners of cultivable land, large in number and more assertive but also known for committing atrocities on the Scheduled Castes.

The relationship between the higher castes and the lower ones has always been very hostile and in such relationship the losers are often those at the bottom of the caste ladder and the gainers are those above due to, as stated before, unjust and unequal distribution of power and status. Any attempt on the part of the lower ones to alter the given power positions is met with dire consequences. These include the murder of a Scheduled Caste leader Shri Thiyahi Imanual at Paramakkudi town and 42 Scheduled Caste persons at Mudukulathur in Ramanathapuram district in 1957, of 44 Scheduled Castes at Keelavenmani in Tanjaur district in 1968, 5 at Unjanai in Pasumpon Muthuramalingam district in 1979 and 16 at Vilupuram in Chengalpat district in 1983. Besides, there were a number of murders of the Scheduled Castes at Kudaloore and Vilupuram in Chengalpat district in 1987 and at Podi in Madurai district in 1988. In 1992 two more persons were killed at Paramakkudi in Ramanathapuram district2.

The higher lower caste and higher castes

To understand the coercive nature of the caste system and the kind of caste discrimination faced by the lower castes, we shall focus on the Pallar caste. The Pallar caste is considered to be the highest caste among the lower or the Scheduled Castes and lower caste among the higher castes or the caste Hindus in Tamil Nadu. The Pallars (people belonging to the Pallar caste) constitute the largest among the 76 Scheduled Castes of Tamil Nadu. According to 1981 census, out of the total Schedule Caste population excluding the Adi Dravida - a category consisting of number of Schedule Castes - the Pallars constituted the maximum with 27.60 per cent followed by the Paryar with 22.96 per cent, the Chakkiliyar with 14.29 per cent and the Arunthathiyar with 11.81 per cent. A majority of Pallars (33.4%) reside in Thanjavur district followed by Madurai (21.2%) and Ramanathapuram (about 3%) districts. Puthira Vannan Caste is considered to be the most polluting caste among the Scheduled Castes as for generations they have been washing clothes of other Scheduled Castes.

Genesis of Pallars

The Pallar caste is said to be the ancient community of Tamil Nadu. The people of this caste are considered to be the great cultivators especially of wet land of Tamil country. The term Pallar seems to have been derived from the word Pallam, meaning a pit or low-lying region. Since wet land is usually found in low lying area and the Pallars were often engaged in cultivation of such land, they came to be known as Pallam and latter as Pallan and Pallar. It is argued with sufficient support of literature that the Pallars of today were actually known as Mallar belonging to the Dravidian race about 2300 years back and were the rulers of Tamil country during the 14th - 15th centuries. It is also asserted that they are the descendants of Pallavas who were ruling the Andhra and Tamil countries once. Since they were known for charity, heading and presiding village panchayat meetings and being kind, they were referred to as Velalar; and for their ability to control flood, they were kudumban. Putting all these qualities together, the Mallar (Pallar) call themselves Devendra Kula Velalar. There are over 84 branches among Pallars. The Mallar were called Pallar only after 15th century by more powerful tribes from other parts of South India with a view to degrading their social status.

Caste Relation among Pallars and those above

Perhaps due to their glorious past and their origin as rulers, the Pallars have been militant in opposing discrimination of every kind. Though the Brahmins and a few upper level middle castes such as the Vellalars and Chettiyars treat the Pallars as untouchables, the latter do not consider them as their opponents or direct enemies. For them the real opponents are a few middle level dominant castes such as the Ahamudayar, Maravar and Kallar who indulge in open violence against them. This is evident from the fact that throughout Tamil Nadu most of the incidence of violence against Pallars have been perpetrated by these castes only. Talking to a Pallar man of Nedumbuli village near Paramakkudi town in the State of Tamil Nadu, it was found that the caste Hindus like the Maravar did not allow the Scheduled Caste women including the Pallar women to wear blouses but only sari to cover their breasts. By this covert means the caste Hindus compelled the Scheduled Caste women to expose their breast to their lust. As this practice was in use for a long time, the Scheduled Caste women did not even develop the habit of wearing blouses. This continued till early 1950s particularly in villages like Nilayambudi village near Paramakudi. Even at the time of this study we found many elderly women not wearing blouses and covering themselves only with sari.

Untouchability in villages

We shall now focus on the magnitude of caste discrimination and untouchability as experienced by the Scheduled Castes in general and the Pallar caste people in particular residing in the two villages: Akramesi and Keelaparthibanur. As stated earlier, Akramesi is one of the villages where the middle level castes (caste Hindus) were large in number and their domination over the Scheduled Castes in general and Pallar in particular was very much prevalent even during this study (November 89 to April 98). Out of 696 households in this village, the Scheduled Castes consisting of the Pallars, Parayars and Chakkiliyars accounted only for 25 households and the rest belonged to the caste Hindus, of whom Marvar caste alone accounted for as many as 500 households. There is not even a single village around Akramesi in about 15 km radius with high concentration of Pallars or other Scheduled Castes. It is surprising to note that many of the observations made as early as 1952 regarding the nature and magnitude of untouchability practised in villages4 were found to be true even at the time of present study. Both economic and political powers were intact in the hands of Maravars and Ahamudayars - the two middle level dominant castes. All the Scheduled Castes including Pallars did not have land of their own and depended on the former both for their livelihood and physical security.

Education for the Scheduled Caste children was generally discouraged. At the time of this study, only one Pallar had studied up to standard XI. Despite having a driving-licence, he had to remain jobless. Whenever he applied for a job or for a loan from the government, the caste Hindus with their easy access to all the officials right from the village panchayat to panchayat union, Tahsildar office and post office did every thing possible to disqualify him for the job and retained him in the village itself. None of the Scheduled Castes were allowed even to walk through the residential area or through the village's main street running through the residential areas of the dominant castes. They had to walk a long way along the periphery of the village to reach their huts. They were not allowed to enter any of the village temples visited by the caste Hindus and had no right to perform any rituals even outside the premises of such temples. The Pallars had a separate temple (but open to all castes) called Maravar Mahan, meaning son of Maravar (the dominant caste). The name of this temple itself indicates that the caste Hindus were equal to a god and the Scheduled Castes had to respect and worship them. The Pallars had to address the caste Hindus only as sami (God), whereas even a ten year old caste Hindu boy addressed the Pallar man of 80 year old by his name or even by his caste in a derogatory manner because of his superior caste status. This is also true in the case of using the community well meant for all castes. The Pallars were prohibited from fetching water from this well on the pretext that their vessels and buckets would pollute the water by their touch. The pond used by the caste Hindus for bathing was not even to be approached by the Scheduled Castes. Each Scheduled Caste

had its own burial ground located far away from that of the caste Hindus and they were not allowed to take funeral processions through the main street of the village. At tea stalls owned by the caste Hindus, the Pallars were provided with tea or water in separate glasses locally known as vattai. Any Scheduled Caste person intending to have tea at such tea stalls was expected to pick-up the vattai kept separately for them at one corner of the stall and show it to the person preparing tea, who would then pour it into the vattai from a distance. They were also expected to wash the vattai on their own and leave it where it was picked up from. While the Pallars were to sit on the ground - many a times out side the stall - the caste Hindus were served tea on benches inside the tea stall. The Pallars were also prohibited from riding bicycle. They were expected to place their towel in their armpit while addressing the caste Hindus and not on their shoulder, the usual practice. The dhoti (white cloth with a thin coloured border) they wore was supposed to cover their legs only upto the knee and not their legs completely as it would cause an insult to their high caste Hindus. These restrictions were applicable not only to the Pallars and other Scheduled Castes of this village but also to all the Scheduled Castes visiting this village.

Besides, the Pallars were expected to do all manual works outside the premises of the caste Hindus' houses both during auspicious and inauspicious occasions. In return they used to get either a meagre amount of wage or a meal. They were generally expected to carry the food to their home or they had to eat at the backyard of the house only when the entire function was over. Sometimes, they were given nothing for their services. Those trying to question the caste Hindus and disobey their demands were met with dire consequences. The common punishment for such disobedience was nothing less than tying the person to a street lamp post or a tree situated within the village premise and beating him in public till he collapsed. One of the respondents (a youth of 14 years old) told that a few years ago his elder sister was raped in a broad daylight at his hut in front of many fellow Scheduled Castes for informing the Collector of Ramanathapuram district about the practice of the caste discrimination in his village. Despite the fact that this youth was one of the active communist party members in the village and has also sought the help of a local communist party leader, he did not get any help from the comrade since the leader was a caste Hindu and his loyalty was more towards his fellow caste men than towards the proletariat which is what emphasised in the party ideology. The police station situated in a small town about 5 km away from this village was of no use for the Scheduled Castes as none in the police station paid any heed to the heinous crimes committed against them. The Pallars from nearby villages, being numerically in the minority and living in a similar situation, never dared to come to their rescue.

In contrast, in Keelaparthibanur village the Scheduled Caste population particularly of Pallar caste is large in number and they stand much ahead in every respect. The caste Hindus here could not discriminate the Pallars in any form. Unlike Akramesi village,

Keelaparthibanur is divided into two hamlets. The Pallars reside on the southern side in one hamlet locally known as Keelavadakur and the caste Hindus in another hamlet known as Melavadakur located a furlong away on the northern side. At the time of this study, the Pallars were more in numbers with 130 houses against only 92 houses of the caste Hindus. Most of the Pallars were land owners and some worked as share croppers on the land of Vellalars in the same village and also in the Parthibanur town located just two km away. Some of them worked merely as agricultural labourers. Though there was no Brahmin in this village, the Pallars often happened to go near the Brahmins when they visited other villages and the nearby town. It was found that prior to Independence, the Pallars were never allowed to enter the residential areas of the caste Hindus particularly of the Brahmins. Whenever a Brahmin came out of his house, no Scheduled Caste person was expected to come in his vicinity as it would pollute his sanctity and if it happened by mistake, he would go back home cursing the latter. He would come out once again only after taking a bath and making sure that no such thing would be repeated. However, as a mark of protest a few Pallars of this village deliberately used to appear before the Brahmin again and again. By doing so the Pallars forced the Brahmin to get back home once again to take a bath drawing water from deep well. From 1960 onwards, most of the Brahmins left the villages selling off their land and other properties and settled in nearby towns. They did so not only because their services in villages were no more considered essential but also because of the necessity that stemmed from their educational achievement and employment prospects in towns.

Though the Pallars interacted with and had access to the residential areas of the Vellalars who are next to the Brahmins in the caste hierarchy, the former were denied entry into the houses of the latter. They had to wait at the thinnai (corridor) of the Vellalar houses. The Vellalars did not accept even water from the Pallars. However, the Pallars did not protest much against these kind of discriminatory practices on the pretext that the Vellalars had extended financial help to them whenever needed. Yet, their younger generation did protest against Vellalars by requesting their parents not to have any relation with them and cultivate their lands any longer. Though there was no Chettiyar caste (goldsmith) in this village, even in the 1950s the Pallars interacted closely with these people living in the nearby towns like Parthibanur, Paramakkudi and Manamadurai in the process of buying and mortgaging gold ornaments.

Further, prior to 1975 the Pallars did not have access to take a bath in the common pond located at the Melavadakur. But they fought against the caste Hindus and took up the matter with the police. Despite stiff protest by the caste Hindus, the Pallars succeeded in getting access to the pond. Moreover, in the late 1970s Mr. K. Ukkirapandyan - one of the Pallars from this village - got elected to the State Legislature from the Paramakkudi reserved Constituency. In the late 1980s, the President for the Keelaparthibanur panchayat union was Mr. S. Malaichamy, a Pallar from this village.

Besides, this village also had one Mr. A.K. Karupaiah whom most of the Pallars of this and nearby villages turned to for help whenever there was caste conflicts and threat from the caste Hindus. Karupaiah could take up caste issues boldly since he enjoyed the support of a few leaders of the Congress (I) Party. The caste Hindus then had no courage to discriminate against them overtly. Whenever they attempted to do so, they were not spared. However, both the caste groups soon reconciled their enmities towards each other and began to interact cordially. Although within the village the Pallars supported various political parties, they got united whenever the status and power of their caste was threatened by the caste Hindus. For all practical reasons, both the Pallars and the caste Hindus tried to maintain a cordial relationship towards each other. A few caste Hindu leaders did eat with the Pallars during the weddings of latter to demonstrate their 'unbiased' attitude towards them and to ensure their votes but, in general, inter-dinning and inter-caste marriages between them are never tolerated.

Untouchability among Scheduled Castes

Another aspect of this paper is to bring to light whether or not there is hierarchy among the Scheduled Castes and if so the nature of caste discrimination and untouchability suffered by those at the lower levels of caste order. As stated earlier in Ramanathapuram district, the more visible castes among the Scheduled Castes are Pallars, Parayars and Chakkiliyars. Evidence discerned from the thirteenth century Tamil inscriptions indicate that the Parayas or Parayars were closer to the bottom in the caste hierarchy and were engaged in diverse fields of activities. The term parayan is derived from the Tamil word parai (drum) as certain Parayars act as drummers at funerals and village festivals6. They are also engaged in cultivation, grass cutting and weaving. The fifteenth century literatures indicate that the Parayars were also engaged in tanning and skinning leather which in the view of classical or Brahmanical Hinduism is considered to be defiling and polluting7. During the eighteenth century they also worked as tank-diggers, construction workers, servants, transport workers and a few as soldiers in armies. This period has been described as the 'golden age for Paraiahs'8. The Parayars worship the common Grama Devta (village deity) such as Ellamma, Mungilamma, Padaiyattal or Pidariyamma9. Although in the southern part of Tamil Nadu the Parayars are considered below the Pallars in the caste hierarchy, in the northern part particularly in Thanjavur district the Parayars do not acknowledge the latter's supremacy over them. Whatever be the history of the Parayars, in Ramanathapuram district most of them are, in the present days, merely landless labourers. Compared to the Pallars, they are still fewer in number in most of the villages of this district. For earning their livelihood, they continue to do their job of playing drums on both auspicious and inauspicious occasions of the caste Hindus and Pallars as well. They also earn their livelihood by making and selling certain palm leaf household items. Though in the past they seemed to have engaged in diverse fields of activities which

had no social stigma, their association with leather works and drum beating, and their habit of eating beef seemed to have had a greater impact in pushing them down the ladder of caste. The Pallars in most of the villages of this district consider themselves to be above the Parayars in their social status and also treat them as untouchables. They allege that the Parayars side with the caste Hindus during caste clashes and, hence, even label them as betrayers. They use the Parayars as symbol of abuses although the only major difference between them and the Parayars is that the former refrain from eating beef while the latter relish it.

The Kuravan or Kuravar caste is found to be on par with or slightly above the Chakkiliyars in the caste hierarchy. Kuravars form the sixth largest Scheduled Caste population both in Tamil Nadu and in Ramanathapuram district. They make certain household items out of bamboos and palm leafs and sell them to earn their living. They hunt birds and rear country pigs (black pigs) both for their consumption and sale. They also hunt cats from the village side for consumption. Some of them work as fortune-tellers. Since they use the trained Kili (parrot) to predict the fortune of the people, they are also known as kili josiyars. However, they do not go to any other castes asking for food. They are also not required to perform any inauspicious tasks and rituals for other Scheduled Castes. The Pallars consider them as lower caste although they have no means to demonstrate their caste supremacy over them. The people of Puthiravannan caste are traditionally the washer-man for the Pallars. They collect the Pallars' used clothes and get them washed; some time they also get the washed clothes ironed. For this service, they are entitled to collect food from the Pallar families. At the end of the year they are also given four to six marakkaal (a cylinder shaped metal container used for measuring the quantity of food grains) of paddy (each marakkaal would contain about four and a half kilograms of paddy).

How Pallars Remain Superior to Other Scheduled Castes

The Pallars have a few traditions which make them different from and also superior to other Scheduled Castes. Compared to Parayars, they are more aggressive, socially and politically conscious, more militant and better organised. This difference is also mythologically expressed since the Parayars claim a Brahman ancestry, while the Pallars are closer to a fierce and warlike middle level castes like the Kallar caste and associate themselves with a more martial tradition12. In recent years, the militant Pallars claim their descent from the God Indira. Secondly, while the Parayars prefer to call themselves Harijans, the Pallars tend to refer to themselves by their caste name so that they are not amalgamated with other lower castes. Besides, the very name 'Pallar' is not as shameful as other untouchable caste and it is not associated with any defiling occupations. Though the Parayars are involved in diverse fields of activities, they continue to be associated

with certain occupations like drum beating. Similarly, the main traditional occupations of the Kuravars are such as rearing pigs, hunting cats and birds, and also fortune-telling. All these occupations are considered to be degrading, defiling, and polluting except agriculture and allied activities in which primarily the Pallars are engaged13. That is why, the Pallars have been defined as a class of agricultural labourers14. Accordingly, the Pallars are held high in the Scheduled Castes hierarchy but all other Scheduled Castes are looked down upon by them. Moreover, they have the history of being the rulers of Tamil country during 14th - 15th centuries.

The Pallars maintain their caste superiority also by means of not eating beef which the other Scheduled Castes do. They do so for two reasons: first, like the caste Hindus they consider beef eating as taboo and sin, and feel that eating beef is below their social status. Second, since the main occupation of most of the Pallars is agriculture and allied activities, they depend completely on the cows and bullocks for ploughing their lands and for transporting their goods. As stated earlier, these animals are indeed part and parcel of their social and economic life and, therefore, they have a sentimental attachment and sympathetic attitude towards them and thus refrain from eating the meat of these animals. It may, however, be noted that some of the educated Pallars who are used to metropolitan life style have adopted the habit of beef eating and have also developed better and friendly relations with other Scheduled Castes. But they are discouraged from eating beef when they get back to their village. In general, the Pallars particularly in Paramakkudi taluk of Ramanathapuram district are also not fond of eating pork which the Parayars and other Scheduled Castes do. A few elderly ones eating pork are ridiculed in public by Pallars themselves calling them, Kattak kaalu, meaning short leg or pig. A few Pallars who reared pigs were indeed laughed at by others and as a result they had to give up pig rearing. The Pallars are considered to be superior to the Chakkiliyars and Puthiravannar also because of certain give-and-take relationships prevailing among them. For instance, those Chakkiliyars and the Puthiravannars staying at the village itself collect food from the Pallars once or twice on almost all days they work. The Chakkiliyars and Puthiravannars come over there on both auspicious and inauspicious occasions with bigger containers to collect the left-over food. Moreover, the Puthiravannans are entitled to collect every year about six marakkal of paddy from every Pallar's family. They also serve as messenger for the Pallars particularly for passing on to other villages the inauspicious information such as death. On such visits most of the times they are fed by the Pallars receiving the message and in some cases they also get a small quantity of food grains like paddy and raggi. The Pallars give them water or food not in their own glasses or plates but in padi (a small size marakkal) and that too in the thinnai (corridor). They in principle discourage the Parayars, Chakkiliyars and Puthiravannar from wearing sandals within their villages. Unlike other Scheduled Castes, the Pallars depend neither on the caste Hindus or nor on the other Scheduled Castes for their living. After all, ritual status alone cannot keep a

particular caste in a particular position in the caste hierarchy. A strong economic base is equally important15. It may however be noted that such discriminatory practices among the Schedules Castes are not common in all the villages. They are more in villages like Akramesi and less in villages like Keelaparthibannur.

The Changing Scenario

Though the above mentioned observations are applicable to the Pallars in general and the studied villages in particular, there has been a considerable decline in the last two decades in the rigidity with which these restrictions are observed and adhered to particularly in villages with high concentration of their population. For instance, in Keelaparthibanur village the Pallars have become relatively liberal in their interaction and social relations with the other Scheduled Castes. Now, the Parayars and Chakkiliyars - considered to be lower to the Pallar caste - do wear sandals while they are in the residential areas of the Pallars. With the initiatives of some of the liberal minded educated Pallar youth, the other Scheduled Castes do participate even in auspicious occasions of the Pallars such as wedding. Here, it is important to note that in the Parthibanur town no caste Hindu visited the saloon run by a Chakkiliyar as it was opened for the Pallars who had no access to the Ambattan's saloons which were meant only for the caste Hindus. With their newly achieved education and government employment, most of the Pallars preferred entry to the Ambattan's saloons causing closer of the Chakkiliyar's saloon. Usually, both Puthiravannars and Chakkiliyars are not allowed to eat along with the Pallars. They eat only when all the guests have had their meals. Though in both types of villages participation of the other Scheduled Castes in the Pallars' auspicious occasions is restricted, this has been relaxed in the recent years especially in villages like Keelaparthibanur. With the initiatives of the young educated Pallars, the other Scheduled Castes are now allowed to dine with the Pallars on all occasions. In a few Pallar houses they are also served food in the plates used often by the younger members of the family. Moreover, the educated young Pallar boys and girls from villages with high concentration of their caste invite their upper caste school and college mates to their home on important occasions. Knowing well that their parents would ask about the caste background of their friends, the host Pallar students generally conceal the caste background particularly of their lower caste friends. They do so fearing that their parents would insult their lower caste friends in some way or the other. In general, the young educated Pallars from such villages do not expect the other Scheduled Castes to adhere to the old customs and practices and remain subservient to them for ever. This of course is a rare practice and very often the elderly ones in the family express their unhappiness over it. But such interaction can never happen in villages with less concentration of Pallars. In fact, in such villages when the Pallars' expected demands are not met and restrictions are violated by the other Scheduled Castes, the former punish them with the support of the caste Hindus there.

Separate Villages

The experiences of Pallar caste people in the two villages - one having high and another having a lower concentration of the Scheduled Caste population - clearly endorses What Dr. B.R. Ambedkar said once. He said that in India each village is a "place of contest between the Hindus who are economically and socially strong and the untouchables who are economically poor and numerically small"16. He further says that in this contest the Untouchables are always at bay specially for two reasons. Firstly, they and the caste Hindus are unequally matched as far as their numerical strength is concerned; they are scattered into a few families in each village all over India. Secondly, they are a disunited body infested with the caste system in which they believe as much as do the caste Hindus. This has given rise to mutual rivalry and jealousy and made common action impossible 17. And therefore he suggested:

"India everyday social life is still governed substantially by the hierarchical attitude and sentiments carried over from the past. The awe for those who are superior by birth or social position (higher caste) and the contempt towards social inferiors (lower castes) are equally wide spread in the rural and urban areas and among the educated and the uneducated". 19 Reflecting on his latest film Samar (conflict), a rich, multi-faceted exploration of caste system, the noted Indian film director Shyam Benegal endorses it by saying that India lives in so many centuries at the same time. He further says, "we don't even realise how deep-rooted our caste prejudice are. We respond to a person's caste, rather than his humanity 20. This indeed reiterates the fact what Dr. Ambedkar once articulated:

Conclusion

Though India is legally bound to make justice, freedom, equality and fraternity a reality, the foregoing discussion clearly brings to light that in Indian villages the concept of freedom articulated by the Indian freedom fighters and that enshrined in the Indian Constitution seems meaningless for the Scheduled Castes. It is so viewed in the light of continuing practice of untouchability and increasing number of atrocities on them in villages and the fact that they still remain the much exploited section of Indian society despite number of protective and development measures to safeguard their interests. What is happening in many Indian villages is in fact inhuman and unjust.

The efforts of Government through the Reservation Policy and protective measures to educate, provide employment, empower the Scheduled Castes politically and provide an opportunity to voice their grievances in State Legislature and Parliament and also to protect them from all kinds of injustice and exploitation have not yielded the desired results. Why? It is primarily because the executives of these measures do not favour them as these would not only dilute the power and status of the upper caste but also raise

scope for those deprived to enhance their power and status position. This in turn would ultimately challenge the supremacy of the upper caste. It is also due to the fact that the number of those controlling bureaucracy and those enjoying political power are greater among the higher caste Hindus compared to the Scheduled Caste people. This number has to be reversed at least for some decades if at all we want a balanced power positions between the oppressing and oppressed caste groups. But as long as the present village setup - with the caste Hindus having a complete control over the Scheduled Castes - continues, this change can never happen.

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Nawab Muhammad Ali's Relationship with Yusuf Khan

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Abstract

Nawab muhammad Ali and Yusuf Khan were two most prominent personalities in Tamil Nadu during 18th century. The study of the relationship between these two personalities is a subject matter of interest. An objective study of their relationship reveals that neither were as harsh as the English historians suggest nor were it as friendly as the native historians' record.

Introduction

Nawab Muhammad Ali was a prominent personality of 18th century Tamil Nadu. His relationship with foreign powers like English and French and Native rulers like the Marathas of Tanjore and Nizam has been subject matter of different historians. But unfortunately the relationship between Nawab Muhammad Ali and Yusuf Khan the Governor of Madurai is an unexplored chapter. This paper is an attempt to study the relationship between these two dynamic personalities. The Works of European writers like Robert Orme's *History of the Military Transactions of the British Nation in Indostan from the year 1745*, S.C. Hill's *Yusuf Khan, The Rebel Commandant* give us a picture that the relationship between Nawab and Yusuf Khan from the beginning itself was strained and except jealousy there existed no good will and grace between the two. A perusal of the Persian work Burhan Khan's Tuzuk-i-Walajahi contradicts the opinion of European writers. It speaks of Yusuf Khan's courageous and valiant service to Nawab of Arcot at different instances and the regard and appreciation of Nawab Mohammed Ali for Yusuf Khan's bravery and courage. Inspite of this regard and appreciation it is certain that it was Nawab Muhammad Ali who got Yusuf Khan executed on 15th October 1764. As we have contradicting views it becomes a matter of great interest to know the truth.

Life of Yusuf Khan

At this juncture it should be mentioned that it is really unfortunate to note that historiography of Tamil Nadu has not given due credit to Yusuf Khan. Professor R.

Sathianathaier writes *the story of Anglo French Struggle in the Karnatak would in a sense be incomplete if Mohammed Yusuf or Yusuf Khan were left out of the picture.* He was a born soldier who though had a humble beginning was able to acquire skills to rise to the position of the Governor of Madurai. He was born at Panaiyur as the son of a poor tailor. He left his home to reach Pondhicherry where he was trained in speaking different foreign languages, horse riding and warfare under foreigners like Jacques Law and Brunton. From Pondhicherry he is supposed to have joined the Tanjore Marathas under Pratap Singh. Later he joined the service of Muhammad Kamal of Nellore. After spending a short span of time under his service he joined the service of nawab as a soldier and after passing through the various posts, he finally became a subedar. It was with this rank as Orme tells us that he entered the English service and was popularly known as Nellore Subedar.

Yusuf Khan's Services to Nawab

He had delivered incredible services to the Nawab of Arcot Muhammad Ali at various occasions. As a consequence of the the Battle of Ambur there was contest for the position of Nawabship between Nawab Muhammad Ali and ChandaSaheb. This contest led to the siege of Trichinopoly by the French. It was at this critical juncture that Mohammed Yusuf appeared on the scene of conflict and made his mark as the bravest and ablest of all the Indian soldiers who ever served in the ranks of the British in India and earned the admiration of the English Commanders and Generals. He entered the arena as a supporter of the French as his previous ruler Mohammed Kamal was an adherent of Chanda Saheb. After the victory of Clive at Arcot andArni600 native Sepoys who fought on the side of the French joined the English army. Yusuf Khan was one among these native sepoys.Major Stringer Lawrence was appointed to deal with relieving the siege of Trichinopoly with the assistance of Clive. Yusuf Khan was very much with Clive in this endeavour. The army of Major Stringer Lawrence marched to Trichy. This British army forced the French to retreat to srirangam and was besieged by the British Army. John Dalton the British captain defeated the French General MonseiurdAuteils force which was on it's way to help the besieged French Army on 3rd May 1752 A.D at Uthathoor. The next day John Dalton wrote a letter to Clive in which he clearly states that *Your Nellore sepoys are glorious fellows, and their Subedar as good a man as ever breated, he is my sole dependence.* After this victory Clive defeated the French again at Volkonda in this battle also Yusuf Khan had played an important role. After the siege of Trichinopoly was lifted the French forces tried to create trouble to the English forces stationed at Trichy by cutting of supplies coming to Trichy from different places.

Yusuf Khan was given the responsibility of bringing the supplies without any interference. He discharged this responsibility to the greatest satisfaction of the British.

In this regard Major Stringer Lawrence wrote *He is an excellent partisan, knows the country well, is brave and resolute but cool and sensible an action in short he is a born soldier, and better of his colour I never saw in the country.* As a consequence of this service he was treacherously trapped in a conspiracy hatched by certain jealous native officials of the British. Though Yusuf Khan was initially arrested he was later released after a thorough investigation as it was found out that the conspiracy was effected in order to bring disrepute to Yusuf Khan who has begun to become popular. As soon as his acquittal he once again began the work of transporting supplies to the British Soldiers. On 12 May 1754, Yusuf Khan and English Major Caillaud were attacked by the French forces while disposing there responsibility of bringing the Supplies. Yusuf Khan by means of sheer courage and war tactics saved Caillaud's column from falling in to the midst of the enemy and from a probable disaster, which would have made it impossible for the convoy to come any further. As a mark of respect for his Valiant service the company gave him the title Commander of the Honourable Company's Sepoys.

The British decided to send Yusuf Khan along with Colonel Heron to Madura and Tinnevelly in order to collect tribute and to evolve order on behalf of Nawab Muhammad Ali. During these expeditions Yusuf Khan displayed his mettle at Kumaravadi and Tirumbur . This gave the company confidence to appoint him as the Chief Military Officer of Madura and Tirunelveli in the place of Mahfuz Khan the elder brother of Nawab Muhammad Ali.

At this moment the famous siege of Madras by the French Commander Lally had begun and Yusuf Khan along with Major Preston did excellent military service by harassing the enemy and cutting off the enemy's supplies of provisions. In this venture Yusuf Khan defeated the Poligar of Thuraiyur from there he marched to Thiyagathurugam and with the help of the poligar of that place he annexed Elvanasurkottai and Thirukoilur. He marched further towards Chennai, on the way near Pondhicherry he tampered the shores of Valuthavoor lake which flooded the area and caused great disturbance to the French. When Khan Saheb reached Kanchipuram he along with Abdul Wahab Khan Bahadur defeated the French Forces. The greatest blow to the French forces was struck at St.Thomas Mount[xii]. The tamil ballad Khan Sahib Sandai dwells at length on the heroic role played by Yusuf Khan in the assault on St. Thomas Mount. After aiding the British in averting the French siege Yusuf khan returned to the South.

In the south the political situation had become alarming for Yusuf Khan. A formidable political alliance of poligars was formed against him by Puli Thevar. Mahfuz Khan the elder brother of Nawab Mohammed Ali had shifted his allegiance to Puli Thevar's Camp. Puli Thevar was also supported by Hyder Ali. This trusted soldier of the company gradually defeated the rebels one after the other and restored the sovereignity

of the Nawab over these territories. Yusuf Khan defeated Hyder Ali and made him to retreat to Dindigul in November 1757. By 1762 he had crushed all the poligars who opposed his masters and had emerged as a great hero of his period. He Paid a nominal rent to his masters and ruled the provinces as an independent ruler by granting jagirs, increasing his resources and army, making his own war materials, entering in to alliance with his powerful neighbours, and by granting favours to temples and dargahs[xiii].

Yusuf Khan's Strained Relationship Nawab

At this juncture the relationship between Yusuf Khan and the Nawab and English had begun to getstrained. Yusuf Khan received a Sanad from the subedar of Deccan Nizam Ali of Hyderabad recognising Yusuf Khan as the Governor of Madura and Tinnevelly. Both the Nawab and the English realised that their own creature had grown too big, powerful and popular and become a source of vexation and trouble if action was not taken against him. Moreover Yusuf Khan by this time had become very popular and powerful and was self-conscious of his own strength and status. The power of the Nawab had also diminished and the new officials of the company where no more friends of Yusuf Khan. Moreover Nawab Mohammed Ali was in debt to the company and the best way for the company to realise the debt was to extract more finance from Yusuf Khan. Yusuf khan had understood the changed policy of his masters and was ready to take up the challenge as circumstances where in his favour. The poligars of the south had accepted his suzerainty and where ready to support him. He was confident of getting the support of the Raja of Travancore and also of Hyder Ali of Mysore. The Raja of Tanjore was inimical to the British and friendly to Yusuf Khan. Moreover he was confident of getting the support of the French. The Maravas of Sivaganga and Ramnad alone had shifted their allegiance to Nawab Mohammed Ali. The Maravas were attacked by the Raja Tondaimanand they in order to defend themselves had aligned with the Nawab of Arcot. Yusuf Khan had invaded the Marava country and plunder their territory. The English had sent a formidable force under Major Preston to attack and besiege Madurai. Hence Yusuf Khan had to return back to Madurai. The first siege of Madurai was in September 1763. It was repulsed effectively by Yusuf Khan.The English suffered heavy losses and had to withdraw after experiencing severe damages. On 26 June 1764 another mighty attack was launched on the Fort of Madurai. Major Preston was mortally wounded and he succumbed to the injuries. The English realised that Yusuf Khan can be tamed only by means of treachery. Yusuf Khan's own men French General Marchand, Srinivasa Rao and Baba Sahib seized him when he was deeply immersed in prayer in a lone room. Yusuf Khan was handed over to the Nawab. The Nawab took full revenge by immediately hanging Yusuf Khan to death on 15th October 1764 A.D. Thus came to end the life of an illustrious hero whose life is a source of inspiration to the youth of this country. The Nawab's relation towards Yusuf Khan was a result of the political expediency. It was not uniform the Nawab changed his policy according to

circumstances and convenience.

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A Scheme for Understanding Rural Nonfarm Sector among the Indian States by using Cluster Analysis

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Abstract

In this paper, we develop a scheme for understanding rural non-farm sector among the Indian states by using cluster analysis.

Keywords: Cluster Analysis, Labour Force.

Introduction

In the most part of the developing world, urban industrial and service sector failed to absorb the labour force. The non-farm activity in rural areas provides a source of employment for 25 to 50 percent of the rural labour force in the developing countries. In India rural non-farm sector plays an important role in terms of generating employment, poverty alleviation and economic growth. It also addresses the problems of the urban migration from the rural areas. In India there has been increasing the rural non-farm activities (Vaidyanathan 1986, Mahendra Dev 1993, Vinoj Abraham 2009, Manoj Jatav and Suchrita Sen 2013). States have shown variability across the regions in the country (Manoj Jatav and Suchrita Sen 2013).

There has been attempt to analysis the cluster or grouping among the Indian states. The multiplicity of rural -urban linkages and other variables influencing the agro-economy of the region, exert their impact in influencing the agro-economy of the RNFE in a given area. All the major states of the country are considered the entire major states our country. It is easy to understand that a single variable cannot possibly the capture all the different aspects of the rural non-farm employment the country. The use of the multiplicity of variables is quite unavoidable. The variables may be expected to

be interdependent.

Keeping in the view of variables identified as determinants of RNFE in variables are considered to explore the rural non-farm employment among the major Indian states. The variables considered for the purpose of their specification and relevance to RNFE is briefly examined.

Main Variables for the Cluster Analysis

Area under the Crops

Food crops supplies raw material for many agro-processing industries. Food crop sector is related to rural non-farm sector by consumption and investment linkages (John Mellor 1976, Hazell and Steven Haggblade(1991). The specification is food crops (cereals) under the irrigated area. Food crops is considered as a vital determinant of rural nonfarm employment among the states.

Area under the Non-food Crops

Farm and non-farm linkages has shown that the degree of commercialization of agriculture influences the shares and growth of rural non-farm economy. Empirical studies have use the percentage of area under non-food crops as an index of commercialization (Basant and Parthasarathy 1991, Murty and Durga 1992). It shows the commercialization of the agriculture (Vaidyanathan 1986). It also shows the urban linkages and growth of the modern non-farm sector (Ranis and Stewart 1993). The specification non-food crops under the irrigated area.

Irrigation

Agro economy is directly influenced by irrigation. Irrigation increases the land productivity and uses of modern inputs (Hazell and Haggblade 1991). It changes the agriculture through changing the cropping pattern, extension of cultivation and increases the cropping intensity (Vaidyanathan 1986). It is the reason for commercialization and mechanisation of farm sector (Peter Hazell and C.Ramasamy 1973). The variable is explained as percentage of gross irrigated area to gross cropped area.

Cropping Intensity

It determines the consumption of inputs-fertilizers, pesticides etc. It is consumption and production linkages of agriculture with rural non-farm employment. It also influences income and employment in rural economy (John Mellor 1976, Mellor and Lee 1961 et al.,)

Occupational Pattern

Occupational patterns classified as cultivators, agricultural labourers, self employment in agriculture, self employed in non-agriculture and others. Occupational groups helps in understanding the growth of the rural non-farm sector among the different states.

Unemployment Rate in Rural Areas

It helps in understanding the distress in rural areas. Unemployment rate show number of persons who unemployed in the rural areas show the distress led rural non-farm sector growth in rural India. The specification is unemployment rate (15-59 years) for both male and females.

Education

Education creates the opportunity to seek employment to outside the agriculture. Education gives new ideas, skills among the people. Literacy promotes the awareness among the enterprises relating to the rural nonfarm employment (Jayaraj 1989). The specification of the variable education (primary and above) for the male and female above the age 7 years.

Age and Gender

Non-farm employment requires skill, mobility and training for enter into the non-farm sector. Child and aged are less inclined to enter the non-farm employment. Gender helps to identify the male and female entering the non-farm sector. Gender helps to identify the mobility of individual to the non-farm sector. Basant and Kumar (1989) states the women in employment is understated in various studies. RNFS there is general tendency of employment growth for man than women. The specification of the variable male and female (15 age and above).

Agricultural Worker

Agricultural worker from consumption demand largely from incomes in agriculture goods and services demanded by rural non-farm sector (John Mellor 1976, John Harriss and C.Ramasamy 1973 et al.,). Agricultural worker supports the growth of non-farm sector.

Non-agricultural Worker

Non-agricultural worker shows the diversification of the agricultural worker to the non farm sector which may be growth or distress oriented (John Mellor 1976, Vaidyanathan 1986). The variable as specified as non-agricultural worker except agriculture worker in rural areas.

Rural Enterprises

Enterprises are engaged in production or trading activity. Enterprises can owned by single household or by several households jointly or institutional body. An enterprise is both owned account establishment and establishment. Enterprises located in rural support the agro based industry or even may not be local linkages with the agriculture (Barbarra Hariss 1986, Daniel Start 1995). The specification of enterprises clubbing together the own account establishment and establishment enterprises together in the rural areas.

Workers in Rural Enterprises

Workers in rural enterprises support the rural based economy but also growth of new demand in the rural towns in the countryside (Barbarra Hariss 1986, Daniel Start 1995). Workers in rural areas demand for the goods and services by the local rural non-farm sector which may lead to the growth oriented rural non-farm sector (John Mellor 1976 etc). The specification of the workers by rural enterprises both owned accounted establishment and establishment enterprises.

Average Wage in Non-agricultural Sector

Wages show the standard of the living of workers in the rural areas among the male and female workers. There are studies supporting positive relation between earnings in agriculture and earnings in rural non-farm activity (Popola 1985, Chadha 1986 etc)

Data and Methodology

The study undertakes the determinants of rural non-farm sector taken from the NSSO's final report on employment and unemployment 2009-10. Report 549 Economic characteristics of unincorporated non-agricultural enterprises (excluding construction) in India 2009-10 and Report 539 Informal sector and conditions of employment in India. Few variables such area under food crops area and under non-food crops which has important for understanding growth of rural nonfarm sector. This variable is not available NSSOs' reports which are taken for Land Statistics Report 2009-10. Hierarchical Cluster analysis is used for grouping the rural nonfarm sector. In hierarchical cluster analysis the vectors (case) are groups together on the basis of their mutual distances. A Hierarchical cluster analysis is visualized through a hierarchical tree called Dendogram. SPSS 16 Version has used for analysis the data.

Results of Cluster Analysis

There has an attempt to identify the groups among states based on some homogeneity by using Hierarchical cluster analysis.

In agglomeration schedule the procedure is followed by cluster analysis at stage 1 is to cluster the two cases that have the smallest squared Euclidean distance them. This process continues until all cases are clustered into a single group. This process helps to know the clustering into single cluster from 1 stage to 16-th stage.

Agglomeration Schedule

	Cluster Combined			Stage Cluster First Appears		Next
Stage	Cluster 1	Cluster 2	Coefficients	Cluster 1	Cluster 2	Stage
1	3	5	6.471E8	0	0	4
2	4	13	2.261E9	0	0	9
3	7	9	4.494E9	0	0	8
4	3	12	8.086E9	1	0	10
5	8	15	2.155E10	0	0	10
6	10	14	7.632E10	0	0	11
7	1	17	1.312E11	0	0	13
8	2	7	2.145E11	0	3	12
9	4	6	3.004E11	2	0	12
10	3	8	3.870E11	4	5	14
11	10	11	8.214E11	6	0	15
12	2	4	1.602E12	8	9	14
13	1	16	2.398E12	7	0	16
14	2	3	6.532E12	12	10	15
15	2	10	1.706E13	14	11	16
16	1	2	9.749E13	13	15	0

Table. 1 Distribution of the states among variables of rural nonfarm sector

Cluster Membership among the Indian States

It is proposed to group the states. It is considered all the major states of the country included newly created states viz., Jharkhand, Uttarkhand, Chattisgarh. It is proposed to cluster states into 3 major clusters.

We can find some justification for the partition into 3 clusters from throughout that the states. The states within each reveals quite a bit of homogeneity with respect to the variable considered. Andhra Pradesh, Uttar Pradesh and West Bengal going together under the one cluster .states in cluster one shows that Andhra Pradesh, Uttar Pradesh

and West Bengal shows agricultural moderate developed states with high population clubbing together. Cluster second shows the majority of Indian states coming together which includes Bihar, Chhattisgarh, Gujarat, Haryana, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Punjab, Rajasthan and Uttarkhand coming together. Newly created states coming together like Jharkhand, Chhattisgarh and Uttarkhand coming together. Further reason has to be probed to know the reason behind the grouping of the different states together. Cluster three shows Maharashtra, Tamil Nadu and Orissa coming to shows the under the one group. Maharastra , Tamil Nadu and Orissa coming together shows low agricultural developed regions with strong mobility of rural labour to Non-farm activities coming together.

SNo.	Case	Clusters
1	Andhra Pradesh	1
2	Bihar	2
3	Chhatisgarh	2
4	Gujarat	2
5	Haryana	2
6	Jharkhand	2
7	Karnataka	2
8	Kerala	2
9	Madhya Pradesh	2
10	Maharashtra	3
11	Orissa	3
12	Punjab	2
13	Rajasthan	2
14	Tamil Nadu	3
15	Uttaranchal	2
16	Uttar Pradesh	1
17	West Bengal	1

Table. 2 Distribution of States Cluster Membership

Dendrogram

Dendogram is treeing structured graph to visual the results of the Hierarchical clustering. Ward method is used which joins clusters based on minimizing the within-group sum of squares and will tend to produce compact clusters. X-axis is shows some measure of the similarity or distance at which clusters join. In the dendogram shown above Shows Chattisgarh, Haryana, Punjab, Kerala, Uttaranchal forms as similar group forming 1st cluster. Sample shown Karnataka, Madhya Pradesh, Bihar, Gujarat, Rajasthan and Jharkhand forming the 2nd cluster. 3rd cluster is formed by the Maharashtra, Tamil nadu and Orissa forming the a cluster. The 4th cluster is formed

by Andhra Pradesh, West Bengal and Uttar Pradesh forming a similar clusters. The strength of the cluster is indicated by strength of the similarity of joining for cluster.
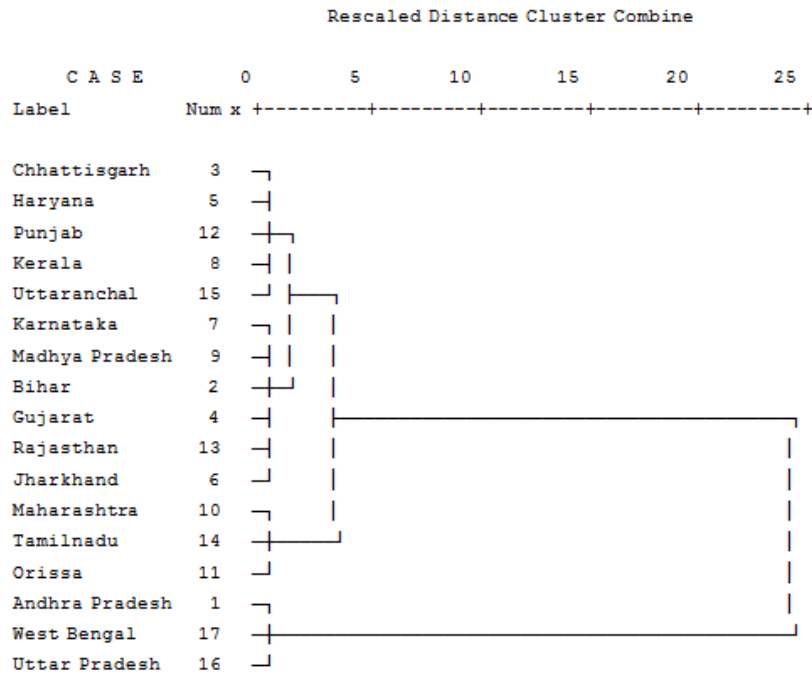
Fig. 1 Dendrogram using Ward Method

In the Dendogram shows the three major clusters 1st cluster formed by Andhra Pradesh, Uttar Pradesh, West Bengal forming the a cluster. Similary 2nd cluster is formed Maharashtra, Tamil nadu and Orissa forming a cluster. 3rd cluster is formed the remaining of the states.Distress in agricultural activities and growth of non-agricultural activities with regions and across the regions have effect on the movement of the labours from agricultural to non-agricultural regions within region and across the regions in country.

Conclusion

It is difficult to analyse the Regional variations across the region within one framework. Distress and Growth across the region's major factors cause for the movements of labour from agriculture to non-agricultural sector. In study there is formation of the three major clusters across the regions. Few states such as with moderate industrialised states and labour intensive agricultural states such Andhra Pradesh, West Bengal and Uttar Pradesh forming one cluster. Interestingly second cluster shows the majority of Indian states coming together which includes Bihar,

Chhattisgarh, Gujarat, Haryana, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Punjab, Rajasthan and Uttarkhand coming together. Agricultural developed states like Haryana, Punjab and low agricultural developed regions of Jharkhand, Rajasthan showing some Homogeneity. States such as Maharastra, Tamil Nadu and Orissa joined together to form third cluster which shows states which has opportunity to migrate from agriculture to non-agricultural sector clubbing together. Push and Pull factors working within regions and across regions to shift from agriculture to non-agricultural across the country.

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A study on Quality of Work Life and Organizational Commitment of Public Sector Bank Employees in Vellore District

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Abstract

Human resource is the most important resources of an organization and thus the management of human resources assumes importance for all organizations. There are many aspects which affects the management of human resources. One such aspect is Quality of Work Life (QWL). The confidence about QWL is also one of the best method to attract, preserving talented staff and to obtain better performance in an organization. The success of any organization is highly depends on how it attracts recruits, motivates, and retains its workforce. Today's organizations need to be more flexible so that they are equipped to develop their workforce and enjoy their commitment. Commitment is the function of sincerity of an individual, which develops the capacity to work hard and give good results even in poor and adverse circumstances. Commercial banks play an important role in the economic development of the country. Banks play a vital role in implementing various plans, programs and policies of the government. So the commercial banks must have satisfied, committed and dedicated employees not only for achieving the organizational goals, but also for successfully implementing the various policies and programmes of the government for the country's development. The banks are the major financial institutions which require highly committed employees. It is important to study quality of work life which ensures the commitment towards the organization. The study related to quality of work life of the commercial bank employees helps to reduce the absenteeism and improve the organizational commitment. Commercial bank employees should have commitment towards the organizations to achieve success. As for as public sector commercial banks are concerned, it is very important to have the committed and loyal employees to carry out all the requirements of the general public.

Keywords: Work Life, Commitment, Public Sector Bank Employees.

Introduction

Human resource is the most important resource of an organization and thus the management of human resources assumes importance for all organizations. There are many aspects which affects the management of human resources. One such aspect is Quality of Work Life (QWL). The confidence about QWL is also one of the best method to attract, retaining talented staff and to obtain better performance in an organization. Working Life is a process of work organization which enables its members at all levels to actively participate in shaping the organization environment, methods and outcomes. The conceptual categories which together make up the quality of working life are adequate, fair compensation, safe and healthy working conditions, immediate opportunity to use and development of human capacities, opportunity for continued growth and security, social integration in the work organization and the social relevance of work life.

The success of any organization is highly dependent on how it attracts recruits, motivates, and retains its workforce. Today's organizations need to be more flexible so that they are equipped to develop their workforce and enjoy their commitment. Therefore, organizations are required to adopt a strategy to improve the employees *Quality of Work Life* (QWL) to satisfy both the organizational objectives and employees' needs.

Quality of Work Life

Quality of work life refers to the favourableness or unfavourableness of a job environment. It is a generic phase that covers person's feelings about every dimension of work including economic rewards, benefits, security, working conditions, organization interpersonal relationship and its intrinsic meaning in a person's life. The basic purpose of quality of work life is to develop work environment that are excellent for people as well as for production. It aims at healthier, more satisfied, more productive employees, more efficient, adaptive and profitable organization.

According to Harrison, *QWL is the degree to which work in the organization contributes to material and psychological well-being of its members*.

According to Cohan, *it is a process of joint decision -making, collaboration and building mutual respect between management and employees*

Quality of Work Life in an organization is essential for the smooth running and success of its employees. The Quality of Work Life can affect such things as employee's timings, his or her work output, his or her available leaves, etc. Quality of Work Life

helps the employees to feel secure and like they are being thought of cared for by the organization in which they work. An organization's Human Resource (HR) department assumes responsibility for the effective running of the Quality of Work Life for their employees.

Concept of Quality of Work Life

The concept of QWL is based on the assumption that a job is more than just a job. It is the center of person's life .There have been increasing concern of QWL due to several factors as shown below.

 (a) increase in education level and consequently job aspiration of employees.

 (b) association of workers.

 (c) significance of human resource management.

 (d) widespread industrial unrest.

 (e) growing knowledge in human behaviour, etc.

QWL exercises a significant influence on productivity of employees. Research has established that good QWL leads to physically and psychologically healthier employees with positive feelings. Quality of work life is concerned with the following type of questions.

 (1) How to develop careers of employees to realize their full capacities and interest?

 (2) How to design jobs to provide meaningful, interesting and challenging work experience?

 (3) How to utilize group dynamics and participative management to improve quality of work life at the workplace?

 (4) What supervisory strategies help to improve the quality of work life?

 (5) How can the desired organizational changes be carried out?

Quality of work life is a major issue for employees, and how organizations deal with this issue is both of academic and practical significance. So, it is not any wonder that thousands of studies have revolved around the concept of job satisfaction and stress as core concepts (Dolan et al, 2008).

Organizational Commitment

Commitment is the function of sincerity of an individual, which develops the capacity to work hard and give good results even in poor and adverse circumstances. Effective employees consider commitment as both the aspect of an individual and organizational importance. A person who is committed towards his job will work with sincerity, honesty and efficiency. He sustains hard work which gives him internal satisfaction of pulling his optimum strength to work.

According to Mowday, Steers et al., (1979) organizational commitment refer to *the extent to which the employee demonstrate a strong desire to remain the member of the organization, the degree of willingness to exert high level of efforts for organization , belief and acceptance of the major goals and values of the organization.*

Mathieu and Zajac, (1990) has defined organizational commitment as *a bond between the individual and the organization.* In addition to the organization as a focus of commitment, some other factors have been suggested which include occupation, top management, supervisors, co-workers, work-unit and customers (Becker, 1992; Becker and Billings, 1993; Gregersen, 1993; Becker et al 1996; Knippenbug and Schie, (2000). The original definition of organizational commitment proposed by Mowday et al (1982) included three components namely acceptance of organizational goals and values, extra effort on behalf of the organization and desire to remain with the employer.

Importance of Organizational Commitment

Organizational commitment is a concept that has to do with the degree of commitment and loyalty that employees exhibit toward their organization. As part of this concept, determining the level of responsibility that employees feel toward an employer is important. The underlying idea is that if an employee is truly committed to the goals and aims of the organization, he or she will manifest that commitment in terms of individual work ethic, the support of company goals and generally be dedicated to the ongoing success of the employer's business.

Commercial banks play an important role in the economic development of the country. Banks play a vital role in implementing various Plans, programs and policies of the government. So the commercial banks must have satisfied, committed and dedicated employees not only for achieving the organizational goals, but also for successfully implementing the various policies and programmes of the government for the country's development. This raises the following questions.

1. Has the quality of work life maintained in public sector bank employees?

2. Whether the public Sector bank employees are committed with their organization or not?

3. Has the quality of work life anything to do with organizational commitment?

So the main purpose of the study is to ascertain the relationship between quality of work life and organizational commitment of the public sector bank employees. This raises the following questions.

1. What is the relationship between personal demographic variables and quality of work life of commercial bank employees?

2. What is the relationship between quality of work life and organizational commitment of bank employees?

Objectives of the Study

The study falls under the broad area of organizational behaviour. Many studies have been made to investigate the relationship between quality of work life and organizational performance of employees. The concept of quality of work life is of recent origin. Its influence on the organizational commitment has not received much attention in research perspective. The main aim of the present study is to understand the nature of relationship between quality of work life and organizational commitment of public sector bank employees.

In the light of the above, the present study has the following objectives.

- To analyze the relationship between demographic variables and Quality of Work Life of public sector employees.

- To study the relationship between Quality of Work Life and organizational Commitment of public sector bank employees.

Hypotheses of the study

- There is no relationship between demographic variables and Quality of Work of public sector bank employees.

- There is no positive correlation between Quality of Work Life and level of Organizational Commitment.

Research methodology

To achieve the objectives and to test the hypothesis of the study, a three part questionnaire consisting of personal information, quality of work life and organizational commitment were developed.

Part I of the questionnaire consisted of personal data which were necessary for testing the relationship between quality of work life and demographic factors.

Part II of questionnaire is Employees Quality of work life survey questionnaire which issued by Karl Albrecht International. It is used to analyze the Quality of Work Life of public sector employees. The questionnaire used in the present study had 25 statements to be filled by the respondents on a five-point Likert scale ranging from 'strongly disagree' to 'strongly agree'.

Part III of organizational commitment questionnaire, the organizational commitment inventory standardized by Meyer and Allen (1991) was adopted. The inventory had 12statements to be filled by the respondents on a five point Likert scale ranging from "strongly disagree' to 'strongly agree'. The scoring pattern was 1 to 5 in positive direction of the organizational commitment.

The study covered employees working in public sector and private sector commercial banks in Vellore District. There are 224 public sector commercial banks in Vellore District(Source: Indian Bank, The Lead Bank for Vellore District) There are 1456 employees are working in public sector banks when the study was conducted. The above employees working in these branches constituted the population for the present study.

The investigators have selected 364 employees from public sector banks by simple random sample which constituted 25% of the population. The employees were given the questionnaire with a request to fill up and hand over personally or sent it by post. The investigators were able to collect 329 responses from public sector bank employees. Out of 329 filled in questionnaire, nine of them were found to be incomplete were rejected. So the final sample for the present study consisted of 320 respondents from public sector banks.

Review of Literature

Various research studies in quality of work life and organizational commitment have been conducted. Some of the studies have been given below. Malarvizhi et al. (2012) studied the relationship between Quality of work life and demographic variables among 200 employees in Jappiaar Cement Pvt. Ltd. The result showed no significant relationship between Age, Educational Qualification, income and QWL among employees.

Alireza Bolhari et al. (2012) studied the relationship between Quality of work life and age among 292 IT professionals. The result showed no significant relation between Educational qualification, Work experience, gender and QWL among IT staff (Sig < 0.05). ANOVA (0.008).

Lam (1995) surveyed 350 teacher trainees from Singapore to examine relationships among Quality of Work Life, Career Commitment, Job Satisfaction and Withdrawal Cognition. Results showed that perceptions of the social status of teaching strongly related to commitment and satisfaction with teaching.

The study conducted by Karrir and Kharuna (1996) showed significant correlations of Quality of work life of managers from three sectors of industry viz., public, Private and Cooperative, with some background variables (educational qualification, native / migrant status, income level) and with all of the motivational variables like job satisfaction and job involvement.

Danna and Griffin, (1999) studied Health and well-being in the work place. The study shows that the Quality of Working Life is a holistic concept, which not only considers work-based factors such as job satisfaction, satisfaction with pay and relationships with work colleagues, but also includes factors that predict life satisfaction and general feelings of well-being.

Walton R. (1979) made a study on "Quality of work life indicators- Prospects and Problems". The findings suggested that there are eight major conceptual areas for understanding quality of work life, namely, adequate and fair compensation, safe and healthy working conditions, development of human competencies, growth and security, social integration, Constitutionalization and total life space and social reliance.

Neha Bhopatkar and Jaya Nema (2008) studied the effects of quality of work life on organizational commitment in service sector in Indore. The study revealed that there is a significant relationship between quality of work life and organizational commitment (Mean=35.87).

Mohammad Hadi Asgari, et.al (2011) examined the relationship of QWL with the Organizational Commitment. The results shows that there is a relationship between Quality of Work Life and affective commitment (r=0.165), continuance commitment (r=0.250) and normative commitment (r=0.207) of the staff.

Hajieh Rajabi (2013) studied the relationship between QWL and organizational commitment. Salary, growth, balance in work life have significant relationship with Normative, Continuance, Affective commitment (Significe Level 0.05).

Analysis and Interpretation

In order to analyze the relationship between the quality of work life and demographic variables among public sector bank employees, the following hypotheses

have been framed, and the results are analyzed.

Quality of Work Life and Demographic Variables

The main purpose of the study is to determine the relationship between the demographic variables and the quality of work life among the public sector commercial bank employees. The following are the various hypotheses and results.

Relationship between age group and Quality of Work Life

Today, the employment opportunities are very competitive at all level. Those who have entered into the service at the earlier age may have more number of years of experience and loyalty towards the organization. Is age has any effect on the quality of work life with public sector employees? To find the answer to the above question, the following hypothesis has been framed and analyzed.

Hypothesis

H_0 There is no significant relationship between age group and quality of work life of the public sector bank employees.

H_1 There is a significant relationship between age group and quality of work life of the public sector bank employees.

Age	Frequency	F value	P value
21 - 30 years	20		
31 - 40 years	160		
41 - 50 years	130	6.608	0.001*
Above 50 years	10		
Total	320		

* Highly significant at 1% level of significance

Table. 1 Relationship between Age group and Quality of Work Life

From the above table it is clear that the P value is less than the value of 0.01 i.e 0.001, hence the null hypothesis is rejected. It can be concluded that there is a significant relationship exists between age and quality of work life of public sector bank employees.

Relationship between Gender and Quality of Work Life

To find out the relationship between the gender and Quality of work life of Public Sector bank employees separately the following hypothesis was framed.

H_0 There is no significant relationship between gender and quality of work life of the public sector bank employees.

H_1 There is a significant relationship between gender and quality of work life of the public sector bank employees.

Gender	Frequency	F value	P value
Male	220		
Female	100	0.773	0.755
Total	320		

Table. 2 Relationship between Gender and Quality of Work Life

The above table shows that the P value is more than 0.01, So, the null hypothesis is accepted and the alternative hypothesis is rejected. Hence it can be concluded that there is no significant relationship between the gender and the quality of work life of public sector bank employees.

Relationship between Educational Qualification and Quality of Work Life

Educational Qualification is one of the main factors in determining the quality of work life. To find out whether educational qualifications have an impact on the quality of work life of the Public sector bank employees, the following hypothesis was framed.

H_0 Educational Qualification and the Quality of Work Life of public sector bank employees are not significantly related.

H_1 Educational Qualification and the Quality of Work Life of public sector bank employees are significantly related.

Educational Level	Frequency	F value	P value
S.S.L.C.	10		
HSC	32		
Under Graduate	145	5.574	0.001*
Post Graduate	133		
Total	320		

* Highly significant at 1% level of significance

Table. 3 Relationship between Educational Qualification and Quality of Work Life

As seen in the above table the P value is less than the 0.01 i.e 0.001. So, the alternative hypothesis is accepted and the null hypothesis is rejected. Hence it is concluded that there is a relationship between the educational qualification and quality of work life of public sector bank employees.

Relationship between Work Experience and Quality of Work Life

To ascertain the relationship between Work experience and the quality of work life among the public sector bank employees the following hypothesis has been framed.

H_0 There is no significant difference between experience and the Quality of Work Life of Public Sector Bank Employees.

H_1 There is a significant difference between experience and the Quality of Work Life of Public Sector Bank Employees.

Work Experience	Frequency	F value	P value
< 10 years	80		
10 - 20 years	190		
Above 20 years	50	15.130	0.001*
Total	320		

* Highly significant at 1% level of significance

Table. 4 Relationship between Work Experience and Quality of Work Life

From the above table it is very clear that the P value is less than the 0.01 i.e 0.001. So, the alternative hypothesis is accepted. The null hypothesis that there is no significant difference between working experience and the quality of work life of public sector bank employees was rejected. Hence it is concluded that there is a relationship between work experience and the quality of work life of the public sector employees.

Relationship between Marital Status and Quality of Work Life

It is quite natural that marital status and quality of work life are highly interrelated attributes. The older the person, the likely that he/she is married.

H_0 There is no significant difference between marital status and the Quality of Work Life of Public Sector Bank Employees.

H_1 There is a significant difference between marital status and the Quality of Work Life of Public Sector Bank Employees.

Marital Status	Frequency	F value	P value
Married	180		
Unmarried	140	3.110	0.002^*
Total	320		

* Highly significant at 1% level of significance

Table. 5 Relationship between Marriage and
Quality of Work Life

The above table clearly shows that the P value is less than 0.01 i.e 0.002. So, the null hypothesis that there is no significant difference between marital status and the quality of work life of public sector bank employees was rejected. Hence it is concluded that there is a relationship between marital status and the quality of work life of the public sector employees.

Relationship between Size of the Family and Quality of Work Life

Higher the size of the family, higher will be the need for job and earning. Now a days many people prefer the unique family to maintain both the work life and family life. Some people many think that smaller family will help to work more on their jobs. To find out the relationship between the quality of work life and size of the family, the following hypothesis has been framed.

H_0 Size of the family and quality of work life are not positively correlated.

H_1 Size of the family and quality of work life are positively correlated.

Size of the Family	Frequency	F value	P value
1-3 Members	150		
4-6 Members	120	4.798	0.091^*
Above 6 Members	50		
Total	320		

Table. 6 Relationship between Size of the Family
and Quality of Work Life

From the above it is clearly understood that the P value is more than 0.01 i,e 0.091. So, the null hypothesis is accepted and it can be concluded that there is no significant relationship between the size of the family and the quality of work life of the public sector bank employees.

Relationship between Type of the Family and Quality of Work Life

Family commitment and the work commitment are the two eyes of any employees. Each has its own importance and at the same time both are interrelated. If the family commitment could not be fulfilled, then it will have its own effect on quality of work life. The hypothesis shows the relationship among these two with the public sector bank employees.

H_0 Type of the Family and the Quality of Work Life of Public Sector bank Employees are not significantly related.

H_1 Type of the Family and the Quality of Work Life of Public Sector Bank Employees are significantly related.

Type of the Family	Frequency	P value
Joint Family	140	
Nuclear Family	180	0.007*
Total	320	

* Highly significant at 1% level of significance

Table. 7 Relationship between Type of the Family
and Quality of Work Life

The above table clearly shows that the P value is less than the 0.01 i.e 0.007. The null hypothesis that type of the family and the quality of work life of public sector bank employees are not significantly related was rejected. The alternative hypothesis was accepted. Hence we can conclude that there is a relationship between the type of the family and quality of work life of public sector bank employees.

Relationship between Monthly Income and Quality of Work Life

The main aim of working in any place is to earn income. Normally the bank employees earns on monthly basis. Monthly income should cover all expenses and saving for their livelihood. To find out the Monthly income and quality of work life relationship the following hypothesis and the table was formulated.

H_0 Monthly Income and the Quality of Work Life of the Public Sector Bank Employees are not positively related.

H_1 Monthly Income and the Quality of Work Life of the Public Sector Bank Employees are positively related.

Monthly Income	Frequency	F value	P value
Rs 10,000 - 20,000	38		
Rs 20,001 - 30,000	49		
Rs 30,001 - 40,000	107	2.442	0.064*
Above 40,000	126		
Total	320		

* Highly significant at 1% level of significance

Table. 8 Relationship between Monthly Income and
Quality of Work Life

It is crystal clear from the above table that the P Value is more than 0.01 (p=0.064). So, the alternative hypothesis is rejected. The null hypothesis which is shown as the monthly income and the quality of work life of the public sector employees are not positively related has been accepted.

Organizational Commitment

Both early and more recent research summaries do show support of positive relationship between organizational commitment and desirable outcomes such as high performance, low turnover and low absenteeism. The level of commitment prevailing among the bank employees are very important to improve and develop the commitment towards the organization. Following table shows the level of organizational commitment prevailing among the public sector bank employees.

Level of Commitment	No. of Respondents	Percentage
Low Commitment	100	31
Moderate Commitment	114	36
High Commitment	106	33
Total	320	100

Table. 9 Level of Organizational Commitment of Bank Employees

It is clear from the above table that 36 percent of the respondents are moderately committed, 33 percent of the respondents are highly committed and 31 percent of the respondents are having low commitment with their organization.

Correlation co efficient among Quality of Work Life Factors and Level of Organizational Commitment

To find out the relationship between quality of work life factors and the level of organizational commitment among the public sector bank employees correlation co-efficient was found among the various factors of quality of work life and level of organizational commitment. The results are shown below.

Variable	Correlation Coefficient
Adequate and Fair Compensation	0.321**
Working Condition	0.179**
Growth and Security	0.192**
Constitutionalism	0.080
Social relevance	0.246**
Social integrity	0.145**
Human capabilities	− 0.047
Work and the total space of life	0.071
Overall Quality of work life	**0.514****

Table. 10 Relationship between the factors of quality of work life and organizational commitment

From the above table it is clear that the various factors of quality of work life like adequate and fair compensation, working conditions, growth and security, social integrity are highly correlated with the organizational commitment of public sector bank employees. Only development of human capabilities is negatively correlated with the organizational commitment.

While overall quality of work life of public sector bank employees are highly correlated with the level of organizational commitment.(r=0.514). Hence the main study pertains towards to find out the relationship between the relationship between quality of work life and the level of organizational commitment has been proved.

Discussion and Conclusion

In the present study, an attempt was made to identify the relationship between the demographic variable and the quality of work life in public sector bank employees

in Vellore district. It is inferred from the analysis there is a relationship between the age, educational qualification, marital status, working experience, type of family. Only income and the size of the family have no relationship with the quality of work life. The factors of quality of work life have impact towards the level of organizational commitment has been proved through the co efficient correlation. Most of the bank employees feel that the management of public sector banks are adopting the policy of over - driving the workers and want to get the maximum out of them. The management can remove this type of feeling by proper counseling and also framing their policies and regulations in such way that it is mutually beneficial to both the workers and management.

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Service Quality at Railway Junction

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Abstract

Railways is the cheapest and quickest means of transport. Railway transportation is important central transport in India. It provide number of benefits/services to the passengers, likes long Distance Travel, Safe Travel, High Speed and High Quality Platform Service. This study is conducted to find out service quality of Railways with special reference to Jolarpettai Junction and to identify the level of passenger's satisfaction on service provided in Jolarpettai Junction. This study is carried out by using structured questionnaire. Random sample of 30 respondents were taken for data collection. The data was analyzed with the help of SPSS 20.

Keywords: Railway transportation, service quality, customer satisfaction, Jolarpettai Junction.

Introduction

A service sector involves creation and delivery of core benefit in order to satisfy an identified needs of the customers. In modern days, service sector provides number of services to customers like bank, insurance, health care, finance, communication, transportation and so on. Service sector is very important for development of the nation like India due to service tax collection. Transportation of goods and service from one place to another is essential in any country. There are three type of transport namely air transport, road transport and railway transport. Railway transport means carrying of goods and passengers from one place to other by means of trains. Railways transport is cheaper as compared to air transport. Goods can be carried in bulk quantities s a result of which a lot of time is saved and number of people gets employment both direct and indirect through Railway.

Indian railway is one of the biggest railways in the world, its network comprising 115000 km of track over a route of 65,436 km and 7,172 stations in 2013-2014. Indian railway carry 8,425 million passengers annually or more than 23 million passengers daily and 1.307 million, employees are working with Indian Railways, there are 17

Railway Zones. Jolarpettai Junction is one of the busiest railway station in Vellore district of Tamil Nadu and an important railway junction in southern railway. This Junction handles about 60 passenger train in a day, it has 5 platforms and 16 tracks. This junction provide more facility like food plaza, toilets and bathrooms, waiting rooms, car parking, ventilation facility, Ramps and so many.

Objectives of the Study

The Researchers have framed the following objectives for the present study

1. To examine the platform service quality offered for Railway passengers in Jolarpettai Junction.

2. To identify the level of customer satisfaction on services provided in Jolarpettai Junction.

3. To give appropriate suggestion to enhance the Customer Service Quality.

Review of Literature

Railway transportation system provide more number of facility to the people, specifically for people from rural and urban areas. Indian railway was providing more service to their passengers to retain the old passengers and get new passenger to improve the railway.

Aggunloye,O.O. and Leke Oduwaye (2010) have identified the factors influencing the quality of rail transport service in metropolitans lagos. In this work most of the respondents feel that cleanliness of the coaches as poor, arrival time of train is not as per the schedule.

Gandhimathi,S. and Saravanan,S (2013) have investigated the railway platforms service quality of the southern railways like Tamilnadu, Kerala, Andra and Karnataka. In this work they express that half of the respondents are satisfied with seating space in platform, lighting quality, reservation chart display service and security of self. The authors have recommended to provide fans in platforms, drinking water facility, parking facility to improve services quality of southern railway.

Gandhimathi,S. and Saravanan,S (2013) have analyzed the customer satisfaction towards railway services at Coimbatore Junction. The findings show that passengers feel comfortable in train travelling.

Kasem Choochrukul and Kerkitt Srivoojvikrai (2013) have studied and analyzed customer satisfaction of Bangkok's Mass Rapid Transit (MRT) system. The results indicate that travel convenience affect the overall satisfaction. Train waiting time, comfort and convenience at platform, seat comfort on train, availability of hand rails, easiness to pass entrance gates to platforms and train line-travel time indirectly influence the overall customer satisfaction.

Devi Prasad Maruvad and Raja Shekhar Bellamkoda (2013) have identified the demographic variables on railway passenger service quality. The authors identified that there is a relationship between gender, income and train service, travel class and employee service, punctuality, reliability. The researcher conclude that upper class passengers expect that Railway authorities must concentrate on providing personal attention from staff throughout the journey, good catering facilities etc.

Ali Akbar Esmaeil, Monire, Aryaee Manesh and Ebrahim Golshan (2013) have taken effort the relationship between services quality and customer satisfaction and loyalty provided by raja rail transportation company in Iran. This work expressed that there was a positive relationship between service quality and customer satisfaction and positive relationship between customer satisfaction and customer loyalty provided by Raja rail transportation in Iran. This research recommended that Railway employees must be given training to understand the customers demand, and handle their problems to enhance service quality.

Rajeshwari,G and Elagovan,D (2014) have taken effort to know the level of satisfaction of passengers on service provided by the Salem division of Southern Railway. The findings showed that passengers are fairly satisfied with the services offered by the rail system and the researcher suggested that improvement in sanitation facility, infrastructures in the train, behaviour of porters, responsiveness of railway doctors, railways staff's knowledge in answering the queries, and also understanding the needs of the passengers is required to enhance the satisfaction of the passenger.

Ram Kumar Balyan and Richa Pandit (2014) have studied and analyzed the factors of service quality offered by Indian railway. The study showed that majority of the time Indian railways are good at record keeping and accurate in timings and sometime employees are unable to provide the prompt service to the passengers.

Rajeswari,V. and Sanata Kumari,K (2014) have made a study to find out the passengers' perception about the quality of service in Indian railways in the area between Kerala and Delhi, and between Mumbai and Delhi. The researchers found that passengers perceive that quality of services delivered to them is not satisfactory. This work recommends increasing catering facilities, and safety.

Bagwan Sing and Devender Kumar (2014) have identified the components of services quality of Delhi metro railways. The researchers found that maximum number of customer is satisfied with air conditioning and maximum respondents are satisfied with the services provided by Delhi metro. The researchers have suggested that metro trains should be increased especially in the morning time.

Aniradha,J (2014) had taken effort to know the level of satisfaction of passengers about services offered by the Indian railways with special reference to Erode junction. The author concluded that majority of passengers have low level of awareness like various classes of travel facility in train, rest room facility etc. He suggested that Indian railway must take all possible steps to enhance the services like quick announcements, good rest room facilities, and education about E-tickets facilities etc.

Garim Malik (2014) have analyzed customer satisfaction on services quality of Delhi metro railways. The study has concluded that maximum number of customer feel unsatisfied with Delhi metro railways. This work recommended that Delhi metro rail must give high level of service to their customer.

Research Methodology

Fundamental to the success of any formal research is sound research design. A research design is purely and simply the frame work or plan for the study that guide the collection of the data. The researchers have used descriptive design for the present study. The study covers sample size of 30 passengers in Jolarpettai junction. Both primary and secondary data were collected. The researchers have used convenient sampling method.

Hypotheses Tested

1. There is no relationship between Age of the Respondents and level of Passengers Satisfaction.

2. There is no relationship between Gender of the Respondents and level of Passengers Satisfaction.

3. There is no relationship between income of the Respondents and level of Passengers Satisfaction.

4. There is no relationship between Educational Qualification of Respondents and level of Passengers Satisfaction

5. There is no relationship between Marital status of the Respondents and level of Passengers Satisfaction.

6. There is no relationship between Occupation of the Respondents and level of Passengers Satisfaction.

Analysis and Interpretation

Analysis of the data is the central step in any research process. The goal of this analysis is to provide answers to the research problem.

		No. of Respondents	Percent
Age of the Respondents	19-40	18	60.0
	41-60	11	36.7
	60 and Above	1	3.3
	Total	**30**	100.0
Gender of the Respondents	Male	24	80
	Female	6	20
	Total	**30**	100
Income of the Respondents	upto 5000	4	13.3
	5001 - 10000	14	46.7
	10001 and Above	12	40.0
	Total	**30**	**100.0**
Marital Status	Single	6	20.0
	Married	24	80.0
	Total	**30**	**100.0**
Occupation	Private Business	12	40.0
	Employee	12	40.0
	Professionals & Others	2	6.7
	Home Maker	4	13.3
	Total	**30**	**100.0**
Educational Qualification	upto SSLC	18	60.0
	HSC	2	6.7
	UG	2	6.7
	PG	5	16.7
	Illiterate	2	6.7
	Professionals	1	3.3
	Total	**30**	**100.0**

Table No. 1 Demographical Detail

The above table shows that three fourth (60%) of the respondents are aged between 19-40 years and more than one third (36.7%) of the respondents are aged between

41-60. Most of the respondents are youngster because they have to travel for the purpose of job and work. The above table indicate that four fifth (80%) of the respondents are male and only one fifth (20%) of the respondents are female. Most of the respondents are male because train travel is less costly transportation system compare to two wheeler and buses. The above table show that nearly half (46.7%) of the respondents income is between Rs.5001- 10000 and two fifth (40%) of the respondents income is between Rs. 10000 and above. Nearly half of the respondents are earning Rs.5001 - 10000, middle class people and lower class people are ready to travel in train because Jolarpettai Junction readily provide more facility to their passengers likes more number of trains, E-ticketing, more than 4 platform etc. The above table shows that 80% of the respondents are married and only 20% of the respondent are single. The above table identified that two fifth (40%) of the respondents are doing Private Business and Private Employees, only 6.7% of the respondents are doing Professional job. 40% of the respondents are doing private Business, because they have to travel different place to make purchase for business. The above table discovered that more than half (60%) of the respondents are Up to SSLC and only 16% of the respondents studied up to PG.

Age of the Respondents	Level of Passengers Satisfaction		Total
	Moderate	High	
19 - 40	9 (50)	9 (50)	18 (100)
	(75)	(50)	(100)
41 - 60	2 (18.2)	9 (81.8)	11 (100)
	(16.7)	(50)	(36.7)
61 and Above	1 (100)	0 (0)	1 (100)
Total	**12 (40)**	**18 (60)**	**30 (100)**
	(100)	**(100)**	**(100)**

Table. 2 Age of the Respondents and Level of Passenger Satisfaction

H_0 : There is no relationship between Age of Respondents and level of Passengers Satisfaction of the Respondents.

H_1 : There is relationship between Age of Respondents and level of Passengers Satisfaction of the Respondents.

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	4.432^a	2	0.109

Chi-Square Tests

Since the level of significance is more than 0.05 H_0 is accepted. Therefore it can be concluded that there is no significant relationship between Age of Respondents and level of Passengers Satisfaction of the Respondents.

Gender of the Respondents	Level of Passengers Satisfaction		
	Moderate	High	Total
Male	10 (41.7) (83.3)	14 (58.3) (77.8)	24 (100) (80)
Female	2 (33.3) (16.7)	4 (66.7) (22.2)	6 (100) (20)
Total	**12 (40)** **(100)**	**18 (60)** **(100)**	**30 (100)** **(100)**

Table. 3 Gender of the Respondents and level of Passengers Satisfaction

H_0 : There is no relationship between Gender of Respondents and level of Passengers Satisfaction.

H_1 : There is relationship between Gender of Respondents and level of Passengers Satisfaction.

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	288^a	2	0.866

Chi-Square Test

Since the level of significance is more than 0.05 H_0 is accepted. Therefore it can be concluded that there is no significant relationship between Gender of Respondents and level of Passengers Satisfaction.

Income of the Respondents	Level of Passengers Satisfaction		
	Moderate	High	Total
Below 5000	2 (50) (16.7)	2 (50) (11.1)	4 (100) (13.3)
5001-10000	5 (35.7) (41.7)	9 (64.3) (50)	14 (100) (46.7)
10001 and Above	5 (41.7) (41.7)	7 (58.3) (38.9)	12 (100) (40)
Total	**12 (40)** **(100)**	**18 (60)** **(100)**	**30 (100)** **(100)**

Table. 4 Income of the Respondents and level of Passengers Satisfaction

H_0 : There is no relationship between Income of Respondents and level of Passengers Satisfaction.

H_1 : There is relationship between Income of Respondents and level of Passengers Satisfaction.

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	0.288^a	2	0.866

Chi-Square Test

Since the level of significance is more than 0.05 the null hypothesis is accepted. Therefore it can be concluded that there is no significant relationship between Income of Respondents and level of Passengers Satisfaction.

Marital Status	Level of Passengers Satisfaction		
	Moderate	High	Total
Single	5 (83.3) (41.7)	1 (16.7) (5.6)	6 (100) (20)
Married	7 (29.2) (58.3)	17 (70.8) (94.4)	24 (100) (80)
Total	**12 (40) (100)**	**18 (60) (100)**	**30 (100) (100)**

Table. 5 Marital Status of the Respondents and level of Passengers Satisfaction

H_0 : There is no relationship between Marital Status of Respondents and level of Passengers Satisfaction.

H_1 : There is relationship between Marital Status of Respondents and level of Passengers Satisfaction.

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	5.868^a	2	0.015

Chi-Square Test

Since the level of significance is more than 0.05 the null hypothesis is accepted. Therefore it can be concluded that there is no significance relationship between Marital Status of Respondents and level of Passengers Satisfaction of the Respondents.

Educational	Level of Passengers Satisfaction		
Qualification	Moderate	High	Total
upto SSLC	4 (22.2)	14 (77.8)	18 (100)
	(33.3)	(77.8)	(60)
HSC	2 (100)	0 (0)	2 (100)
	(16.7)	(0)	(6.7)
UG	1 (50)	1 (50)	2 (100)
	(8.3)	(5.6)	(6.7)
PG	3 (60)	2 (40)	5 (100)
	(25.1)	(11.1)	(16.7)
Illiterate	1 (50)	1 (50)	2 (100)
	(8.3)	(5.6)	(6.7)
M.Phil.	1 (100)	0 (0)	1 (100)
	(8.3)	(0)	(3.3)
Total	**12 (40)**	**18 (60)**	**30 (100)**
	(100)	**(100)**	**(100)**

Table. 6 Educational Qualification of the Respondents and
level of Passengers Satisfaction

H_0 : There is no relationship between Educational Qualification of Respondents and level of Passengers Satisfaction.

H_1 : There is relationship between Educational Qualification of Respondents and level of Passengers Satisfaction.

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	7.870[a]	5	0.164

Chi-Square Tests

Since the level of significance is more than 0.05, the null hypothesis is accepted. Therefore, it can be concluded that there is no significant relationship between Educational Qualification of Respondents and level of Passengers Satisfaction.

Occupation of the Respondents	Level of Passengers Satisfaction		
	Moderate	High	Total
Private Business	3 (25)	9 (75)	12 (100)
	(25)	(50)	(40)
Employee	6 (50)	6 (50)	12 (100)
	(50)	(33.3)	(40)
Professionals & Others	2 (100)	0 (0)	2 (100)
	(16.7)	(0)	(6.7)
Home Maker	1 (25)	3 (75)	4 (100)
	(8.3)	(16.7)	(13.3)
Total	**12 (40)**	**18 (60)**	**30 (100)**
	(100)	**(100)**	**(100)**

Table. 7 Occupation of the Respondents and level of Passengers Satisfaction

H_0 : There is no relationship between Occupation of Respondents and level of Passengers Satisfaction.

H_1 : There is relationship between Occupation of Respondents and level of Passengers Satisfaction.

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	5.000^a	3	0.172

Chi-Square Test

Since the level of significance is more than 0.05, the null hypothesis is accepted. Therefore, it can be concluded that there is no significant relationship between occupation of the Respondents and level of Passengers satisfaction.

Findings

1. More than half of the respondents (60%) are aged between 19 - 40.

2. Four fifth (80%) of the respondents are male.

3. Nearly half (46.7%) of the respondents are earning between Rs.5001- 10000.

4. 80% of the respondents are married.

5. 60% of the respondents are Up to SSLC.

6. There is relationship between Marital Status of the respondents and level of Passengers satisfaction in Jolarpettai junction regarding service offered.

7. There is no relationship between Age, Income, Gender, Educational qualification, and occupation of the respondents and level of Passengers satisfaction in Jolarpettai junction regarding service offered.

Conclusion

This paper has examined the platform service quality offered for railway passengers in Jolarpettai Junction. It also evaluates the demographical factors like age, income, gender, educational qualification and its relationship on level of Passengers satisfaction. The study also confirmed that more than 80% of the respondents are male and also married. More than half of the respondents are aged between 19- 40 years old. There is no significant relationship between age, income, gender, educational qualification, occupation and level of Passengers satisfaction. The research discovers that there is relationship between marital status and level of Passengers satisfaction with Jolarpettai Junction in relation to the services offered over there.This study concludes that more than half of the respondents are satisfied with the services offered at Jolarpettai Junction to their passengers. And the study suggest that Jolarpettai junction should improve the number of ticket counters, parking facility and facility for disabled person to enhance the services to its passengers.

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Employee's Motivation: An Energizer for Philosophical Thinking

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Abstract

Motivation is a psychological process that gives purpose and direction to the behaviour. Motivation is inner force that drives individuals to achieve personal and organizational goals. It is a drive towards purposive manner to achieve the unsatisfied needs and goals of an individual. Motivated employees are more productive and always create positive situations around them. Self motivation is important feature for creating self awareness and to treat themselves as self respect and recognition. The researchers have selected 200 teaching and non-teaching employees of Salalah College of Technology, Oman for the present study. The findings showed that the employees strongly agree that they are being paid reasonable salary for their work and they have vast opportunities to do their best in contributing to the community in general.

Keywords: Motivation, Teachers of Higher Education, Non-teaching staff at Higher Education.

Introduction

Motivation is the only solution for people to get rid of their inner problems and to treat themselves satisfied on personal and professional endeavor. It is important to study the role of motivation in every organization since the motivated employees change workplace rapidly and they will try to help organizations to survive for long run. The study is crucial as the concept of motivation result in reducing, eliminating or diverting the tension.

Need and Importance of the Study

The purpose of the study is to describe the importance of certain factors in motivating employees at the place of work. Motivation is something stemming from within a person and mostly refers to a dynamic driving force. It is an inner striving condition which activates individual into action enthusiastically. It helps to activate, energize or move behaviour towards goal. Motivation is an important function performed by manager for activating the people to work for the accomplishment of organizational objectives. Manager is always makes appropriate use of various techniques to enthuse the employees to follow them. Effective motivation is not only accepting order but also in gaining a determination that is executed efficiently and effectively. It is an effective and dynamic instrument in the hands of manager for inspiring the work force and creating confidence in them. The study would make important contribution to the employer to route their labour into right corridor.

Statement of the Problem

The study of the motivation has very close relationship with the behaviour. It is important part of any management to help, satisfy and reward the employees to keep them happy at the work. The study is inevitable as the motivation applies to the entire class of urges, drives, desires, needs and similar forces. It is one of the most important tactics to use in every organizational activity to get done the required work. The more incentive employees gets, the more production the company will receive back. This study would help the employers to identify the nature of motivation requires to make employees pleasure.

Research Methodology

The present study has adopted empirical methodology and the study has done on the employees of Salalah College of Technology which include both teaching and non teaching staff. The fully targeted employees and their views have been ascertained through structured questions and statements in Likert's five point scale. The study has adopted the well-known branch of multivariate techniques using SPSS latest version (Statistical Package for Social Sciences) package, in order to get interpretable solutions clearly.

Review of Literature

Mohammed Naseeruddin revealed that the motivation is the heart of teaching and learning process. It is the process of arousing, sustaining and regulating activities to be precise a concept limited to some aspects such as the energetic behaviour or purposive regulation. Motivation is the one of the most important components of learning. Though a teacher's level of motivation occupies a very important position

it always depends on the student's level of motivation which plays even more role in the cycle of teaching and learning process. The main purpose of this study was to find out the motivational techniques used by heads of institutions to motivate teachers for an excellent performance. The analysis was concluded that the majority of heads used constructive as well as optimistic, appreciate intentionally, reward, constructive criticism, incentives, expressing expectation, promotion, recognition and personal loyalty. The study recommended for the improvement of teaching and learning situations in higher education and the heads should be honest, fair, polite, kind hearted, adjustable and punctual.

Motivating employees has become one of the most significant and most demanding activities for the human resource management in any organization. Salary alone does not prove to be vital motivator for everyone in an organization. Various factors motivate people differently depending upon the nature of an organization and its key contributors in developing learning environment. The study has elaborated various motivational factors that are influential to educational institution teachers for their work effectiveness in enhancing their performance in order to increase institutional effectiveness. This research has addressed the most unaddressed area of educational system that is teacher's motivation. According to Martin (2003) much of the research is available on student's motivation but little on motivating teachers. In Pakistan motivation of educational institutional teacher's by salary only quite challenging for the government as it is difficult to compete with the private sector institutions in compensation, hence they must have to give attention to the non monetary factors such as recognition, feedback and opportunities for career development to retain their high quality teachers.

Motivation is considered to be a soul achievement of human resource management practices as almost all the human resource practices have fundamental aim which includes job involvement and job satisfaction of an employee and acquiring high level of work motivation (Jerris 1999). Any organization cannot sustain without increased worker's motivation that is inevitable in the current scenario of hyper competition in corporate world. Robbins et al (2005) said that employee's motivation is the willingness to exert high level of inspiration to reach organizational goals, conditioned by the efforts ability to satisfy some individual need. This definition clearly states that motivation is the willingness of employees to perform excellent work efficiently and this willingness only comes when they perceive that their effort would result in their need satisfaction.

Filak and Sheldon (2003) put their opinion that the motivation is crucial to the long term success and performance of any educational system. Similarly, Porter et al (1973) stressed that teacher's motivation is important for several different reasons. It is important for teachers self satisfaction and accomplishments, and for the reason that motivated teachers more probably level and finally it is the motivated teacher

who assures the completion of reforms that are originated at the educational policy making level. They further emphasized that teacher's job satisfaction and motivation is associated with decreased number of Institutional absenteeism and turnover. Ololube (2004) explored the same point of view that increased motivation of teacher's leads to an increase in productivity that gives boost to the educational system, hence the function of educators motivational methods cannot be underemphasized.

Maslow's (1943) need based theory of motivation is the most commonly known theory of motivation according to which there are five fundamental needs of a person i.e., physiological, security, affiliation, esteem and self actualization. This theory can be true for teachers by understanding their physiological needs that may include pay, benefits, health and medical facility, accommodation and transportation and comfortable working environment. A teacher's security needs are similar to any other employee who is always concerned about the job security, fair treatment, protection against threats and many more. Adams (1963) described motivation concept in terms of balance between employee's input and output. According to their theory if there exist more work satisfaction, in the result of which motivated workforce will play effectual role in organizational development.

As Kyriacou et al (1979) stressed in their research that the reasons for leaving teaching profession may include lack of support from the department head, work overload, increased administrative task burden rather than engaging teachers in academic assignment. On the other hand Herzberg (1959) has divided the motivational factors in terms of job satisfaction. He pointed out that factors giving job satisfaction are different from the factors that give job dissatisfaction. He further emphasized that hygiene factors will not necessarily increase job satisfaction but can lead towards low motivation as compare to motivators.

As Adams et al (1989) highlighted in their study that student achievement can be a factor of motivation for teachers, if students are hardworking talented and high achievers, teachers will be more motivated as a strong relationship between teacher satisfaction and student achievements not only will raise teacher's job satisfaction but also will prompt him to pub his best. Clarke et al (1995) have also found some relationship between students and teachers and have asserted that students can be more satisfying aspect for teachers than an administrative support. However, Bohlender et.al. (2001) stressed upon compensation as one of the important considerations in human resource management. They emphasized that it is a tangible reward to the employee for the services; therefore compensation must be in accordance to the need fulfillment of employees.

Along with compensation Fuhrman (2006) pointed out that job descriptions

are important factors in motivating or de motivating employees. As unclear job description, stressful working environment, irrelevant administrative assignment can create overburden upon teachers and lead them to job dissatisfaction. Davidson (2007) concluded in his research that high workload, large number of students in classes and burden of non teaching activities are the problems in creating a good job design for teachers in higher education institution. On the other hand Ofoeqbu (2004) established that a teacher needs different resources like technology such as computers, projectors, multimedia and internet and facilities for effective classroom management and institution's improvement.

Data Analysis

Frequency Distribution

The distribution of sample respondents according to sex perceived on the Salalah College of Technology is shown in table No.1.1. It reveals out of the total 200 respondents 23 are Female occupying 11.5% and 177 in Male category occupying 88.5%. It is clear that the majority of the respondents considered for this study are male.

Gender	Frequency	Valid percent	Cumulative percent
Male	177	88.5	88.5
Female	23	11.5	100.0
Total	**200**	**100.0**	

Table No. 1.1

Classification of Respondents Based on Age

Age	Frequency	Valid percent	Cumulative percent
Below 30 years	22	11.0	11.0
31 - 40 years	115	57.5	68.5
41 - 50 years	55	27.5	96.0
Above 51 years	8	4.0	100.0
Total	**200**	**100.0**	

Table No. 1.2

From the table 1.2, it is found the distribution of respondents based on age. Respondents belonging to the age group of below 30 years are found 22 forms

11% followed by 115 respondents occupying 57.5% in the age group of 31-40. 55 respondents consist of 27.5% from the age group between 41-50 and 8 respondents constituting 4% in the age above 51 years

Classification of the Respondents Based on Educational Background

The table No.1.3 exposes the number of respondents on the basis of educational background. The study has considered 18 respondents consisting 9% with qualification up to diploma, 20 respondents occupying 10% with Bachelor degree as educational background followed by 132 respondents with 66% with Post Graduation and 30 respondents with 15% With Doctorate degree.

Education	Frequency	Valid percent	Cumulative percent
Diploma	18	9.0	10.5
Bachelor	20	10.0	27.5
Post Graduation	132	66.0	84.0
Doctorate	30	15.0	100.0
Total	**200**	**100.0**	

Table No. 1.3

Classification Based on Marital Status

From the table No.1.4, it reveals that 183 respondents occupying 91.5% belongs to the married category and 17 respondents possessing 8.5% belongs to single category are considered for the study.

Marital Status	Frequency	Valid percent	Cumulative percent
Unmarried	17	8.5	8.5
Married	183	91.5	100.0
Total	**200**	**100.0**	

Table No. 1.4

Classification Based on Monthly Income

The table No.1.5 divulged the number of respondents on the basis of their respective income levels, 18 respondents (9%) belongs to the category of income below R.O 700 out of the total 200 respondents considered for the study. This is followed by 163 respondents (81.5%) belonging to the income group of RO 700-1200 and 19 respondents (9.5%) belonging to the income group of above RO 1200. One RO (Omani Riyal) of Oman currency is equal to 165 Indian Rupees on an average.

Income	Frequency	Valid percent	Cumulative percent
Below RO 700	18	9.0	9.0
RO 700-1200	163	81.5	90.5
RO above 1200	19	9.5	100.0
Total	**200**	**100.0**	

Table No. 1.5

Classification Based on Designation

From the table 1.6, it is found the distribution of respondents based on designation. 182 respondents (91%) belong to teaching staff and 18 respondents (9%) belong to Non teaching staff.

Designation	Frequency	Valid percent	Cumulative percent
Teaching Staff	182	91.0	91.0
Nonteaching Staff	18	9.0	100.0
Total	**200**	**100.0**	

Table No. 1.6

Classification Based on Department

From the table 1.7, it is observed that out of total 200 respondents 44 respondents (22%) are from English Language Centre, 15 respondents (7.5%) belongs to Educational Technology centre, 42 of them (21%) based on the Business Department, 50 respondents (25%) are from Department of Information Technology and 49 respondents (24.5%) are from Engineering Department.

Department	Frequency	Valid percent	Cumulative percent
English Language Centre	44	22.0	22.0
Educational Tech Centre	15	7.5	29.5
Buss Dept	42	21.0	50.5
IT Dept	50	25.0	75.5
Engg. Dept	49	24.5	100.0
Total	**200**	**100.0**	

Table No. 1.7

Classification Based on Work Experience

From the table No.1.8, it is clear that 55 respondents occupying 27.5% has been working below 2 years, 119 respondents constituting 59.5% of the respondents has been working between 2-5 years, 15 respondents forming 7.5% has been working between 5-10 years and 11 respondents occupying 5.5% has been working above 10 years in Salalah College of Technology.

Duration	Frequency	Valid percent	Cumulative percent
below 2 years	55	27.5	27.5
2 - 5 years	119	59.5	87.0
5 - 10 years	15	7.5	94.5
Above 10 years	11	5.5	100.0
Total	**200**	**100.0**	

Table No. 1.8

t-Test

Employees Motivation with Reference to Salalah College of Technology

From the table No.2.1 it is found that the mean values of 5 statements are 2.29, 1.77, 4.61, 4.17 and 2.09 significantly. The standard deviation also ranges from .574 to 1.141 for all the 5 statements respectively. From the one sample test table it is found that the t-values are -8.798, -20.535, 39.663, 18.173 and -13.856 statistically significant at 5% level with respect to the test value 3.

Variables	Mean	SD	SE Mean	t-values	Sig (2-tailed)
Adapt New Environment	2.29	1.141	0.081	-8.798	0.000
Opportunities to learn and Develop	1.77	-0.851	0.060	-20.535	0.000
Honest and Professional	4.61	0.574	0.041	39.663	0.000
Opportunities to do Best	4.17	0.907	0.064	18.173	0.000
Your are motivated by Superiors	2.09	0.934	0.066	-13.856	0.000

Table 2.1

Assertiveness

From the table No.2.2 it is found that the mean values of 5 statements are 2.06, 2.17, 2.29, 2.03 and 3.23 significantly. The standard deviation also ranges from .679 to

1.465 for all the 5 statements respectively. From the one sample test table it is found that the t-values are $-18.108, -13.421, -10.702, -20.195$ and 2.173 statistically significant at 5% level with respect to the test value 3.

Variables	Mean	SD	SE Mean	t-values	Sig (2-tailed)
Opportunities to innovative work	2.06	0.738	0.052	−18.108	0.000
Invied for New Working Methods	2.17	0.875	0.062	−13.421	0.000
You have Team spirit at work	2.29	0.938	0.066	−10.702	0.000
You have effective Performance Appraisal	2.03	0.679	0.048	−20.195	0.000
Your are Recognized and Acknowledged	3.23	1.465	0.104	2.173	0.000

Table 2.2

Pay Benefits

From the table No.2.3 it is found that the mean values of 5 statements are 4.00, 4.20, 4.12, 2.35 and 2.33 significantly. The standard deviation also ranges from .539 to .827 for all the 5 statements respectively. From the one sample test table it is found that the t-values are 17.107, 22.228, 22.429, -16.438 and -17.701 statistically significant at 5% level with respect to the test value 3.

Variables	Mean	SD	SE Mean	t-values	Sig (2-tailed)
You are adequately remunerated	4.00	0.827	0.058	17.107	0.000
Satisfied Leave Salary	4.20	0.763	0.054	22.228	0.000
Effective Performance Appraisal	4.12	0.703	0.050	22.429	0.000
Good Safety Measure at Work	2.35	0.564	0.040	−16.438	0.000
Satisfied with incentives	2.33	0.539	0.038	−17.701	0.000

Table 2.3

Relationship

From the table No.2.4 it is found that the mean values of 6 statements are 1.72, 3.92, 4.15, 4.43, 4.30 and 2.53 significantly. The standard deviation also ranges from

.453 to .924 for all the 6 statements respectively. From the one sample test table it is found that the t-values are $-40.156, 14.388, 19.152, 34.934, 28.996$ and -7.195 statistically significant at 5% level with respect to the test value 3.

Variables	Mean	SD	SE Mean	t-values	Sig (2-tailed)
Smooth Work Relations	1.72	0.453	0.032	-40.156	0.000
Boss leads by Example	3.92	0.904	0.064	14.388	0.000
You have Friends at work	4.15	0.849	0.060	19.152	0.000
Boss updates you at Work	4.43	0.581	0.041	34.934	0.000
You are being consulted for your work	4.30	0.634	0.045	28.996	0.000
You have good relations with co-workers	2.53	0.924	0.065	-7.195	0.000

Table 2.4

Findings and Suggestions

It is found that the majority of the respondents occupying 88.5% are male employees working is Salalah College of Technology. It is clear from the data that most of the respondents forming 57.5% are from the age group of 31-40 who works in the Salalah College of Technology in different departments. It is observed from the educational background of the employees in each department of the college under the research study the majority of the employees occupying 66% are with the qualification of Post Graduation level. On referring the different marital status of the study it is clear that the majority of the employees consist of 91.5% are settled overseas working in Salalah College of Technology are married. On analysing the different income groups of the employees with respect to the Salalah College of Technology, most of the respondents occupying 81.5% fall into the income category of RO 700-1200. It is found from the assessment that the majority of the respondents forming 91% working as teaching staffs in the Salalah College of Technology. The majority of the respondents considered for the research study are from the department of Information Technology followed by engineering department. It is clear that majority of the employees working between 2 to 5 years in the different department of the Salalah college of Technology.

It is inferred from the respondents of Salalah College of Technology, they strongly

agree that all the employees are most honest and professional and they have vast opportunities to do their best in contributing to the community in general. The respondents strongly disagree to adapt to new environment when they get an opportunity to work and have opportunities to learn and develop their knowledge at the workplace. They strongly disagree that the employees are motivated by their respective superiors in the college.

It is inferred from the respondents of the Salalah College of Technology, they moderately agree that employees are well recognized and acknowledged at workplace. They strongly disagree that they have more opportunities to innovate new work and they were invited for new working methods. They also disagree that all employees have team spirit and have effective performance appraisal at the Institution.

It is inferred from the respondents of Salalah College of Technology, they strongly agree that all the employees are adequately remunerated always provides leave salary satisfactorily and employer follows effective performance appraisal. They also strongly disagree that they have safety measures at work in the case of emergency and satisfied with incentives provided. It is inferred from the Salalah College of Technology, they strongly agree that their boss updates every activity at work, everyone has friends at workplace and every employee is being consulted for their work. They moderately agree that their boss always leads by example. They strongly disagree that they have smooth work relations and good relations with co-workers at educational Institution.

It is suggested to provide orientation programmes to new employees who come from different parts of the country in large to adapt themselves. It will ultimately pave ways to develop their knowledge and contribute their best to the student community. It is also important to bring to the kind notice of the management to provide safety measures to every employee to live safely in case of emergency situations and unexpected incidents. It is recommended to the educational institution to create opportunities for the faculties to contribute their innovative work and for facilitating different new working methodologies for the welfare of the students. It is also suggested to the management of the institution to construct possible environment for the staff to work with team spirit which ultimately helps to construct good working relations with co-workers at the work place. It is also opined to craft a very good performance appraisal system to extract quality teaching.

Conclusion

The study would make vital contribution to the organizational community to identify factors influencing the motivation among employees and to keep them happy around the company which will give different meaning and purpose of individual human

being lives. It is in short referred as psychological word which can be described as behaviour and the way a person thinks and then acts on what is important. It would subsequently help the organizations to set a goal and find motivation everyday to help and accomplish such goals to achieve the objectives framed. It is important to identify motivation which helps to implement in the organization and to keep focused on the right tract of prescribed goals. This study has carried out with intention to identify the serious factors influencing the motivation and to suggest measures to overcome such issues to the best satisfaction of employees and organizational objectives.

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Organizational Climate and Job Satisfaction of Arts and Science College Teachers

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Abstract

An organisation is a social arrangement consisting of number of individuals with different tasks for each individual. The interdependence and interaction of these individuals is essential for the achievement of prefixed objectives. The behavioral scientists had a long standing concern with the impact of specific behaviour of individuals and groups on the effectiveness of the organisation. Using a sample of 320 teachers working in private arts and science colleges in Vellore and Tiruvannamalai District, the researchers have made an attempt to find out the relationship between organizational climate and job satisfaction. The finding of the study has showed that there is a positive relationship between organizational climate and job satisfaction.

Keywords: Organizational Climate, Job Satisfaction.

Introduction

Organizational Climate is the human environment within which the employees of an organization work together. It may refer to the environment within a department, a section, a unit or the organization as a whole. Organizational climate cannot be seen or touched but can be felt by its members. Job satisfaction is one of the most widely discussed and enthusiastically studied constructs in such related disciplines as industrial-organizational psychology, organizational behavior, personnel and human resource management and organizational management.

Definition of Organizational Climate

According to Renato Taguiri, (1968) *Organizational climate is a relatively enduring quality of the internal environment that is experienced by the members, influences their behavior, and can be described in terms of values of particular set of characteristics of the organisation.*

Garg and Rastogi (2006) defines the concept as a *feeling* that is the result of the physical layout of the organisation, the way in which participants interact with one another and how they conduct themselves with other organizational members or outsiders.

Definition of Job Satisfaction

According to Hoppock (1935) Job satisfactions is any combination of psychological, physiological and environmental circumstances that causes a person truthfully to say *I am satisfied with my job.*

Importance of Organisational Climate and Job Satisfaction

A sound organizational climate is a long-term proposition. In order to build up a sound organizational climate, management must understand their people in the organization. The individual differences suggest that there cannot be any all-purpose organizational climate. Job satisfaction of the employees is important for management also. A satisfied work force translates higher productivity which benefits society in general. Job satisfaction affects society as a whole. When employees are happy with their jobs, it improves their life off the job. The dissatisfied employees carry that negative attitude home. Satisfied employees are more likely to be satisfied citizens. These people will hold a more positive attitude towards life in general and make up a society of more psychologically healthy people. The effect of satisfaction in the job carries over off the job hours. So the goal of high job satisfaction of employees can be defined in terms of both money and social responsibilities.

Statement of the Problem

Human resources working in the organization play a vital role in the achievement of organizational goals and objectives. The organizational goals cannot be achieved successfully without an active participation of employees. Organizational Productivity is directly linked to employees satisfaction and quantum of attention paid to their physical and mental needs. The organizational commitment of an employee depends not only on the smooth organizational climate prevailing in an organization but also the inter-relationship between the employee and the superior and the co-workers.

Objectives of the Study

- To measure the degree of job satisfaction among self finance arts and science college teachers.

- To study the relationship between job satisfaction and various intrinsic and extrinsic factors.

- To ascertain the relationship between organizational climate and job satisfaction of self finance arts and science college teachers.

Hypotheses Tested

To achieve the above objectives, the following general hypotheses were formulated.

■ Job satisfaction and various intrinsic and extrinsic factors are positively correlated.

■ There is a positive relationship between organizational climate and job satisfaction.

Methodology of the Study

The study covered self finance arts and science college teachers working in Vellore and Tiruvannamalai Districts. There are 35 self finance arts and science colleges in these two districts. The researcher selected all 35 colleges by simple random sample method. There are 1262 teachers working in the above colleges. The researcher selected 378 employees by simple random method which represents 30% percent of the total teachers and received responses only from 328 respondents. Eight of them were found to be incomplete and were rejected and the final sample for the present study consisted of 320 respondents.

Results and Discussion

One of the important objectives of the present study was to determine the relationship between job satisfaction and various intrinsic and extrinsic factors. Intrinsic (internal) factors or content factors are those factors which come from the job itself. Extrinsic (external) factors or context factors refer to those factors which are external to the job. In order to find out the relationship between various intrinsic (motivating factors) and extrinsic factors (hygiene factors) and the level of job satisfaction of private arts and science college teachers, correlation analysis and t - test was applied. The following table shows the summary of correlation and t - test results.

S.No.	Independent Variables	Mean	S.D	Correlation	t Value df.319	Level of Significance
1	Recognitions	3.70	1.25	0.775	20.406	0.01
2	Training	3.55	1.51	0.762	16.650	0.01
3	Decision Making	3.47	1.23	0.752	16.238	0.01
4	Authority	3.98	1.17	0.742	27.316	0.01
5	Communication	3.65	1.27	0.720	18.610	0.01
6	Grievance	3.78	1.17	0.699	22.839	0.01
7	Increment	3.47	1.35	0.616	13.353	0.01
8	Working Condition	4.02	1.22	0.610	24.613	0.01
9	Present Profession	3.62	1.42	0.608	14.716	0.01
10	Sense of belongingness	3.81	1.06	0.560	23.639	0.01
11	Freedom	3.52	1.37	0.533	13.428	0.01
12	Leadership	3.71	1.32	0.517	16.764	0.01
13	Supervision	3.73	1.19	0.465	18.542	0.01
14	Promotion	2.97	1.51	0.445	4.354	0.01
15	Achievement	3.92	1.08	0.432	23.610	0.01
16	Interpersonal Relation with Colleagues	3.58	1.42	0.425	13.115	0.01
17	Fulfilment of Needs	2.73	1.43	0.398	1.317	0.01
18	Fringe benefits	3.21	1.50	0.395	7.396	0.01
19	Social Status	4.06	1.16	0.389	23.970	0.01
20	Inter-Relationship with Students	4.07	1.11	0.338	24.426	0.01
21	Job Security	3.12	1.33	0.284	6.805	0.01
22	Management Policy	3.77	1.24	0.214	16.453	0.01
23	Workload	2.52	1.37	0.211	1.573	0.01
24	Scale of Pay	3.58	1.20	0.194	14.074	0.01
25	Management Treatment	3.63	1.34	0.090	12.877	NS*
26	Salary	2.22	1.52	−0.025	4.672	NS*

*Not Significant

Table. 1 Relationship between Job Satisfaction and Other Variables

The above table clearly shows that except six variables, all other variables selected are significantly correlated with job satisfaction and are relevant for explaining variation in the level of job satisfaction. It may however, be noted that the strength of the relationship between job satisfaction and other variable is not uniform but ranges widely between 0.775 (highest) and 0.90 (lowest). It is also evident from the above table that among the 26 variable, 12 variables shows a strong and significant correlation with job satisfaction and other 14 variables, namely, Supervision, promotion, achievement, interpersonal relation with colleagues, fulfilment of needs, fringe benefits, social status, inter-relationship with students, job security, management policy, work load, scale of pay, management treatment and salary shows a moderate to very weak correlation.

It is also evident from the above table that several variables have been considered by the respondents as sources of satisfaction. Both intrinsic or content factors (recognition, sense of belongingness and achievement) and many of the extrinsic or context factors are significantly related with the level of job satisfaction of arts and science college teachers. The t - test result shows that only two variables (i.e., management treatment and salary) show no significant relationship. So it is clear from the above analysis that both intrinsic factors and extrinsic factors contribute towards the job satisfaction of arts and science college teachers. The present study supports the findings of Birmingham (1985), Sinha and Sarita Singh (1995), Joshi G. (1998), Ifineo (2003), Noor Mohamed (2006) and Sreemathi (2011). Satisfaction is not independent or contextual. Hygiene factors like pay and conditions of work are basics for performance. Human system may still function in the absence of hygiene, but human labor cannot work without hygiene at the place of work. Hence, according to them, separating motivators and hygiene is irrelevant. Form the above table it is clear that both intrinsic factors and extrinsic factors determine the level of job satisfaction of arts and science college teachers.

It is a fact that the large number of statistically significant relationship between job satisfaction and other variables reported in the above table do not necessarily suggest that job satisfaction is caused by so many factors. While it is reasonable to believe that complex human response like job satisfaction is unlikely to be caused by any single factor, it is equally unlikely that as many as 20 factors must combine to produce job satisfaction. It so happens that the predictors used by social scientists, instead of being independent on one another, are often inter-correlated.

Factor Analysis

In order to analyze the data further, factor analysis was applied to know the inter correlations among different variables and to analyze among the factors, which of the factors contribute much for the job satisfaction of arts and science college teachers. The following table shows the result of factor analysis.

	Initial Eigen Value			Extraction Sums of squared Loadings			Rotation Sums of squared Loadings		
Factor	Total	% of Var.	cum %	Total	% of Var.	cum %	Total	% of Var.	cum %
1	8.860	34.075	34.075	8.536	32.832	32.832	4.184	16.093	16.093
2	2.733	10.512	44.587	2.465	9.480	42.312	3.721	14.311	30.404
3	2.106	8.098	52.686	1.759	6.765	49.077	2.912	11.199	41.603
4	1.768	6.800	59.485	1.432	5.506	54.582	2.234	8.591	50.193
5	1.486	5.716	65.201	1.012	3.894	58.476	1.564	6.016	56.209
6	1.291	4.963	70.164	0.862	3.316	61.792	1.451	5.583	61.792
7	0.989	3.804	73.969						
8	0.929	3.575	77.543						
9	0.746	2.870	80.414						
10	0.721	2.773	83.186						
11	0.663	2.549	85.736						
12	0.590	2.270	88.006						
13	0.557	2.140	90.146						
14	0.443	1.702	91.848						
15	0.375	1.442	93.290						
16	0.332	1.275	94.565						
17	0.288	1.108	95.674						
18	0.257	0.989	96.663						
19	0.208	0.801	97.464						
20	0.188	0.723	98.187						
21	0.122	0.468	98.655						
22	0.117	0.449	99.104						
23	0.009	0.366	99.470						
24	0.005	0.222	99.691						
25	0.004	0.185	99.876						
26	0.003	0.124	100.00						

Total variance Explained   Extraction Method: Principal Axis Factoring.

Table. 2 Factor Analysis - Initial Eigen Value

The above table shows the extraction of Initial Eigen value by adopting principal Axis Factoring method. It is clear from the above table that among the 26 variables, only eight factors, whose Eigen values are more than .9. These factors are recognition, grievance, decision making, authority, communication, training, leadership and freedom. Factor matrix was used to know that among the eight variables, which variables inter correlates very much and thus considered as contributing factors for the job satisfaction of arts and science college teachers.

	Factor					
	1	2	3	4	5	6
Recognition	0.823	0.255	-.490	-.822	3.416E-04	-.118
Grievance	0.810	0.283	-.176	-.107	-8.132E-02	.154
Decision making	0.808	008	.102	6.340E-02	.156	-.087
Authority	0.804	−0.398	.213	.114	-3.223E-02	-.036
Communication	0.764	0.115	.211	.162	.398	-.015
Training	0.734	0.001	.093	-.385	9.475E-02	.195
Leadership	0.665	−0.317	.303	.263	-.345	.073
Freedom	0.651	0.272	-.211	-.287	-.161	-.188
Increment	0.616	0.185	-.643	-.434	-5.259E-02	-.272
Working condition	0.600	-.419	.302	2.626E-02	.151	-.200
Supervision	0.580	0.157	-.228	-.316	-.123	.358
Fulfilment of needs	0.567	-3.776E-02	-.187	.311	.193	-.041
Achievement	0.547	−0.221	-.716	-2.052E-02	-.363	.211
Present profession	0.519	−0.170	-.488	-.264	-.152	-.323
Fringe benefits	0.516	−0.106	.845	.241	.120	.005
Social status	0.499	0.061	-.353	5.295E-02	.208	.285
Interpersonal relation with colleagues	0.497	.133	-.594	7.615E-02	-4.182E-02	.053
Inter-relationship with students	0.489	-.420	-.305	.133	6.055E-03	-.074
Promotion	0.367	.108	.188	-.106	.270	-.279
Workload	0.360	.266	-.392	9.111E-02	-.317	-.120
Management treatment	0.189	.716	.328	.362	-.187	-.043
Management policy	0.223	.642	.550	9.705E-02	-6.969E-02	.128
Sense of belongingness	0.531	-.583	.409	-5.182E-02	-5.812E-02	.269

Factor						
	1	2	3	4	5	6
Salary	−0.115	.221	.375	-.272	.258	.235
Job security	0.286	.105	-.318	-2.567E-02	.304	.128
Scale of pay	0.470	.193	-.455	.542	-4.489E-03	.015

Method: Principal Axis Factoring

Table. 3 Factor Matrix

The above table showing the factor matrix analysis reveals that among the eight variables which were initially extracted, the scores of only six variables, i.e. recognition, grievance, decision making, authority, communication, and training are more than 0.7. Therefore it is concluded that only these six variables inter correlated more frequently with other variables and they may be considered as the contributing factors as far as the job satisfaction of private arts and science college teachers are concerned.

It may be correct to say that good recognition received for the efforts and sincere work will always be a source of satisfaction for the employees. Grievance encourages employee problems to be brought into the open, so that management can learn about them and take corrective action. Proper decision making is the essence of management. It involves choosing a course of action from alternative courses of action available to them in solving a problem. The effective responsibility of the each individual employee working in the organization should be clearly laid down. The success of the organization depends on co-ordination which can be achieved effectively by communication. By training, the employee will acquire new manipulative skills, technical knowledge, problem solving ability or attitudes etc. It makes new recruits to become fully productive in a minimum time.

Relationship between Organisational Climate and Job Satisfaction

The important objective of the study is to analyze the relationship between organizational climate and job satisfaction of arts and science college teachers. Correlation analysis is carried out to see whether the two variables are related. The following table shows the relationship between organizational climate and job satisfaction of arts and science college teachers.

		Job Satisfaction Level	Organization Climate Level
Level of Satisfaction	Pearson Correlation	1.000	0.514**
	Sig (2-tailed)		0.000
	N	320	320
Organizational Climate Level	Pearson Correlation	0.514**	1.000
	Sig (2-tailed)		0.000
	N	320	320

** Correlation is significant at 0.01 level (2-tailed)

Table. 4 Relationship between Organisational Climate and Job Satisfaction

The above correlation analysis shows that there is a positive relationship between organizational climate and job satisfaction of arts and science college teachers. (r = .514 significant at 0.01 level). The findings of Pratap and Srivsastava (1895), Sharma (2000), Natarajan (2001), Grotto (2001), Peek (2003) and Fisher et al. (2007) also showed similar results as in the present study.

	Independent Variables	Correlation	Level of Satisfaction
1	Teamwork and Support	.585	0.01
2	Relationship	.542	0.01
3	Quality of Service	.485	0.01
4	Role of Clarity	.469	0.01
5	Career Development	.463	0.01
6	Respect Level	.456	0.01
7	Direction	.455	0.01
8	Conflict Management	.434	0.01
9	Planning and Decision Making	.430	0.01
10	Commitment and Morale	.427	0.01
11	Communication	.424	0.01
12	Training and Learning	.388	0.01
13	Reward System	.379	0.01
14	Innovation	.307	0.01

Table. 5 Relationship between Organisational Climate Variables and Job Satisfaction

In order to further analyze the data, correlation analysis was carried out between various organizational climate variable and job satisfaction. The above table shows the relationship between organizational climate and job satisfaction variables.

Conclusion

The results revealed that job satisfaction is found to be affected by both intrinsic and extrinsic factors. The managements can further improve the level of organizational climate and job satisfaction of arts and science college teachers by means of adopting the following recommendations. Firstly, the management can further improve the organizational climate and job satisfaction of teachers by means of increasing the salary of teachers to a reasonable level. Many teachers felt that they are not being given a reasonable salary. So it is high time that the managements make an upward revision of salary to the teachers. Secondly, though optimum number of work force is considered good for the efficient management, it should not be at the cost of over burdening the workers by assigning more work load. So the management may take steps to reduce the burden of long hours of work by recruiting reasonable level of teachers. Thirdly, many arts and science college teachers feel that they are not satisfied with the increments policy being followed by the managements. So the managements may offer increments at a regular interval with a reasonable amount to all.

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Social and Family Role Stress and Job Satisfaction

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Abstract

It is a known fact that stress is a subject which is hard to avoid. The term is discussed not only in our everyday conversation but has become enough of a public issue to attract widespread media attention whether it be radio, television, newspapers or magazines, the issue of stress figures everywhere. It is a common myth that stress comes only from work place. Of course, there is a kind of stress called organisational role stress which emanates from the work place or the profession to which we belong to. Moreover, the organisational role stress is comparatively more influential. But this is not the only source or kind of stress. Societal stress and family role stressors also have considerable impact on an individual's behaviour. These social and family role stresses have its impact on Job Satisfaction of the employees. Therefore, social stressors and family stressors are important factors to be considered. It is assumed that the quantum of stress faced by the employees of Information Technology Industry is much more than the others connected to any other profession and occupation. The researchers have selected six major firms in the IT sector. The researchers by adopting Quota Sampling method has selected twenty five employees from each of the six companies mentioned above in two cities constituting 300 respondents. The sampling technique adopted for this study is 'Quota Cum Accidental Sampling' Method. The findings reveal that at the first level 'Societal (Family/Friends) Unsupport'; at the second level 'Work-Family Interference'; and at the third level 'Avoidance of Home Responsibilities for the sake of Appreciation'; and at the fourth level 'Lack of Job Related Knowledge in Family Members' are contributing to Social and Family Role Stress. The findings also reveal that at the first level 'Job Content, Freedom and Opportunities' and at the second level, 'Industrial Relations, Working Conditions and Recognition' are contributing to Job Satisfaction of IT Professionals.

Keywords: Social Role, Family Role, Satisfaction.

Introduction

It is a fact that the modern world which is said to be a world of achievements, is also a world of stress. One finds stress everywhere, whether it be within the family, business organisation or enterprise or any other social and economic activity. Right from the time of birth till the last breath, an individual is invariably exposed to various stressful situations. Thus, it is not surprising that interest in the issue has been rising with the advancement of the present century which has been called the 'Age of Anxiety and Stress'. Stress is a subject which is hard to avoid. The term is discussed not only in our everyday conversation but has become enough of a public issue to attract widespread media attention whether it be radio, television, newspapers or magazines, the issue of stress figures everywhere.

The researchers have observed that the stress is identified in every individual's life irrespective of age, sex, marital status, educational level and designation. It is a common myth that stress comes from occupation only. The researchers have perceived that the stress is not only emanating from work place but also from family and societal relationships. One can also not deny that, of the above mentioned sources, the later source is somewhat significant as they have some amount of their impact on other sources of stress. All these stresses either individually or collectively have their impact on Job Satisfaction of the employees. It is assumed that the quantum of stress faced by the employees of Information Technology Industry is much more than the others connected to any other profession and occupation. Today, people from all walks of life are attracted towards stress and hence this era is called as 'Stress Era' or 'Stress Age'. This era is also called as 'Information Technology Era' (IT Era) or 'Information Technology Age' (IT Age) (Rupashree Khubalkar, 2008)[1]. Hence, the researchers wish to explore the relationship of Social and Family Role Stressors with the Job Satisfaction of IT Professionals.

Need for the Study

The researchers have observed that Indian IT Professionals, in contrast to similar professionals in other parts of the world (where the single parent family or the nuclear-family system is a more common way of life) must be facing and confronting lot more pressures and conflicts in their attempts to meet the varying and contrasting demands of work and family roles. The pressures are likely to be high, primarily because of the Indian socio-cultural context, where the joint-family-structure and the extended family system, with its emotionally loaded familial bonds and close-knit character, is the dominant way of life. Hence, the researchers have found that the IT Professionals in India, about whom not enough data and information is generated and available, as interesting source materials for exploring and furnishing new insights into the problems

of work-family-integration. Indian IT Professionals were considered an interesting study material for one more reason also. It is a commonly known fact that the socio-cultural ethos in the sub-continent is quite different because of its strong social and family support system. In the face of industrialization, modernization, urbanization, globalization and growth in the standards of education and economy levels, rapid transformation is taking place in the social fabric and social structure of the nation. The typical joint-family structure, especially in urban areas and amongst the educated lot, is rapidly getting destroyed and substituted by nuclear and close single families. In such a situation, how do IT Professionals in India, within this kind of family structure and social-context, respond to and cope with the conflicts and pressures (and resultant stress) from societal relationships and family interface? Do these social and family role stressors have a say in the level of Job Satisfaction? These are some very pertinent questions that triggered the interest and attention of the researchers to carry out such a study which will be helpful to IT Professionals, Employers, IT Industry and the society as a whole.

Research Problem

It has been observed that the present large segment of young educated youth - both men and women in India including other countries show preference to IT industry over other sectors in the society. This may be due to its attractive monetary benefits, respectability in the society, pleasant and ever young work environment, inherent challenging feature, tour and travel opportunities, medical reimbursement, holiday packages and quick opportunity for career development. IT profession that is likely to provide the above mentioned benefits draws the maximum number of educated youth both men and women towards it (the growing demand of institutions offering IT industry based courses and the increasing number of enrolments in them, is sufficient evidence to support the claim). Thus, it is no wonder, that most Indian family as also its prospective employees regard IT Profession to be one of the most suited and respectful profession for both the genders. This is more with respect to the middle-class segment of the population (that probably constitute the largest chunk of the literate and educated population of the country) which, in its attempt to meet economic challenges and acquire the mantle of a modern, liberal and forward class, is increasingly allowing its youth irrespective of the gender bias to join the work force, but without enough will or courage (or probably preferring the status quo) to break the traditionally assigned differential roles of a gender stratified social system. However, the IT Profession seems to be much attractive, one cannot deny the level of stress experienced by IT Professionals, particularly the Indian IT Professionals. Their experience of stress does not restrict to their profession alone but also affecting comparatively a lot in their societal and personal lives also. Often they experience work-family conflict and family-work conflict. It is within this experimental, theoretical and research based background

framework that the researchers thought of examining the nature of conflicts and stress emanating from societal and family domains of IT Professionals and their relationship with their job satisfaction - a strong and predictive factor of burnout. Though many researches carried out earlier to study the stress among IT Professionals, many of them just attempted to prove only work role related stress in them. Few studies were done to prove the work-family conflicts and family-work conflicts among them. Few measured the social as well as family stressors among other group of respondents belonging to other industries like teaching. But none of the study took place so far by correlating these two segments namely, social role stressors, family-role stressors and relating them with the Job Satisfaction levels of the Information Technology Professionals. In short, the present study intends to explore the relationship of Social and Family Role Stressors with the job satisfaction of IT Professionals. This Research Problem has raised the following questions.

1. What are the levels of Social and Family Role Stress and Job Satisfaction?

2. What is the relationship of Demographic Factors with Social and Family Role Stress and Job Satisfaction?

3. What is the relationship of Social and Family Role Stress with Job Satisfaction of IT Professionals?

Important Concepts

Stress

Different people have different views about it as stress can be experienced from a variety of sources. If we ask the opinions of five different people, we may likely to get at least five different definitions for the term stress. The business person views stress as frustration or emotional tension; the air traffic controller sees it as a problem of alertness and concentration; the biochemist thinks of it as pure chemical event.

The concept of stress was first introduced in the life sciences by Hans Selye in 1936. It is a concept borrowed from the natural sciences. The word was derived from the Latin word 'Stringere'. Stress was popularly used in the seventeenth century to mean hardship, strain, adversity or affliction. It was used in the eighteenth and nineteenth centuries to denote force, pressure, strain or strong effort with reference to an object or person. In engineering and physics, the term implies an external force or pressure exerted on something with the intention to distort and being resisted by the person or object on which it is exerted. In psycho-physiology, stress refers to some stimulus resulting in a detectable strain that cannot be accommodated by the organism and which ultimately results in impaired health or behaviour. In common parlance, however, the

terms 'stress' and 'strain' are used synonymously in a non-scientific manner. The popularity of this concept has dwindled in the physiological field where it was first introduced but the use of stress terminology continues to flourish in psychological and social sciences. (Pestonjee D M, 2009)[2]

The common man today faces stress every now and then, in every walk of life. Stress accompanies us wherever we are, wherever we go, like a shadow it follows us. Stress is so close to each of us that its presence is barely perceived. It has become an inbuilt ingredient of today's life and this does not mean that in those earlier days, people had no stress; perhaps, they were not aware of it and its impact.

Social and Family Role Stress (SFRS)

Stress, most representatives of pressures in the family domain, includes family conflict and parenthood. Family conflict refers to incompatible role pressures within the family. Married women who assume home roles and non-home roles frequently experience conflict between the competing demands of these two roles. Women's family role often combines a high level of psychological demand with a low level of control. In their study of women's social roles, Barnett and Baruch (1985)[3] found that role conflict and levels of role overload were significantly associated with the role of a paid worker or that of a wife.

Inter-role-conflict in the family can be seen to increase as one's obligations to the family expand through marriage and arrival of children. This is particularly true for women, who more than men, tend to assume the responsibilities of household and childcare (Gutek, Nakamura and Nieva, 1981)[4]. Gove and Geerken (1977)[5] found a positive relation between the number of children and psychiatric symptoms of employed mothers. Women with young children are more likely than others to experience incessant demands and limited freedom. They report loneliness, depression and concern about having a nervous breakdown [Gove and Geerkan, (1977)[5]; Campbell, Cenverce and Rogers, (1976)[6]; Brown and Harris, (1978)[7]]. Children can produce inter-role conflicts, not only to parent versus spouse roles but also to family versus work roles. Brown and Harris (1978)[7] found that employment outside the home offsets the vulnerability to health problems of women with children.

With respect to men, Bachman, O'Malley, and Johnston (1978)[8] concluded that marriage and parenthood could have positive effects on the self-esteem and job motivation of young males. The presence of children was related to higher level of job involvement and organisational identification (Gould and Werbel, 1983)[9]. Furthermore, in another survey, childless couples were perceived as having neither the most satisfying lives nor the most satisfying marriages (Blake, 1979)[10]. In the present research,

parenthood and family conflict both will be considered as sources of family role stressors.

Job Satisfaction

Job satisfaction is an attitudinal concept central to work psychology (Bass and Barnett, 1972)[11]. Bullock (1952)[12] defined job satisfaction as an attitude, which results from a balancing and summation of many likes and dislikes experienced in connection with one's job. Locke (1969)[13] defined job satisfaction as 'a pleasurable or positive emotional state resulting from the appraisal of one's job values or job experience. According to Wexley and Yukl (1977)[14] job satisfaction is the way an employee feels about his job. Ilies and Judge (2004)[15] have defined job satisfaction as a latent evaluative tendency of one's job that accounts for the co-variation between work stimuli and responses is manifested through discrete evaluative states during the working day.

Seybolt (1976)[16] supported the idea that job satisfaction is a function of the person-environment interaction. Although a number of factors (such as wages, opportunity for achievement and advancement, security, company, management, social aspects of job, communication and benefits) are related to the job satisfaction, it is the interaction among these factors rather than any one of them in isolation that accounts for job satisfaction.

In simple terms, Job Satisfaction is the way how people feel about their job and its various aspects. It has to do with the extent to which people like or dislike their job. That is why job satisfaction and job dissatisfaction can appear in any given work situation.

Objectives of the Study

The main objective of the research study is to determine the relationship between the stressors of Social and Family Roles and Job Satisfaction of IT Professionals. For this, the researchers have framed the following objectives.

1. To study the level of Social and Family Role Stress and Job Satisfaction of IT Professionals.

2. To study the relationship of Demographic Factors with that of Family-Role Stress and Job Satisfaction.

3. To know the relationship of Social and Family Role Stress with that of Job Satisfaction of IT Professionals.

Hypotheses

Based on the above objectives, the following hypotheses were framed.

- There is no significant relationship between Demographic Factors and Social and Family Role Stress and Job Satisfaction.

- There is no significant relationship between Social and Family Role Stress with that of Job Satisfaction.

Research Methodolog

Population

The researchers have targeted six major firms in the IT sector namely

(1) Tata Consultancy Services (TCS)

(2) Cognizant Technology Solutions (CTS)

(3) Infosys

(4) Wipro

(5) HCL and

(6) Microsoft Corporation India (Pvt.) Ltd.,

having offices both at two major cities (to have uniformity) namely Bengaluru (Karnataka) and Chennai (Tamilnadu) as the former is considered as the IT Hub of India and the later is equivalently having major IT firms. All categories of IT Company employees are included in the population.

Sampling Design

Sample. The researchers by adopting Quota Sampling method have selected twenty five employees from each of the six companies mentioned above in two cities constituting 300 respondents. The researchers have not differentiated respondents based on their designation. The researchers have personally visited the above mentioned IT Companies and the required data was collected from the IT Professionals who voluntarily came forward to respond to the questionnaire. Hence, the sampling technique adopted for this study is 'Quota Cum Accidental Sampling' Method.

Pilot study. A pilot study was carried out in all the six firms of both the cities. Three respondents in each firm were selected and the tool was administered to them. All the

36 respondents were promptly responded. Based on the pilot study, necessary changes were carried out in second and third part of the questionnaire to suit the present study.

Questionnaire. The researchers have designed a questionnaire with the following three parts:

Part I — Personal Information;

Part II — Social and Family Role Stress Scale

(SFRS Scale; S. Sultan Akhtar and Priti Vadra)[17];

Part III — Job Satisfaction Questionnaire (Shailendra Singh)[18];

Part I - Personal information. This part of the questionnaire consists of questions relating to Demographic Factors and few other personal factors relevant for the study.

Part II - Social and family role stress scale (SFRS Scale) This part is to obtain information in connection with the stressors purely connected to social and family life. The researchers have used the scale called Social and Family Role Stress Scale (SFRS Scale) containing 25 statements developed and standardised by S.Sultan Akhtar and Priti Vadra in 1989 with a slight modification in rating scale. In the original scale, five values are there as 5, 4, 3, 2 and 1 to represent total agreement, agreement, undecided, disagreement and total disagreement about the statements. The researchers have not allocated any values but adopted four point likert scale as Strongly Agree, Agree, Disagree, and Strongly Disagree. There is no provision to record as 'Undecided' or 'Neutral' so as to get compulsorily the best response for all the statements. However, all the 25 statements were adopted with few small changes as necessitated by the present study.

Part - III Job satisfaction questionnaire (JSQ) This is the last part of the questionnaire. This part is to measure the Job Satisfaction level of the respondents. For this, the researchers have used the questionnaire called the Job Satisfaction Questionnaire consisting of 20 statements developed and standardised by Shailendra Singh. The original questionnaire has five points namely 1, 2, 3, 4 and 5 to represent the agreement with respect to satisfaction about the statements as Very Dissatisfied, Dissatisfied, Neutral, Satisfied and Very Satisfied respectively. But the researchers have made a small change with respect to the scaling though they have adopted all the statements as it is. Four point likert scale is adopted to measure the responses as Very Much Satisfied, Satisfied, Dissatisfied and Very Much Dissatisfied.

Reliability Test

In order to test the reliability of the questionnaire Cronbach Alpha test was carried out and the value came to 0.761. Hence it was concluded that the tool designed and used for this study was reliable.

Analysis of Data

For the purpose of analysis, chi-square test, correlation analysis, factor analysis have been used. The detail of analysis is as follows.

Level of Social and Family Role Stress and Job Satisfaction

The following table shows the level of social and family role stress and job satisfaction of IT Professionals.

Levels	Social & Family Role Stress (SFRS)		Job Satisfaction JS	
	Frequency	Percentage	Frequency	Percentage
High	126	42	258	86
Moderate	174	58	36	12
Low	–	–	06	02
Total	300	100	300	100

Table. 1 Level of Social and Family Role Stress and Job Satisfaction of IT Professionals

Social and Family Role Stress (SFRS) Level

It is found from the above table that majority of the respondents i.e., 58 % are experiencing moderate level of social and family role stress and rest of the respondents were found to be experiencing high level of social and family role stress. It is to be noted that there is no one experiencing low level of social and family role stress.

Job Satisfaction (JS) Level

The above table indicates that more than 4/5th of the respondents are highly satisfied and only 12% of the respondents come under the category of moderately satisfied with their job. Though not considerable, 2% of respondents were experiencing low level of job satisfaction.

Testing of Hypotheses

To study the relationship of demographic factors with that of Social and Family Role Stress and Job Satisfaction, the following hypothesis is formulated.

There is no significant relationship between Demographic Factors and Social and Family Role Stress and Job Satisfaction.

The above mentioned hypothesis was tested using the chi-square analysis as shown in the following table.

Sl. No.	Factors Compared	Chi-Square Value	d.f.	Significance
1	Age & SFRS	58.485	3	0.000
2	Gender & SFRS	21.337	1	0.000
3	Marital Status & SFRS	34.649	3	0.000
4	Family Type & SFRS	32.853	1	0.000
5	Family Size & SFRS	6.496	2	0.039
6	Educational Qualification & SFRS	31.004	5	0.000
7	Designation & SFRS	4.307	4	0.366
8	Experience & SFRS	48.575	4	0.000
9	Remuneration & SFRS	44.102	4	0.000
10	Working Hours & ORS	7.643	2	0.022
11	Working Shift & ORS	30.944	4	0.000
12	Spouse Working Status & ORS	1.943	1	0.163
13	Nature of Spouse Work & ORS	22.826	3	0.000

Table. 2 Demographic Factors and Social & Family Role Stress (SFRS)

The chi-square analysis showed that there exist a significant relationship of age, gender, marital status, family type, family size, educational qualification, experience, remuneration, working hours, work shift and nature of spouse work with that of Social and Family Role Stress of IT Professionals. But there exist no significant relationship of Designation and Spouse Working Status with that of Social and Family Role Stress of IT Professionals.

Demographic Factors and Job Satisfaction

In order to test the relationship between demographic factors including few other important personal factors and job satisfaction, various hypotheses were formulated and the following table gives the results of chi-square analysis.

The chi-square analysis showed that there exist a significant relationship of age, gender, family type, family size, educational qualification, designation, working hours, and nature of spouse work with Job Satisfaction of IT Professionals. But there exist no

significant relationship of marital status, experience, remuneration, working shift and spouse working status with Job Satisfaction of IT Professionals.

Sl. No.	Factors Compared	Chi-Square Value	d.f.	Significance
1	Age & JS	49.512	6	0.000
2	Gender & JS	7.022	2	0.030
3	Marital Status & JS	9.831	6	0.133
4	Family Type & JS	7.089	1	0.029
5	Family Size & JS	25.129	4	0.000
6	Educational Qualification & JS	44.149	10	0.000
7	Designation & JS	39.171	8	0.000
8	Experience & JS	11.742	8	0.163
9	Remuneration & JS	14.959	8	0.060
10	Working Hours & JS	10.185	4	0.037
11	Working Shift & JS	12.373	8	0.135
12	Spouse Working Status & JS	7.311	2	0.026
13	Nature of Spouse Work & JS	15.578	3	0.001

Table. 3 Demographic Factors and Job Satisfaction

Relationship between Social & Family Role Stress (SFRS) and Job Satisfaction (JS)

Another objective of the study was to know the relationship between social and family role stress (SFRS) with that of job satisfaction of IT professionals and for this the following hypothesis was formulated.

> **There is no significant relationship between social and family role stress with that of job satisfaction.**

In order to test the above mentioned hypothesis correlation analysis and paired sample t-test was applied. The following table shows the summary of correlation and t-test.

Since the level of significance in case of t-test is more than 0.05 Ho is accepted. Therefore it can be concluded that there is no significant difference in the mean value

between Social and Family Role Stress (SFRS) and Job Satisfaction (JS).

As far as correlation between Social and Family Role Stress (SFRS) and Job Satisfaction (JS) is concerned, there exist a correlation (r = - 0.131) at 0.05 significance level and as the level of significance is less than 0.05, the null hypothesis was rejected. Hence, it can be concluded that there exist a significance relationship between Social and Family Role Stress and Job Satisfaction.

SNo	Variables	Mean	SD	r		t (df 299)	
				r value	Sig Level	t value	Sig Level
1.	Social and Family Role Stress (SFRS)	62.72	11.30	-0.131	0.023	-1.026	0.306
2.	Job Satisfaction (JS)	63.76	12.05				

Table. 4 Relationship between SFRS and Job Satisfaction

Factor Analysis

In order to analyze the data further, factor analysis was carried out to know the inter correlations between factors studied and to analyse among the factors which of the factors contribute to the maximum.

Factor Analysis was carried out for Social & Family Role Stress consisting of 25 factors and Job Satisfaction consisting of 20 factors.

Factor Analysis for Social & Family Role Stress (SFRS)

The following table shows the result of factor analysis for social and family role stress.

The table 5 shows the extraction of 'Initial Eigen Value' by adopting Principal Component Factoring Method. It is clear from the above table that among the 25 variables, only four factors whose Eigen values are more than one is selected. The factors are Social & Family Role Stress (SFRS) - 5 i.e, Underpayment, Social & Family Role Stress (SFRS) - 4 ie., Unsuitability of the Job, Social & Family Role Stress (SFRS) - 2 ie., Lack of Social Prestige, and Social & Family Role Stress (SFRS) - 18 ie., Work-Role Tension.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulativ e %	Total	% of Variance	Cumulativ e %	Total	% of Variance	Cumulativ e %
1	14.838	59.353	59.353	14.838	59.353	59.353	6.319	25.278	25.278
2	1.646	6.584	65.938	1.646	6.584	65.938	4.451	17.802	43.080
3	1.217	4.867	70.804	1.217	4.867	70.804	4.397	17.590	60.670
4	1.008	4.030	74.835	1.008	4.030	74.835	3.541	14.165	74.835
5	.720	2.879	77.713						
6	.657	2.630	80.343						
7	.607	2.427	82.770						
8	.563	2.253	85.023						
9	.425	1.700	86.722						
10	.384	1.534	88.257						
11	.365	1.461	89.718						
12	.332	1.327	91.045						
13	.326	1.304	92.348						
14	.278	1.110	93.459						
15	.239	.954	94.413						
16	.222	.890	95.303						
17	.202	.807	96.110						
18	.182	.729	96.839						
19	.160	.642	97.481						
20	.141	.565	98.046						
21	.136	.542	98.589						
22	.113	.452	99.041						
23	9.819E-02	.393	99.434						
24	7.607E-02	.304	99.738						
25	6.547E-02	.262	100.000						

Extraction Method: Principal Component Analysis.

Table. 5 Factor Analysis (Initial Eigen Value) - (SFRS)

Factor matrix called 'Rotated Component Matrix' was used to know among the four variables, which variable correlates very much and thus considered as contributing factors for the social and family role stress of IT Professionals on hierarchy basis.

The following table shows 4 different levels consisted of group of factors which contribute to the Social and Family Role Stress (SFRS) of IT Professionals. The following table explains in detail these group of factors classified in 4 levels which

are named based on some common features exist among the factors come under each group.

Rotated Component Matrix [a]

	Component			
	1	2	3	4
SOCIAL & FAMILY ROLE STRESS (SFRS) - 3	-.828	-.246	-.229	-.184
SOCIAL & FAMILY ROLE STRESS (SFRS) - 4	-.811	-.287	-.288	-.165
SOCIAL & FAMILY ROLE STRESS (SFRS) - 5	-.775	-.239	-.264	-.311
SOCIAL & FAMILY ROLE STRESS (SFRS) - 7	.726	.125	.232	.429
SOCIAL & FAMILY STRESS (SFRS) - 2	.638	.312	.462	.137
SOCIAL & FAMILY ROLE STRESS (SFRS) - 16	.637	.459	.382	5.928E-02
SOCIAL & FAMILY ROLE STRESS (SFRS) - 18	.627	.110	.359	.505
SOCIAL & FAMILY ROLE STRESS (SFRS) - 17	.603	.187	.415	.383
SOCIAL & FAMILY ROLE STRESS (SFRS) - 15	.575	.448	.480	2.434E-02
SOCIAL & FAMILY ROLE STRESS (SFRS) - 8	.319	.744	.147	.239
SOCIAL & FAMILY ROLE STRESS (SFRS) - 9	.326	.701	.331	2.531E-02
SOCIAL & FAMILY ROLE STRESS (SFRS) - 14	3.131E-02	.696	.334	.202
SOCIAL & FAMILY ROLE STRESS (SFRS) - 6	-.387	-.687	-.111	-.354
SOCIAL & FAMILY ROLE STRESS (SFRS) - 24	9.956E-03	.583	.402	.564
SOCIAL & FAMILY ROLE STRESS (SFRS) - 1	.529	.575	.119	.341
SOCIAL & FAMILY ROLE STRESS (SFRS) - 10	.344	.321	.735	8.767E-02
SOCIAL & FAMILY ROLE STRESS (SFRS) - 12	.338	.369	.679	.159
SOCIAL & FAMILY ROLE STRESS (SFRS) - 11	.193	.499	.583	.316
SOCIAL & FAMILY ROLE STRESS (SFRS) - 21	-.458	-6.59E-03	-.544	-.511
SOCIAL & FAMILY ROLE STRESS (SFRS) - 23	.378	.258	.544	.376
SOCIAL & FAMILY ROLE STRESS (SFRS) - 22	.403	9.142E-02	.537	.536
SOCIAL & FAMILY ROLE STRESS (SFRS) - 13	.343	.304	.529	.265
SOCIAL & FAMILY ROLE STRESS (SFRS) - 25	.470	.235	.517	.348
SOCIAL & FAMILY ROLE STRESS (SFRS) - 20	.237	.364	.135	.788
SOCIAL & FAMILY ROLE STRESS (SFRS) - 19	.361	.407	.177	.695

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 18 iterations.

Table. 6 Factor Matrix (Rotated Component Matrix) - (SFRS)

Level 1 - [Societal (Family / Friends) Unsupport]		
Contributing Factor	Value	Factor Explanation
SFRS-3	-.828	There is no room for expressing talent to the fullest. (Peoples' View)
SFRS-4	-.811	Non-suitability of the present job. (Family View)
SFRS-5	-.775	Underpayment. (Family View)
SFRS-7	.726	No room for fulfilling personal objectives. (Family View)
SFRS-2	.638	Lack of social prestige. (Family View)
SFRS-16	.637	Untrustworthy colleagues. (Family View)
SFRS-18	.627	Association between work role and family support.
SFRS-17	.603	No permission to bring colleagues in to the home. (Family View)
SFRS-15	.575	Over squeeze by employer. (Societal View)
Level 2 - [Work Family Interference]		
Contributing Factor	Value	Factor Explanation
SFRS-8	.747	Tension at home due to job.
SFRS-9	.701	Bringing pending work to home.
SFRS-14	.696	Impact of work overload on health. (Family View)
SFRS-6	-.687	No room for recreation due to job. (Family View)
SFRS-24	.583	Doing pending work at home results in conflict.
SFRS-1	.575	Unsuitability of the job (Family View)

Level 3 - [Avoidance of Home Responsibility for the sake of Appreciation]		
Contributing Factor	Value	Factor Explanation
SFRS-10	.735	Appreciation from Hardworking people.
SFRS-12	.679	Avoidance of Home Responsibilities.
SFRS-11	.583	Neglecting the studies of children and other family members.
SFRS-21	-.544	Appreciation for challenging nature of the job.
SFRS-23	.544	Contribution of family for the progress.
SFRS-22	.537	Family aversion due to acceptance of more work related responsibilities.
SFRS-13	.529	Earning in alternate job (societal view)
SFRS-25	.517	Foregoing Career Development Opportunities for the sake of family.
Level 4 - [Lack of Job Related Knowledge in Family Members]		
Contributing Factor	Value	Factor Explanation
SFRS-18	.505	Association between work role and family support.
SFRS-24	.564	Doing pending work at home results in conflict.
SFRS-21	-.511	Appreciation for challenging nature of the job.
SFRS-7	-.544	No room for fulfilling personal objectives. (Family View)
SFRS-22	.536	Family aversion due to acceptance of more work related responsibilities.
SFRS-20	.788	Non consideration of recommendations of my near and dear ones for certain favours pertaining to my job and results in mental agony.

Table. 7 Factor Matrix for SFRS - 4 Levels Explained

The above table reveals that at the first level 'Societal (Family/Friends) Unsupport'; at the second level 'Work-Family Interference'; and at the third level 'Avoidance of Home Responsibilities for the sake of Appreciation'; and at the fourth level 'Lack of Job Related Knowledge in Family Members' are contributing to Social and Family Role Stress.

Factor Analysis for Job Satisfaction (JS)

The following table shows the result of factor analysis for Job Satisfaction.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	11.781	58.907	58.907	11.781	58.907	58.907	7.706	38.529	38.529
2	1.126	5.628	64.535	1.126	5.628	64.535	5.201	26.006	64.535
3	.908	4.540	69.075						
4	.839	4.193	73.268						
5	.671	3.355	76.623						
6	.597	2.986	79.609						
7	.523	2.614	82.222						
8	.477	2.383	84.606						
9	.434	2.171	86.776						
10	.411	2.056	88.832						
11	.378	1.891	90.723						
12	.344	1.721	92.444						
13	.282	1.409	93.853						
14	.266	1.330	95.184						
15	.236	1.181	96.364						
16	.214	1.072	97.436						
17	.163	.815	98.251						
18	.128	.639	98.890						
19	.120	.602	99.492						
20	.102	.508	100.000						

Extraction Method: Principal Component Analysis.

Table. 8 Factor Analysis (Initial Eigen Value) - (Job Satisfaction)

The above table shows the extraction of 'Initial Eigen Value' by adopting Principal Axis Factoring Method. It is clear from the above table that among the 20 variables, only two factors whose Eigen values are more than one is selected. The factors are JSQ-2 (Freedom in Work) and JSQ-14 (Variety of Task in the Job).

Factor matrix called 'Rotated Component Matrix' was used to know among the two variables, which variable correlates very much and thus considered as contributing factors for the job satisfaction of IT Professionals on hierarchy basis.

Total Variance Explained

Compone	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	11.781	58.907	58.907	11.781	58.907	58.907	7.706	38.529	38.529
2	1.126	5.628	64.535	1.126	5.628	64.535	5.201	26.006	64.535
3	.908	4.540	69.075						
4	.839	4.193	73.268						
5	.671	3.355	76.623						
6	.597	2.986	79.609						
7	.523	2.614	82.222						
8	.477	2.383	84.606						
9	.434	2.171	86.776						
10	.411	2.056	88.832						
11	.378	1.891	90.723						
12	.344	1.721	92.444						
13	.282	1.409	93.853						
14	.266	1.330	95.184						
15	.236	1.181	96.364						
16	.214	1.072	97.436						
17	.163	.815	98.251						
18	.128	.639	98.890						
19	.120	.602	99.492						
20	.102	.508	100.000						

Extraction Method: Principal Component Analysis.

Table. 9 Factor Matrix (Rotated Component Matrix) (Job Satisfaction)

The above table shows 2 different levels consisted of group of factors which contribute to the Social and Family Role Stress (SFRS) of IT Professionals. The following table explains in detail these group of factors classified in 2 levels which are named based on some common features exist among the factors coming under each group.

Level 1 - [Job Content, Freedom and Opportunities]		
Contributing Factor	Value	Factor Explanation
JSQ -18	.812	Power and prestige in the job.
JSQ -17	.782	Chances to learn new things.
JSQ -15	.765	Job security.
JSQ -12	.750	Attention paid to employees suggestions.
JSQ -19	.738	Opportunities to make decisions.
JSQ -20	.701	Opportunities to achieve something worthwhile.
JSQ -10	.700	Chances of promotion.
JSQ -11	.699	Management style.
JSQ -14	.674	The amount of variety in the job.
JSQ -13	.661	Working Hours
JSQ -16	.646	Opportunity to help others with personal problems at work.
JSQ -8	.611	Relationship between Management and Employees.
JSQ -7	.590	Opportunities to use abilities.
JSQ -2	.501	Freedom in choosing working method.
Level 2 - [Industrial Relations, Working Conditions and Recognition]		
Contributing Factor	Value	Factor Explanation
JSQ - 8	.520	Relationship between Management and Employees.
JSQ -7	.555	Opportunities to use abilities.
JSQ -1	.787	The physical work conditions.
JSQ -4	.711	Recognition for good work.
JSQ -2	.710	Freedom in choosing Working Method.
JSQ -5	.708	Satisfaction with Immediate Boss.
JSQ -3	.681	Satisfaction with Colleagues.
JSQ -6	.652	Amount of given responsibility.

Table. 10 Factor Matrix for Job Satisfaction - 2 Levels Explained

The above table showing the factor matrix analysis reveals that at the first level 'Job Content, Freedom and Opportunities' and at the second level, 'Industrial Relations, Working Conditions and Recognition' are contributing to Job Satisfaction of IT Professionals.

Suggestions for Tackling the Stress

It is a known fact that very few IT companies have done something substantial to tackle the problems of stress at the family environment and society in general when compared to work place. It has been realized that over emphasizing the achievement oriented work cultures and simply linking employee motivation with material incentives may not always increase job satisfaction among employees. The stress factor is intangible and cannot be quantified so easily, and thus neglected. It is a great hidden cost for the companies. In recent times, many companies are waking up and are taking stress as a serious concern for their employees. The organizations are suggested to concentrate on the following measures to tackle the social and family role stresses.

- stress management workshops

- training programmes

- medical examination

- time-management techniques

- work-life and family-life integration programmes

- providing opportunities for social interaction

- providing moral education

- holding family day

- counseling through psychiatrists

- yoga, gym and spa sessions

- movie ticket bookings, travel plans, gift deliveries

- marriage leave, parental leave, maternity leave, paternity leave and bereavement leave

- child care arrangements (vacation child care programmes, child care referral services, child care network, work-based child care for nursing mothers, family room and telephone access

- providing elder care

- in-house store/services

- arranging vacation trips

- conducting stress audit

- hypnosis by expert

It is suggested that the IT Companies at their level should try to diagnose the root cause of stress and then try to rectify the problem from its origin. Unrealistic targets, communication gap, and negative motivation which are some of the root causes, should be avoided. It is advised not to stick with one or two techniques known to them or practiced in their firm rather it is suggested to try other alternatives mentioned above depending on the basic nature and root of stress. It will work out and as an organization it can manage the said stress.

However, all the factors that cause stress among employees may not be controllable for the organization like recession, social demands or employees' personal lives. Moreover, the causes and effects of stress are often different for different employees. So, along with the organizational level programmes, it is important for the organizations to build awareness and encourage employees to adopt stress management techniques at their own individual levels. It is also quite evident that any organizational level intervention technique is not without limitations in terms of ensuring a long term healthy stress-free work environment for its employees. Infact, the role of organizations in stress management is more of a facilitator than anything else. Therefore, managing stress should be an equal responsibility of the individuals as well.

An individual cannot change the world, but he can change his reactions to situations by changing himself. Understanding the individual stress level is the first step towards successful stress management. It involves recognizing the stressors or the factors that causes stress and affects health. Employees have to identify certain stress symptoms and relate it with the stress situation they are going through. Difficulty in sleeping, frequent burst of anger and depression are common stress symptoms related to various stress situations. Recognizing the stress symptoms can help people to keep stress from snowballing to chronic from an acute stage. It may also prompt them to adopt life styles techniques of stress management and seek medical help when it becomes necessary. So, once the stress level is understood, next step is to select a suitable stress management technique. There are several techniques of stress management today which includes anything from yoga to aromatherapy. Yoga includes postures (asana), breathing (pranayama), and meditation (dhyana). It helps to increase the body awareness, releases muscular tension and increases coordination between mind and body. Another technique getting popular is the 'laughter therapy'. No one can deny that 'laughing is the best medicine'. In this 21st century, life has become too fast, too mechanical and somewhat over materialistic, people often forget to laugh. We must adopt humor as a part of our life to reduce stress. Simply, inculcating a general habit of being organized and managing time by prioritizing tasks according to their importance

takes a lot of pressure out of our daily lives. Besides, every individual has to understand his own strengths and limitations and should not strive beyond his capacity. Adopting a healthy lifestyle means proper diet, routine sleep, regular exercises, and taking some time out for ourselves for the things that we like. But on the other hand, taking to smoking or drinking may temporarily help one to cope with stressful situations but at the same time they do serious damage to our health in the long run.

Use of simple stress busters like listening to music, deep breathing, drinking sufficient water, indulging in leisurely activities and hobbies, stop worrying and remain positive, taking breaks, talking with closed ones, playing simple games on computer or cell phones, reading and sharing jokes with colleagues and friends, taking a shower, if possible, body massage and meditation (Mantra/Prayer/Recitation of Holy Books, Recitation of Sacred Books) provides quick relief in stressful situations. It is recommended that the IT Professionals as individuals can adopt any one or more of the above mentioned techniques to reduce the stress level. It is a fact that the above mentioned techniques are though simple stress management techniques and are very helpful and effective at most of the times, still it is recommended and advisable to seek medical and specialist's intervention in severe cases of chronic stress.

Conclusion

The most important thing for individuals to remember is that stress is created by people's reactions to situations, rather than the situations themselves. The growing stress among IT employees in recent times has reached to an alarming level as indicated by various studies. Just like workplace stress, social and family role stresses are also not only threats to the individual health of employees working in IT companies but also brings down the organizational productivity in the long run (though indirectly). Managing stress in growing economies like India that too in a sector like IT industry has become quite a challenge as there is a mismatch between existing health infrastructure and the pace at which IT industry is expanding. The Government and the policy makers have to assist the IT companies in bringing stringent rules and guidelines for the organizations and develop adequate health infrastructure inside the companies as well as outside the company's compound. The thrust should be more towards promoting preventive health care practices.

The IT companies cannot simply concentrate on organizational role stress alone. They have to equally concentrate on social role stress and family role stress and their impact on the job satisfaction as all are inter-correlated and inter-related except a few. The IT companies should consider its employees as its valuable asset. Each and every employee working at different capacities play an important role in the development of the organization. Therefore, understanding, accommodating and giving sympathetic

approach to manage the IT employees' stress will certainly increase the job satisfaction among them and in turn organizational productivity and effectiveness will improve.

No organization and individual remain silent under stressful situation. The study will help the IT firms to realize the relationship that exist between different kinds of stresses and job satisfaction. Similarly, no organization especially an IT company can attain the milestones without a satisfied workforce. Hence, it is right time to introduce suitable stress management programmes at the organizational level and bringing improvement in the existing stress management programmes and thereby increase job satisfaction that will lead to increased productivity, improved relationships both on and off the job, better team work and communication, improved morale, retention of valued employees and what not? At the individual level, employees working in IT companies should be much aware of their stress levels, be more concerned about their health and practice healthier lifestyle so as to be a part of developing India. India's competitive advantage in the global economy is substantially dependent on its young and productive work force. But this advantage may not remain sustainable, if stress and its implications are not addressed immediately with seriousness. Equivalent attention need to be given to social and family role stress as of organizational role stress.

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A Study on Working Capital Management of Footwear Companies listed in BSE

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Abstract

Working capital means the funds required to meet the short term financial obligations/requirements of an organization. Efficient management of working capital is vital for the survival, growth and success of any organization irrespective of its size and nature of business. Working capital management has a significant influence on liquidity and profitability of the organization. The study was conducted to examine the working capital management in two reputed Footwear Companies listed in BSE and is based on Secondary Data (Annual Reports) for five years.

Keywords: Working Capital, Footwear Companies, BSE.

Introduction

Working capital management (WCM) is the management of short-term financing requirements of a firm. It is concerned with the management of Current Assets and Current Liabilities so as to minimize the risk of insolvency and maximize the return. The aim of working capital management is to make sure that a firm is able to continue its operations and that it has sufficient ability to pay maturing short-term debts and upcoming operational expenses.

Management of working capital involves managing inventories, accounts receivables, accounts payable, cash, etc. It includes maintaining optimum balance of working capital components viz., inventory, receivables, payable, cash, etc. It is the process of planning and controlling the level and mix of current assets of the firm and financing these assets. Efficient management of working capital increases cash flow of organizations which in turn creates an opportunity for the growth of organizations and maximizes the return to shareholders.

Management of working capital is an important function of a Financial Manager. Working Capital Management plays a critical role in maintaining the financial strength of a firm and thereby it helps in the endurance of any organization. Working Capital Management means the management of short term assets and short term liabilities (Khan, 2002). To get best possible returns in terms of profitability, firms should not keep any unproductive assets and choose the cheapest available source of funds to finance its working capital.

The basic objective of Working Capital Management is to manage the firm's current assets and current liabilities in such a way that the satisfactory level of working capital is maintained, i.e., it is neither excessive nor inadequate. The current assets should be sufficient enough to cover current liabilities in order to maintain a reasonable safety margin.

Working Capital Management includes maintaining optimum balance of working capital components viz., receivables, inventory and payables and efficiently maintaining cash balances for day-to-day business operations. Optimization of working capital balance means minimizing the working capital requirement and realizing maximum possible returns (Ganesan, 2007). A well designed and implemented working capital management policy is expected to contribute positively to the creation of a firm's value (Padachi, 2010).

Efficiency in working capital management is so imperative for firms whose assets are mostly held as current assets which directly influence liquidity and profitability of any firm (Raheman and Nasr, 2007).

Every firm is required to maintain a balance between liquidity and profitability while doing business. Liquidity ensures firm's ability to meet short term obligations and the continued flow can be guaranteed for a profitable firm (Padachi, 2010). The term profitability refers to the firm's ability to earn proft and profit is determined by matching revenue against cost associated with it (Salahuddin, 2001).

Excessive working capital levels result in substandard return on assets and most of the successful firms keep its working capital ratio as low as possible and keep its cash balance circulating to maximize profits. If a firm's management does not constantly monitor the working capital, then the business can find itself in a difficult situation with its creditors (Padachi 2010). Conversely, if a firm maintains low liquidity of working capital to get a higher return, then the firm will be facing risk.

Working Capital Management is vital to all types of business firms, whether small or big and whether manufacturing or trading organizations (Chittenden, Poutziouris and

Michaels, 1998). As a result of this, the researchers decided to embark on a study to look at how reputed firms manage their working capital.

Concepts of Working Capital

Firms divide its funds/capital into two categories viz., Long-term funds and Short-term funds. Long term funds are invested in Fixed Assets like land, building, etc. Short term funds also known as Working Capital refers to that part of capital which circulates in business. Firms' profitability lies on the efficient usage of the working capitals. There are two concepts of working Capital viz., Gross Working Capital and Net Working Capital. Working capital is also known as Circulating Capital.

Gross Working Capital refers to the total of Current Assets and Net Working Capital refers to the excess of Current Assets over Current Liabilities. Excess of Current liabilities over Current assets will result in Working Capital Deficit which happens in abnormal cases.

Current Assets are those assets which have short span of life and transforms into other form of assets (e.g., A/C Receivables are converted into Cash) within twelve months. Eg., Inventory, Receivables, Cash, etc.

Current Liabilities are those liabilities which have to be paid out normally within twelve months. Eg., Bank overdraft, Payable, etc.

Working capital can be categorized as *Permanent Working Capital* and *Temporary Working Capital*. That part of working capital which will be there in the business at all times on a permanent basis is the former one and whereas the later refers to the part of capital which is introduced only when there is such a need and taken back at a later point of time as soon as the purpose is served.

Importance of Working Capital

For the smooth running of any business firm, adequate amount of working capital is important. There must be sufficient amount of working capital to meet the short term obligations of a business firm. It is a part of capital which is not retained in a particular form for longer than a year. Flow of funds is as essential as flow of blood in the human body. Success of a firm depends hugely on efficient and effective management of working capital.

Review of Literature

Deloof (2006) conducted a research study in Belgium for Non-Financial firms for the period from 1992 to 1996 and observed a positive correlation between Cash Conversion Cycle and Profitability. The result of the study highlighted that an increase in Inventory days, Accounts receivable days and Account payable days affects profitability negatively.

Lazaridis and Tryfonidis (2006) confirmed the association between management of working capital and profitability for 131 Greek companies listed in Athens Stock Exchange. The result revealed a significant negative relationship between Cash Conversion Cycle and Gross Operating Profit.

Afza T and Nazir MS (2007) research highlighted a negative relationship between the Profitability Measure of firms and degree of aggressiveness of Working Capital Investment and Financing policies for 208 public limited companies listed in KSE for a period of 1998-2005.

Samiloglu and Demirgunes (2008) analyzed the effect of working capital management practices on firms' profitability by conducting an Empirical Study and revealed that the Accounts Receivable Period, Inventory Period and Leverage affect Firms' Profitability negatively and growth in Sales positively affects the Profitability of Firms.

Uyar (2009) examined the relationship between Cash Conversion Cycle with Firm's size and Profitability for 166 firms listed in Istanbul Stock Exchange for the year 2007 and publicized that Retail/Wholesale industry has shorter Cash Conversion Cycle than the Manufacturing Industries. The study also revealed that Cash Conversion Cycle is longest for textile industries and there is a negative relationship between the length of cash conversion cycle and the Firm's size. It also revealed that smaller firms have longer Cash Conversion Cycle and there existed negative relationship between length of Cash Conversion Cycle and the Firms' profitability.

Kulkanya Napomech (2009) conducted a study in Thailand for 255 companies listed in the Stock Exchange of Thailand from 2007 to 2009, the result confirmed an inverse relationship between the Operating Profits and Inventory Conversion Period and Receivables Collection Period.

Sarbapria Ray (2010) found positive relationship between Working Capital Management and Profitability of 311 Indian manufacturing firms. The research was carried out for the period from 1996 to 2010.

Vijayakumar (2011) observed significant relationship between Liquidity and Performance. The study revealed a strong negative correlation between Accounts Receivable Period and Performance. Cash Conversion Cycle had a negative correlation with Performance and so was the Inventory Conversion Period whereas the relationship between Accounts Payable Period and Profitability was positive. These findings hold that longer Payable Period and shorter Receivable Period enhance profitability of the firm.

G. Azad Basha and A. Khaleequzzaman (2014) conducted a research study to find out the relationship between Working Capital Management and Profitability for a Departmental Store. The study was based on the five years' (2008-09 to 2012-13) Annual Reports of a Departmental Store listed in BSE. The study revealed significant relationship between working capital components and profitability.

Marco Muscettola (2014) conducted an extensive research study taking a sample of 4226 Italian SME's to verify the impact and the influence of Cash Conversion Cycle on the profitability of firms. Results revealed that the Average Receivables Period is having significantly positive relationship with the Profitability of firms. It was also observed that the lesser Cash Conversion Cycle (CCC) do not always result in higher Profitability. It was concluded that CCC does not always have significant relationship with the firm's profitability.

In general, all the studies discussed above have shown significant relationship between Working Capital Management components and Profitability of a firm. Some of these studies have shown a positive relationship between CCC and Profitability and some others have shown a negative relationship between the same. Hence, researcher felt a need for conducting a study on Working Capital Management of Footwear Companies listed in BSE. The present study is about the working capital management of two prominent footwear companies listed in Bombay Stock Exchange.

Objectives of the Study

(1) To examine the Working Capital Management of the Two Footwear Companies Listed in BSE.

(2) To study the relationship between Working Capital Components and Profitability

Research Design/Methodology

The data used in this study were obtained from the Annual Reports of Two Prominent Footwear Companies Listed in BSE. Five years' Financial Statements

were analyzed for Interpretation. Due to time Constraint, sample size is restricted to two. Ratio Analysis and Correlation Analysis were carried out for Analysis and Interpretation. Few important Liquidity Ratios and Operating Profit Ratio were considered for the study.

Analysis and Interpretation

Analysis and Interpretations were carried out with the help of Financial Ratio Analysis and Correlation Analysis.

Ratio Analysis

Ratio Analysis is a powerful tool of financial analysis. Analysis and interpretation of financial statements with the help of ratios is termed as Ratio Analysis. A Financial Ratio can be defined as *a quantitative relationship between two items of the financial statements, connected with each other*.

Company I	Mar '14	Dec '13	Dec '12	Dec '11	Dec '10
Current Ratio	2.08	2.05	2.01	1.98	1.6
Quick Ratio	0.79	0.84	0.84	0.76	0.78
Inventory Turnover Ratio	3.88	3.6	4.05	4	4.28
Debtors Turnover Ratio	49.28	43.08	48.27	50.09	45.43
Number of Days In Working Capital	76.69	86.32	76.21	71.94	69.05
Operating Profit Margin (%)	12.43	15.58	14.89	14.94	14.45

Table. 1 Financial Ratios

Company II	Mar '14	Mar '13	Mar '12	Mar '11	Mar '10
Current Ratio	0.86	0.79	0.81	0.83	0.8
Quick Ratio	1.3	1.24	1.28	1.36	1.54
Inventory Turnover Ratio	4.3	3.28	3.47	3.07	3.37
Debtors Turnover Ratio	4.96	4.84	5.34	4.71	3.67
Number of Days In Working Capital	115.78	139.25	136.22	161.51	163.88
Operating Profit Margin (%)	8.47	8.24	8.63	7.77	8.46

Table. 2 Financial Ratios

The present study is about Working Capital Management and hence Current Ratio, Quick Ratio, Inventory Turnover Ratio, Debtors Turnover Ratio and Number of Days in Working Capital along with Operating Profit Margin were taken.

Current Ratio

This ratio is mainly used to give an idea of the firms' ability to pay its short-term obligations (Creditors, O/D, etc.) with its short-term assets (Cash, Stock, Debtors, etc.). The higher the current ratio, the more capable the company is of paying its obligations. A ratio under 1 suggests that the company would be unable to pay off its obligations if they came due at that point. While this shows the company is not in good financial health, it does not necessarily mean that it will go bankrupt - as there are many ways to access financing - but it is definitely not a good sign.

Table 1 shows that the company is maintaining its Current Ratio at around 1.94 (Average) consistently in the last four years and also that the Current Ratio trend is increasing which signifies the strong liquidity position of the company. Table 2 depicts that the company' Current Ratio is 0.82 (Average) and less than 1 which is not a good sign and hence the company's liquidity position is weak and at risk.

Quick Ratio

This ratio is an indicator of a firms' short-term liquidity. It measures a firm's ability to meet its short-term obligations with its most liquid assets. For this reason, the ratio excludes stock from current assets.

Table 1 portrays that the Company is maintaining its Quick Ratio at around 0.80 (Average) continuously and to some extent it is acceptable but the ideal ratio of Quick Assets to Current Liability is 1. Table 2 reveals that the Company's Quick Ratio is around 1.34 (Average) and it is more than the ideal ratio. The short term liquidity position of the firm is more than required. It shows that the firm is keeping more cash equivalent assets than stock.

Inventory/Stock Turnover Ratio

The ratio indicates how fast the stock is sold. Stock Turnover ratio is calculated by dividing the cost of goods sold by average stock. Average Inventory Turnover Ratio in case of Company I is 3.962 and Company II is 3.498. Hence, Company II is in a better position.

Debtors Turnover Ratio

This Ratio indicates the speed at which the debtors are converted into cash. This is obtained by dividing the Net credit sales by Debtors. A high ratio means shorter time

lag between credit sales and cash collection. At the same time a low ratio means that debts are not been collected rapidly.

Debtors Turnover Ratio in case of Company I is 47.23 (Average) and Company II is 4.70 (Average). Company I is having a very high ratio when compared to Company II.

Number of Days in Working Capital

It is a term used to express how many days a firm takes to convert its working capital into revenue. When utilizing any ratio, it is important to consider how this firm has evolved over time and how it compares to similar firms in the same industry. By comparing this ratio in a historical and relative basis, firm will get a better understanding of how efficient it actually is.

It takes, for Company I, averagely 76.042 days to convert its Working Capital to Revenue whereas Company II takes 143.328 days averagely to convert its Working Capital to Revenue

Operating Profit / Income Margin

Operating margin is a measurement of what percentage of a firm's revenue is left over after paying for variable costs of production such as wages, raw materials, etc. A healthy operating profit margin is required for a company to be able to pay for its fixed costs, such as interest on debt. It gives an idea of how much a firm makes (before interest and taxes) on each rupee of sales.

Company I yields 14.458% (Average) Operating Profit per year where as Company II earns 8.314% (Average) Operating Profit per year.

Correlation Analysis

Correlation Analysis is a powerful tool in knowing the relationship between two variables. The present study adopted Karl Pearson Correlation Analysis for determining relationship between variables.

Current Ratio (CR), Inventory Turnover Ratio (ITOR) and Debtors Turnover Ratio (DTOR) are inversely related to Operating Profit (OP). Days Sales Outstanding (DSO) is positively correlated with Operating Profit. Days Inventory Outstanding (DIO) is significantly related to Current Ratio. Days in Working Capital (DIWC) is also significantly related with Current Ratio. The Correlation Analysis I also reveals that Quick Ratio (QR) is significantly related to Days in Working Capital, Days Inventory Outstanding and Days Sales Outstanding. The relationship between Days in Working Capital is highly correlated to Days Inventory Outstanding. Days Sales Outstanding is also positively correlated to Days in Working Capital and Days Inventory Outstanding.

None of the variables in Working Capital Management is significantly related to Operating Profit of the company except Days Sales Outstanding and Quick Ratio.

	OP	CR	QR	ITOR	DTOR	DIWC	DIO	DSO
OP	1							
CR	-0.115	1						
QR	0.362	0.385	1					
ITOR	-0.155	-0.777	-0.498	1				
DTOR	-0.497	0.276	-0.528	0.332	1			
DIWC	0.265	0.671	0.751	-0.940	-0.528	1		
DIO	0.183	0.739	0.510	-0.998	-0.387	0.949	1	
DSO	0.506	-0.251	0.525	-0.361	-0.999	0.549	0.416	1

Table. 3 Correlation Analysis - I

	OP	CR	QR	ITOR	DTOR	DIWC	DIO	DSO
OP	1							
CR	-0.082	1						
QR	0.003	-0.135	1					
ITOR	0.549	0.710	-0.192	1				
DTOR	0.092	0.297	-0.914	0.244	1			
DIWC	-0.494	-0.516	0.685	-0.838	-0.671	1		
DIO	-0.625	-0.649	0.182	-0.996	-0.237	0.840	1	
DSO	0.478	0.589	-0.621	0.887	0.616	-0.994	-0.883	1

Table. 4 Correlation Analysis - II

Inventory Turnover Ratio is positively correlated with Operating Profit suggesting that increase in Inventory Turnover Ratio will increase the Operating Profit. Days Sales Outstanding is also positively correlated with Operating Profit. Current Ratio is significantly related to Inventory Turnover Ratio and Days Sales Outstanding. Days in Working Capital is significantly related to Quick Ratio. Days Sales Outstanding is also significantly related to Inventory Turnover Ratio and Debtors Turnover Ratio. There is hardly any relationship between Operating Profit and Current Ratio which shows that the current assets consists of relatively low stock compared to cash and its equivalent.

The above Correlation Analysis for both the companies reveals that a firm's receivables management policy is affected by its inventory outstanding and sales outstanding. Thus, a firm aiming at increasing its short term financial efficiency shall

try to reduce its inventory outstanding and sales outstanding days.

It also reveals that a firm's short term financial efficiency is not that much directly related to Operating Profit since there may be several other factors peculiar to the particular industry affecting its profitability especially operating profit.

It is also inferred from the analysis that same analysis carried out for two similar firms in the industry gives contrasting results. Hence, the researcher could not arrive at a concrete conclusion with regard to the relationship between Working Capital Management and Profitability of the firms.

Conclusion and Suggestions

Company I is maintaining required/ideal Current Ratio whereas Company II's Current Ratio is less than 1. Hence, Company II has to increase its Current Ratio.

Company I's Liquidity Ratio is also good to some extent and Company II's Liquidity Ratio is more than required/ideal Quick Ratio. Hence, Company II has to decrease its Cash/Cash Equivalent Assets and Increase its Inventory Level so as to increase the Current Ratio.

Company I's Debtors Turnover Ratio is quite high when compared to Company II. Hence, Company II has to shorten its collection period.

In case of Conversion of Working Capital into Revenue, Company I is fairly doing well when compared to Company II. Company II has to take initiatives to reduce the conversion period.

Operating Profit of Company I is fairly better when compared to Company II. Hence, Company II should focus increasing the Operating Profit by increasing sales and decreasing the operating expenses.

The Correlation Analysis of Company I reveals that the Current Ratio, Inventory Turnover Ratio and Debtors Turnover Ratio are inversely related to Operating Profit. Days Sales Outstanding is positively correlated with Operating Profit. Days Inventory Outstanding is significantly related to Current Ratio. Days in Working Capital is also significantly related with Current Ratio. The Correlation Analysis I also reveals that Quick Ratio is significantly related to Days in Working Capital, Days Inventory Outstanding and Days Sales Outstanding. The relationship between Days in Working Capital is highly correlated to Days Inventory Outstanding. Days Sales Outstanding is also positively correlated to Days in Working Capital and Days Inventory Outstanding.

None of the variables in Working Capital Management is significantly related to Operating Profit of the company except Days Sales Outstanding and Quick Ratio.

As for Company II, the Correlation Analysis reveals that the Inventory Turnover Ratio is positively correlated with Operating Profit suggesting that increase in Inventory Turnover Ratio will increase the Operating Profit. Days Sales Outstanding is also positively correlated with Operating Profit. Current Ratio is significantly related to Inventory Turnover Ratio and Days Sales Outstanding. Days in Working Capital is significantly related to Quick Ratio. Days Sales Outstanding is also significantly related to Inventory Turnover Ratio and Debtors Turnover Ratio. There is hardly any relationship between Operating Profit and Current Ratio which shows that the current assets consists of relatively low stock compared to cash and its equivalent.

The above Correlation Analysis results of both the companies signify that a firm's receivables management policy is affected by its inventory outstanding and sales outstanding. Thus, a firm aiming at increasing its short term financial efficiency shall try to reduce its inventory outstanding and sales outstanding days.

It also reveals that a firm's short term financial efficiency is not that much directly related to Operating Profit since there may be several other factors peculiar to the particular industry affecting its profitability especially operating profit.

It is also inferred from the analysis that same analysis carried out for two similar firms in the industry gives contrasting results.

Hence, the researchers could not arrive at a concrete conclusion with regard to the relationship between Working Capital Management and Profitability of the firms with the Analysis of Five Years Financial Statements.

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Role of NPTEL for e-Learning

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Abstract

This Paper highlight the features of NPTEL (National Programme on Technology Enhanced Learning). There are a large number of open online courses available in India and abroad. Massive open online courses (MOOCs) are revolutionizing the field of higher education by giving a new learning opportunity for aspiring students, faculty of colleges / universities. This article particularly define the NPTEL online courses on Engineering communities, Management and Science & Humanities. The web courses and video courses which are downloadable format and also it provides the services and benefits of the NPTEL e-learning programme.

Keywords: NPTEL, online courses, open coursewares.

Introduction

Technology is the lifeline of online education and the acceptance of technology by both the students and faculty plays a crucial role in it success (Gibson, 2008). There are many open coursewares available in the universe. To improve the quality of higher education in India, IIT, Madras has come up with an initiative called NPTEL. As per this initiative, all the IITs, along with IISc Bangalore would come up with a series of lectures across all the streams of science and engineering. These videos are being used by several institutes as part of their programmes. This initiative has gained wide popularity in India and the lectures are being used by several engineering students from across India. In India, the Ministry of Human Resources Development, Government of India taking initiatives for the online courses to develop the higher education particularly for Rural areas. In Indian Institute of Technology Madras (IITM) or IIT-M is an autonomous public engineering and research institution founded in 1959 with technical and financial assistance from Government of the former west Germany. Open coursewares and online courses are the latest time saving method for the students. To aid the rapid growth of higher education, institutes today are gravitating towards the options of online education.

NPTEL

NPTEL is one of the best open coursewares in India. There are 982 institutional members in NPTEL programme. It provides webcourses and video courses. Bothe the courses free and easy downloadable from the NPTEL website. It provides services to three category that is Government funded / Aided institutions / Government Agencies/ Government Enterprises / private Institutions secondary corporate sectors and individuals. There are more than 1000 courses proposed by the Institute. Among these Engineering courses, social science and Management. Online course instructors also have to focus on the scope of student interaction. Teacher-Student interactions have traditionally been validated more than peer interaction in a learning however, learners are affected by the discussions and classroom conversations with their peers' (Bober & Dennen, 2001). Online course instructors also have to focus on the scope of student interaction.

Services of NPTEL

NPTEL extends its services to all the Enginnering colleges, Arts colleges and Management institutes.

- Online video courses through youtube

- Online courses and video lectures , web courses study material provides through Internet

- Downloading of video courses and web courses in the 8Tb Hard disk

NPTEL Study Centres

IIT Madras to develop the online courses in Rural & Urban introduced NPTEL study centres. All the institutions including Governmental, Aided institutions and self financing organizations those who are interested to establish study centre they may apply to IIT,Chennai NPTEL Web studio.

Requirements

To establish NPTEL, the following requirements need to be fulfilled by the study centre.

- The college should obtain the contents created under NPTEL by sending 8TB of external hard disk to Madras who will copy the contents free of cost that can be

made available on the college's LAN for the benefit and easy access of the faculty and students there.

- There should be a single point of contact (SPOC) in concerned college, who could be a faculty member, librarian or any other staff members interested / nominated to interface between NPTEL and the college.

Computer and Headphone

To establish the study centre, sufficient computer facility need to be provided with Internet facility with a minimum speed of 1 GB speed is required. Head phone facility to be provided to all the computer systems. It is essential for individual concentration and attention.

Responsibilities of the SPOC are

- He / She will be the brand ambassador of NPTEL in the college

- He / She will be kept informed of all the initiatives of NPTEL which he / she should publicise amongst the Students and faculty of the college

- Brouchers / Posters of NPTEL content will be sent to him/her, who should ensure that they are displayed at the places frequented by faculty/students of the college to get maximum visibility

- If emails about the activities/updates are sent to the SPOC, he / should forward them to the concerned persons

- Ensure that content in the college is up to date by sending hard disks to NPTEL on a regular basis for updation

Role of the SPOC in online certification courses offered by NPTEL.

- The SPOC should publicize the online certification courses amongst the students and inform them about the courses being offered currently

- He / she should encourage students to enroll in these courses

- He / she should identify faculty members who can act as mentors for the enrolled students who can encourage them to be active in the course, submit the assignments on time and register for the examinations.

- He / she should talk to faculty members and students across departments and give suggestions to NPTEL regarding the courses they wish to see offered and in which time frame (Jan-Mar or July-Sep)

- He / She should aid the students in registering for the certification exam by assisting with the online exam registration process, if necessary.

- Ensure that students enrolled in online certification courses have access to the content for studying and to computer systems so that can complete their assignments

As the SPOC of the concerned college, should do the following:

Go to http://nptel.ac.in/studycentre and login using the SPOC id mentioned by their institute(which should be a google account) and update the college details, also their profile details

Next Steps for the SPOC:

(i) He should publicise these courses among the students and the faculty members of the respective departments

(ii) collect the list of students who wish to enroll in the various courses and also get the names and email id's of the faculty who would act as mentors for the courses

(iii) On the NPTEL study centre web page, kindly upload the details of students who wish to enroll in earch course (in the format-Name, email id, mobile number, SC/ST (Y/N) along with the details of the mentor, if any, for the course

(iv) Inform the students to go to https://onlinecourses.nptel.ac.in and enroll in the courses they wish to join.

Focus

NPTEL focuses on the Engineering, Arts and science colleges Managements Institutions in order to reach the higher education through online learning method throught the country. It provides certificate courses related to Physics, Chemistry, Biochemistry, Biotechnology, Nanotechnology, Computer Science and Management subjects apart from engineering subjects. NPTEL provides individual course certificate for the students. Special features of the NPTEL courses are that it can be completed in addition to the regular courses of university / college.

Advantages of NPTEL

- NPTEL Provides online courses to all the user community

- It provides individual course certificate

- Large No of courses available

- Individual attention in study centre

- Subject mentors will help during the course period

- Teaching by subject experts

- Subject experts from different parts of the country may enroll / take part of teaching

- Option will be provided to Subject experts to upload their study material in website

- Scholarship facility available

- These courses will be completed within the period of their regular courses in the university / College

- Audio and video lectures feel the class Room climate

- Student may interact with the faculty & Mentors will interact with the faculty

- Concentration of subject due to Headphone provision

Conclusion

The Major challenge in front of Indian institutes is availability and adoption of reliable broadband Internet connectivity, especially in rural India. If institutions Government or private can work around this challenge, the online learning module opens up a whole new area of educational revolution that can make education more accessible and relevant to the current technological needs. The government / private institutions may take initiatives to implement the NPTEL online courses which will help the student and faculty. Initiative is the important key factor for each and every development of a particular concern. Awareness of online certificate courses not enough present situation because lot of rural students awaiting for these type of courses. If the ministry of Human Resources Development may assist in financially to the rural Institutions the online learning education will bring revolution among the rural students.

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An Overview of Internet Usage and Awarness of Open Resources of CBSE School Students in Dubai

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Abstract

The purpose of using internet has increased among the school students but the purpose varies from student to student like academic sources, social networks and entertainment. Life without internet cannot be imagined. Electronic gadgets are playing a vital role among them Open Educational Resources are available at free of cost. This study aims to find out the avenues of students using internet, devices that they are using to browse and the awareness level of Open Educational Resources and the most preferred search engine.

Keywords: Internet, Open Resources, Search Engine.

Introduction

The world of Education has been changed simply by deep impact of internet. Revolutionizing the way education is imparted, the classrooms have been brought right in the homes of the students. Without any doubt, the internet is the modern engine of progress and has had a far more invasive effect on our education. There is a fresh approach with online education. Hats off to the world of internet that our Information Superhighway along with personal computers is fast transforming the world. The impact of Internet on education can be felt in homes, schools, colleges, universities, with information available at lightning speed. Today a vast amount of information is available at just a click of the mouse. Students and teachers are using a large number of learning tools.

The idea of open educational resources (OER) has numerous working definitions. The term was firstly coined at UNESCO's 2002 Forum on Open Courseware and

designates *teaching, learning and research materials in any medium, digital or otherwise, that reside in the public domain or have been released under an open license that permits no-cost access, use, adaptation and redistribution by others with no or limited restrictions. Open licensing is built within the existing framework of intellectual property rights as defined by relevant international conventions and respects the authorship of the work.* **Flora Hewlett Foundation** defines OER as *teaching, learning, and research resources that reside in the public domain or have been released under an intellectual property license that permits their free use and re-purposing by others. Open educational resources include full courses, course materials, modules, textbooks, streaming videos, tests, software, and any other tools, materials, or techniques used to support access to knowledge.*

Education System in Dubai

The educational system in Dubai is a four-tier system covering fourteen years of education, from the primary to the secondary. It is highly notable that the primary and the secondary education are offered free for every citizen of UAE. The Ministry of Education of the UAE government works closely on the educational policies, syllabus and studies performed in every institution at all levels.

Students, after completing their primary education are generally admitted to the secondary or high schools for further education. A number of international schools are also a part of Dubai. They follow syllabi ranging from the Indian CBSE to the British Cambridge system. The students have to spend three years in secondary school.

Objectives of the Study

1. To find out avenues through which the students get access to internet.

2. To find out the various purposes of using internet by the respondents.

3. To identify the most preferred search engine.

4. To examine the level of awareness of Open Resources

5. To suggest the ways and means to maximize the usage of open resources

Limitations

Time is the major constrain and, hence the study is limited to five Higher Secondary schools out of fifteen in Dubai affiliated with CBSE. The sample has been collected from students of Grade 11 and 12 only.

Review of Leterature

In her study *Use and awareness of Open Access E-Resources among academicians in India* Jomy Jose from Kerela, says that only 19.16 respondents uses different kind of E-resources when necessary, 21.96 use them occasionally and 58.88 use the E-Resources often. Sandhya Milind Khedekara and Sunita Magre from India found that there is significance difference in the level of Awareness and Academic Performance of SSC and CBSE school students; it is higher in CBSE school students than SSC school students. Siddiqui M.A., Abraham Jessy and Khan Mohsin Ali (2009) intended to study the availability and use of Information and Communication Technology (ICT) in schools in Delhi. The major findings were availability of software and hardware facilities was not very good, there should be more software for teaching purposes and there should be more periods allocated for computers at all levels. Ton, Mooij., Ed Smeets. (2000) studied the use of Information and Communication Technology (ICT) in education. Finally, educational and policy support actions to the ICT transformation process in school are presented in a structured way. The results are worthwhile for school practice and national policies, but they also need further underpinning and validation through research in other schools.

Analysis and Findings

Table 1 shows the list of schools under the study and there are 98 Male respondents and 86 Female respondents taken part in the study. Delhi Private School, Dubai stands with the maximum number of respondents with 39 male and 30 female respondents.

S.No	Name of the School	No. of Male Respondents	No. of Female Respondents	Total
1	Buds Public School	11	9	20
2	Crescent English School	14	18	32
3	Delhi Private School	39	30	69
4	The Elite English School	17	13	30
5	Gulf Model School	17	16	33

Table. 1 Schools under Study

Table 2 describes that among the population 48.9% of them belong to Mathematics group, 32.9% of them are of Science group and 18.5% of them are from Commerce group. It shows that the maximum percentage of students prefers to go for Mathematics stream with other science subjects so that they have varied options to choose after their schooling.

Group	No. of Respondents	Percent	Valid Percent
Mathematics	90	48.9	48.9
Science	60	32.6	32.6
Commerce	34	18.5	18.5
Total	**184**	**100.0**	**100.0**

Table. 2 Respondents Group Wise

Table 3 shows that male students 52.2% and the female students are 47.8%. With a very menial difference of 4.4% the male students are dominating the female in the participating schools.

Gender	No. of Respondents	Percent	Valid Percent
Male	96	52.2	52.2
Female	88	47.8	47.8
Total	**184**	**100.0**	**100.0**

Table. 3 Respondents Gender Wise

Table 4 describes the response of students when asked they were asked whether they are satisfied with the number of Computer terminals with internet facility in the library there are about 60.3% of them strongly disagree with the statement. A very less percentage of students (3.8%) said that they disagree and about 17.4% of them were not able to decide on this and about 18.5% of the respondents feel and agree that the school library has enough computer terminals with internet facility.

Description	No. of Respondents	Percent	Valid Percent
Strongly disagree	111	60.3	60.3
Disagree	7	3.8	3.8
Undecided	32	17.4	17.4
Agree	34	18.5	18.5
Total	184	100.0	100.0

Table. 4 Availability of Computer Terminals with Internet Facility in Library

The students were asked to respond about the availability of e-resources in their library. The above Table 5 shows that the majority percentage of students i.e 82.1% of them strongly disagree and saying that their library do not have any e-resources and 17.9% of them were not able to decide on this area. So we come to understand that the school libraries do not give importance to the e-resources and hence they don't subscribe or not showing interest on available free e-resources.

Description	No. of Respondents	Percent	Valid Percent
Strongly disagree	151	82.1	82.1
Undecided	33	17.9	17.9
Total	184	100.0	100.0

Table. 5 Availability of e-Resources

Table 6 shows that 100% of the respondents use internet at home and about 17.9% of them use internet at school library and 14.1% of them use at computer laboratory of school besides using at home. With the available date we come to know that all the students in the participating schools have computers with internet facility at home.

Avenues	yes	Percentage	No	Percentage
Home	184	100.0	0	0
School Library	33	17.9	151	82.1
Computer Laboratory	26	14.1	158	85.9
Cyber Café	0	0	184	100.0
Friends Home	0	0	184	100.0
Other Places	0	0	184	100.0

Table. 6 Avenues of Using Internet

Table 7 picturize that a high percentage of students i.e 88% of them use the internet everyday and 7.6% of them uses internet two times in a week and only 4.3% of them uses internet rarely that is once in a week. It given us the idea that internet has become very vital in students life like they use any other commodity.

Description	No. of Respondents	Percent	Valid Percent
Every day	162	88.0	88.0
Twice in a week	14	7.6	7.6
Once in a week	8	4.3	4.3
Total	184	100.0	100.0

Table. 7 Frequency of using NET

Through the given Table 8 we come to know that a high percentage of students i.e about 92.4% of them browse internet using their laptop and 62.5% of them uses Mobile phones besides other devices like lap top or desktop computers. There are about 27.5% of them uses I-pad and 14.1% of them uses desktop computers to browse internet. Dubai is a place that we get electronic gadgets at a reasonable price and parents of the students are affordable to get gadgets like this to their wards.

Description	No. of Respondents	Percent	Valid Percent
Desktop Computer	26	14.1	14.1
Laptop	170	92.4	92.4
i-pod	47	27.5	27.5
Mobile	115	62.5	62.5

Table. 8 Devices used to browse internet

Open Resources	Aware	Percentage	Unaware	Percentage
NCERT	160	87.0	24	13.0
KHAN	25	13.6	159	86.4
NORER	25	13.6	159	86.4
NOTEMONK	25	13.6	159	86.4

Table. 9 Awareness Level of Open Resources

Table 10 states that 87% of respondents are aware of NCERT open resource 13.6% of them are aware of the other open resources like KHAN Academy, NORER and NOTEMONK. When some of them were personally questioned by the researcher about the usage of the above open resource, they responded that they are just aware of them but not aware of the usage part of it lack of guidance and encouragement by the teachers.

Search Engine	No. of Respondents	Percent	Valid Percent
Google	182	98.9	98.9
MSN	3	1.6	1.6
Yahoo	13	7.1	7.1
Bing	0	0	0

Table. 10 Pregferred Search Engine

Study shows that Google is the most preferred search engine which tops with 98.9% of the respondents followed by Yahoo with 7.1% and MSN with 1.6% and none of the respondents uses Bing for their search according to the above Table No 10.

Table 11 is a Cross-tabulation between the Grade of students versus purposes of using internet. It shows that 83% of Grade XI students uses internet for E-mails and communication purpose and high level of 86.3% students of Grade XII uses for similar purpose. 73% from Grade XI and 75.3% from Grade XII uses internet for browsing Social Networks. 66.7% from Grade XI and 67.1% from Grade XII are having a good time of entertainment in the world wide web and 64.9% of Grade XI and 58.9% from XII are downloading resources/videos/animations from the net.

Only 24.3% of Grade XI students and 23.3% of Grade XII students are actually using internet for Education purpose. It is a very discouraging percentage that uses internet for Education purpose. Lack awareness and proper guidance are said to be the reasons. More than that they students are mainly depend upon their prescribed textbooks and other work sheets given by the teachers are the main reasons that was found out through the personal encounter with the teachers of the school.

Purpose	Grade XI (out of 111)				Grade XII (out of 73)			
	Yes	Percent	No	Percent	Yes	Percent	No	Percent
Education	27	24.3%	84	75.7%	17	23.3%	56	76.7%
Social Network	81	73.0%	30	27.0%	55	75.3%	18	24.7%
Downloading Resources	72	64.9%	39	35.1%	43	58.9%	30	41.1%
e-mails & Communication	93	83.8%	18	16.2%	63	86.3%	10	13.7%
Entertainment	74	66.7%	37	33.3%	49	67.1%	24	32.9%

Table. 11 Purposes of using internet - Cross Tabulation

Suggestions and Conclusion

1. The schools libraries may increase the number of computers in the library premises with proper internet connections for students to browse for related information during their library classes.

2. CBSE authorities may organize refresher courses for the affiliated school librarians/Teachers about the usefulness of Open Resources.

3. The librarians/Teachers in turn may arrange orientation to the students about the

effectiveness of the Open Resources. This will encourage the students to use them for their educational purposes.

Educational resources developed in an open environment can be vetted and improved by a broad community of educators resulting in materials that represent what the educational community sees as most valuable. By providing educators with new access to educational material, open resources have the potential to spur pedagogical innovation, introducing new alternatives for effective teaching. OER have the potential to expose students and instructors to the long tail of content,

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Relationship Between Selected Psychological Variable and Achievement of High School Students

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Abstract

All parts of the world is connected through web, because of the rapid development in science and technology. Specifically, in the field of education, competition rapidly increases among the students. To survive, educational achievement is necessary and compulsory to all and for good educational achievement, anxiety free, a positive environment is also essential. Anxiety is one of the selected psychological variables which is a deliberating factor and has impact on students' achievement. In this research work, the investigators have made an attempt to investigate the gender difference in relation to anxiety and achievement of the students of high school level students. The correlation between anxiety and achievement has also been found. A sample of 800 (432 boys and 368 girls) of secondary level students of class IX were selected randomly. Analyzing the data, the result shows that girls students has more academic anxiety than boys. It was also found that there is a negative and significant correlation (r= -0.10) between academic anxiety and academic achievement.

Keywords: Anxiety, Achievement.

Introduction

Education is one of the best processes of development. In this century, everywhere in educational field, there is a race, a tuff competition. To survive in this competition, students always feel some pressure and tension in their academic field as the academic achievement is important for taking decision in future life. This type of pressure and tension in academic field create uncontrollable nervousness, stress, and fear among

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students, called academic anxiety (Encyclopedia of Children's health). With other types of anxiety, a little quantity of academic anxiety is normal for the students but when it extreme, adrenal gland become more active and a biochemical change starts in body and mind. As a result of academic anxiety in students creates psycho-physiological situation such as headache, hypertension, insomnia and other conditions. On the other hand academic achievement could be defined as the capability of reading, writing and mathematical functioning. Thus for good academic achievement, stress free learning is necessary. Both parents and teachers agree that there is lot of pressure on students in the way (standardized testing) of their academic achievement. A notable academic anxiety always creates negative environment for the students. So there will be some relation between academic anxiety and academic achievement.

Anxiety and Achievement

Anxiety is complicated psychological situations which have an effect on cognitive, behavioral and psychological states. Anxiety disorders are common mental health conditions among all children in almost every field of their life specially in the academic field. Anxiety can be classified into three sections in which academic anxiety is situation-specific form of anxiety related to academic circumstances. Test anxiety, any particular subject's anxiety, and any type of institutional related anxiety, all are included to academic anxiety. From very beginning of children's education, they are trained to acquire more knowledge and high scores in academic field. To achieve the target, students are bound to carry extra educational load compare to their age. This type of pressure creates psychological stress on them. As a result they feel anxious in academic field in the form of panic, helpless, hypertension and mental disorganization.

Anxiety leads to academic difficulties through irrelevant thoughts, preoccupation and reduce attention and concentration (Eysenck, 2001). In present education system, academic achievement is the students' performance in School, measured by grade reports, teachers' observation and self-perception. It is outcome of the education and determine the level to which a student or institution can achieve their educational goals. In secondary level, a high academic achievement is necessary for the students as it will decide their further better educational scope and future life. Academic achievement indicates the knowledge and skill of a student acquire in school subjects. Crow and Crow (1969) define academic achievement by the quantity to which a learner is profiting from instruction in a given learning area. Academic achievement defined by Kohli (1975) is the degree of skill in academic work or attained knowledge in school subjects which generally represented by percentage of marks.

Achievement stands for intellectual growth and the capacity to take part in construction of knowledge at its best (Ladson, 1999). From these definitions it can

be concluded that academic achievement in student's life is Educational Growth. From research in academic field, researchers indicate that success in academic achievement increases the self-confidence and self-esteem of the students. So, for success in academic achievement it is necessary to provide the students a positive Environment but academic anxiety opposes this situation. Due to test anxiety students results poor at end of test which causes 'achievement stress' throughout their academic life (Cheek, Bradley, Reynolds and Roy 2002). When academic anxiety in the students is high, it interferes with concentration and memory which is critical for academic success. Toibas (1979) suggests that anxiety plays important role in students' learning and academic performance. Academic achievement of young pupil is hampered by anxiety (Reilly and Lewis, 1991, p.104). So, from the above conclusion of psychologists, researchers consider that there has some negative relation between Anxiety and Achievement.

Objectives of the Study

In the present research, the researchers performed their study to attain the following objectives:

- To find out the difference between academic anxiety scores of boys and girls students in secondary level.

- To find out the difference between academic achievement scores of boys and girls students in secondary level and

- To explore the relation between academic anxiety and academic achievement of students in secondary level.

Methodology of the Study

Population and Sample

All the students of high school level were the population of this study. In the present work, the investigators selected a sample of 800 (432 boys and 368 girls) students randomly from both the English and Tamil medium schools of Vellore district of Tamil Nadu. The sample group comprises of the students of class IX from different schools. The selection of samples is shown below in figure 1.

Tools Used

In the present research, the investigators used two psychological tests.

- Academic Anxiety Scale for pupil (AASC-SG) - prepared and standardized by A. K. Singh and A.Sengupta.

● Academic Achievement Test for pupil - a criterion test was developed and standardized by the investigators on all the subjects of class IX. The test was applied to the sample group by the researcher to collect scores.
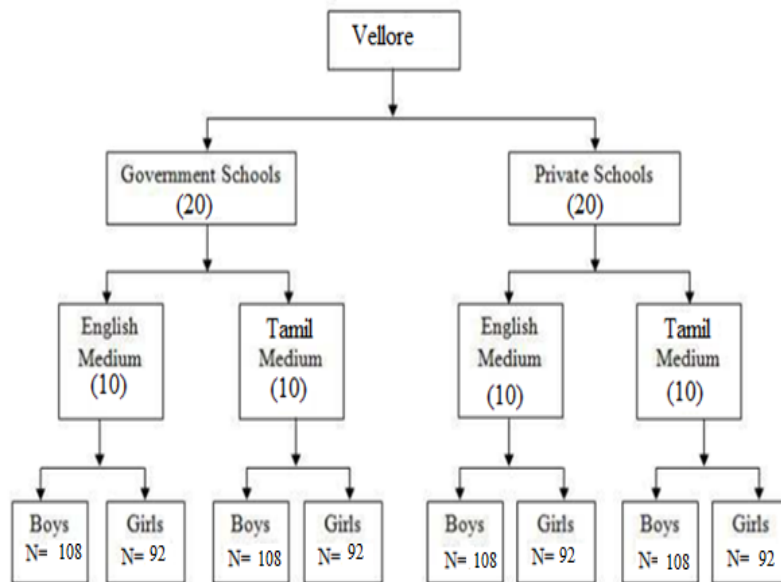

Figure. 1 Sample Design for the Present Study (Stratified Random Sampling)

Limitations

In the present study, the investigators selected their sample group from various high schools of Vellore Educational District in Tamil Nadu. The investigators further delimited the study within forty schools and sample group was comprised of 800 students including 432 boys and 368 girls from both Tamil and English medium high schools of Tamil Nadu Secondary Education Board.

Hypotheses

● There is no significant difference between anxiety scores of boys and girls students in high school level.

● There is no significant difference between achievement scores of boys and girls students in high school level.

Analysis and Interpretation

The investigators applied and analyzed the collected data through descriptive and inferential statistics. The descriptive statistics is as follows:

	Gender	N	Mean	S.D.	S.E. of Mean
Anxiety	Boys	432	11.45	2.24	0.11
	Girls	368	11.96	3.13	0.16
Achievement	Boys	432	846.23	72.13	3.47
	Girls	368	875.92	69.76	3.63

Table. 1 Descriptive statistics of the collected data on Academic Anxiety and Academic Achievement

In case of academic achievement, mean score of girls is higher than boys. In both cases, the difference of mean and standard deviation is very close to each other. On the other hand, the academic achievement of boys and girls is up to the satisfactory level in respect to their mean score.

		Academic Achievement	Academic Achievement
Academic Anxiety	Pearson's Correlation	1.00	−0.10
	Sig (2-tailed)		0.12
	N	800	800
Academic Achievement	Pearson's Correlation	−0.10	1.00
	Sig (2-tailed)	0.12	
	N	800	800

Table. 2 Correlation between Academic Anxiety and Academic Achievement

From Table 2, the correlation between academic anxiety and academic achievement is - 0.10. This in-turn implies that there is negative relationship between academic anxiety and academic achievement. Here the correlation is not significant, as p-value 0.12 which is higher than 0.01 level (for 2-tailed). Thus, it is concluded that there is no significant correlation between academic anxiety and academic achievement.

Conclusion

Academic Anxiety is a hindrance factor of Academic Achievement. High academic anxiety reduces the efforts and motivation of the students in case of academic achievement. But a little amount of academic anxiety is possible to exist in students. The study also indicates that academic anxiety and academic achievement is negatively correlated. The correlation is very low which indicates that the negative correlation is not statistically significant. Thus the academic anxiety does not impact much on students' academic achievement.

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