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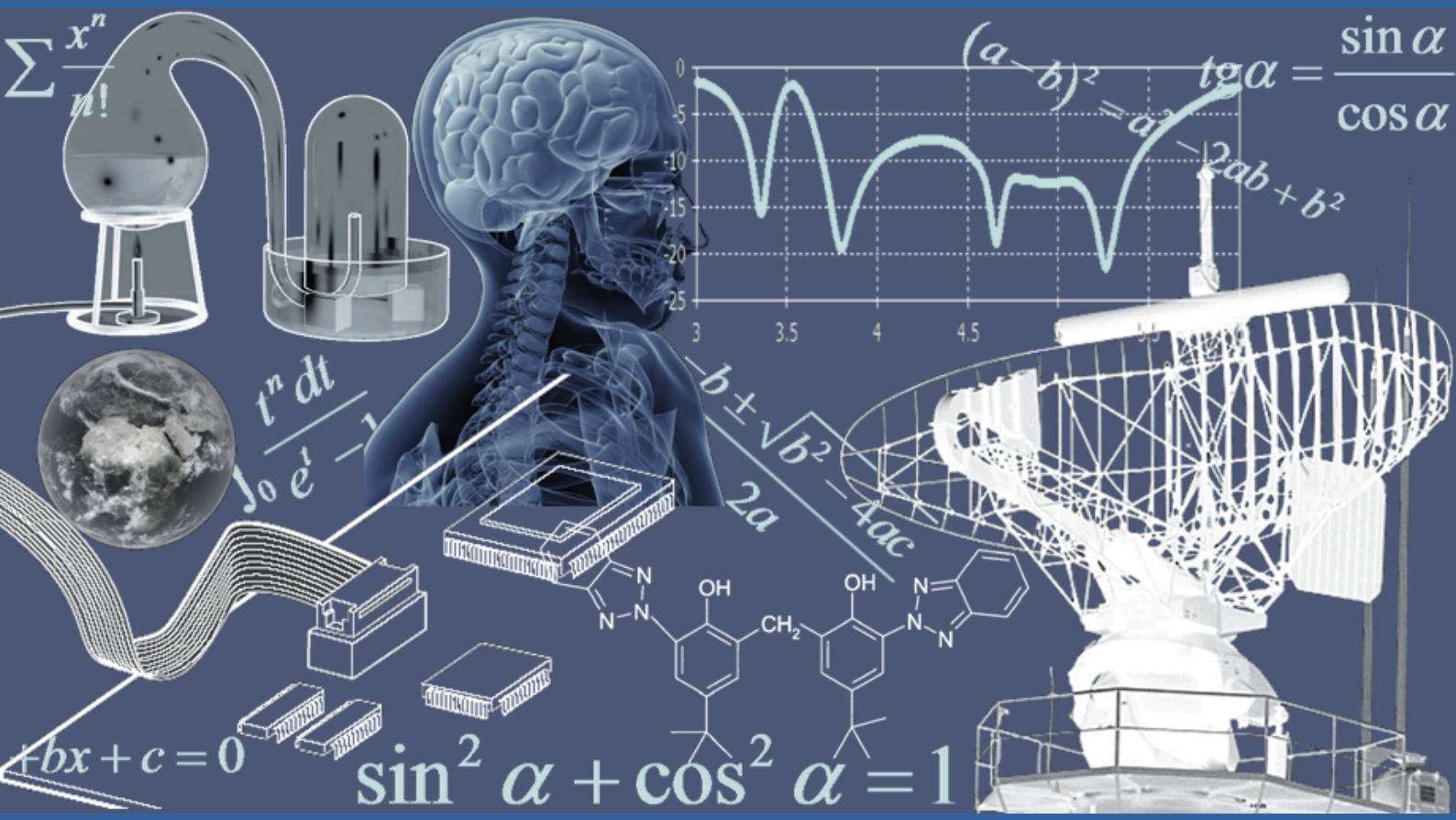

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A Lifetime Extension Protocol for Data Gathering in Wireless Sensor Networks

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ABSTRACT: Wireless Sensor Network (WSN) is a collection of large number of tiny sensor nodes that are deployed to monitor the physical environment such temperature, humidity, etc. The sensor readings must be routed to the base station and then to the end-user. These sensor nodes have limited capabilities, especially the energy reserve, the processing ability and the memory storage. So, the routing protocols design for this kind of networks is a crucial challenge. Since these routing protocols should be simple, energy-efficient, and robust to operate with a very large number of nodes. They should also be auto-configurable to node failures and changes of the network topology dynamically. This paper presents a new algorithm for gathering data in WSN based on chain forming using greedy algorithm. It focuses on equitably distributing the energy load over the whole network nodes. To avoid fast node dying, the leader role is better distributed over nodes based on their required energies to transmit to the sink. Thus, the entire network nodes would have the same lifetime and then as result, the network lifetime would be extended. We have conducted simulation-based evaluations to illustrate the performance of the proposed technique. The simulation results show that this algorithm allows network stability extension compared to the most known chaining algorithm.

KEYWORDS: Wireless Sensor Networks, Data Gathering, PEGASIS, Greedy algorithm, Network lifetime.

1 INTRODUCTION

A Wireless Sensor Network (WSN) is a collection of tiny, lightweight and inexpensive sensor nodes deployed in large numbers to monitor the surrounding conditions [1]. These WSN have diverse application domains such as environmental survey, smart home, medical and agriculture monitoring. Since they have small size, the available energy at each sensor nodes is considered as the major constraint. Hence energy consumption is the important criteria for designing protocols for this kind of networks [2], [3]. Some of the early works on WSNs have discussed the benefits of WSNs in detail [4], [5], [6]. WSN have main advantages over the conventional networks deployed for the same purpose such as greater coverage, accuracy, reliability and all of the above at a possibly lower cost. In the last few years a variety of protocols have been proposed for prolonging the WSN duration service when routing the collected data to the sink. Most of the protocols can be classified as either flat or hierarchical based. In a densely deployed sensor network, the physical environment would generate very similar data in close-by sensor nodes and transmitting such data is more or less redundant. An event is often detected by more than one sensor and duplicated data is generated. This redundancy is often eliminated, which cannot only diminish the global data to be transmitted and localized most traffic within individual groups, but reduces the traffic and consequently, contention in a wireless sensor network. A way to reduce energy consumption is data aggregation, which consists of suppressing redundancy in different data messages. This data aggregation is the key idea for the most hierarchical routing protocols. In addition, scalability is one of the major design attributes of sensor networks. A single-tier network can lead the gateway to overload with the increase in sensors density. The main target of hierarchical routing is to efficiently maintain the energy consumption of sensor nodes by involving them in multi- hop communication within a particular cluster and by performing data aggregation and fusion in order to decrease the number of transmitted messages to the sink. Many research projects have explored hierarchical clustering in WSN from different perspectives. Some of the hierarchical

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protocols are LEACH [7], [8], PEGASIS [9], TEEN [10], [11], SEP [12], DEEC [13] and APTEEN [14]. LEACH is the first popular energy-efficient hierarchical clustering algorithm that was proposed for reducing power consumption. It uses clusters to prolong the life of the WSN where cluster-head (CH) collects the data from all nodes in its cluster, fuses and sends the information to BS. The CH uses an aggregation technique that combines the original data into a smaller size of data that carry only meaningful information to all individual sensors. Thus, LEACH reduces the number of nodes communicating directly with BS and allows better network lifetime extension. Lindsey et al. proposed PEGASIS [9] a chain- based protocol that minimizes the energy consumption at each sensor node. This protocol is considered as an optimization of the LEACH since that rather than classifying nodes in clusters, the algorithm forms chains of the sensor nodes. Based on this structure, each node transmits to and receives from only one closest node of its neighbors in the chain. PEGASIS organizes all sensors to form a data chain for data transmission and reception and each node take turns being the leader for communication to the base station. The algorithm starts data gathering from each endpoint of the chain and aggregated along the path to the designated leader node that transmits that data to the base station (BS)(e.g. see Fig. 1).

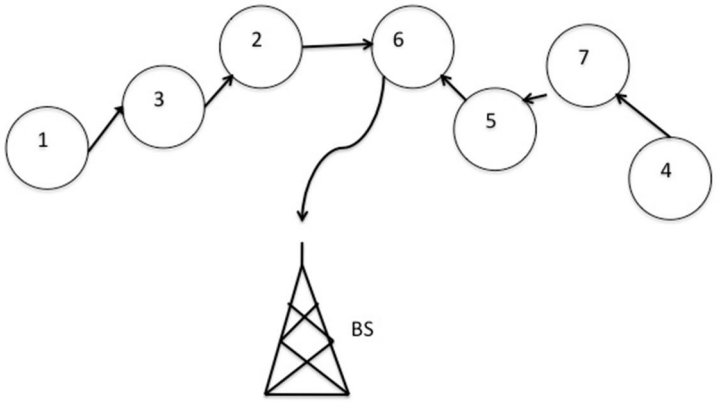

Fig. 1. Transmission chain used in PEGASIS

Thus, PEGASIS achieves reduction in energy consumption as compared to LEACH since it requires only one designated node to send the combined data to the base station. Unlike LEACH that uses hierarchical clustering, PEGASIS uses a flat topology that permits to avoid the overhead of dynamic cluster formation as in LEACH. For constructing the chain, network nodes use the greedy algorithm; each node selects the closest neighbor that is not chained yet and so as until all network nodes are chained. The greedy algorithm for constructing the chain is done before the first round of data transmission. To construct the chain, PEGASIS starts with the furthest node from the BS to make sure that nodes farther from the BS have close neighbors, since in the greedy algorithm the neighbor distances will augment gradually because nodes already on the chain cannot be revisited again. In data transmission phase, node can deplete its residual energy, and then the chain will be reconstructed in the same manner to avoid the dead node. Seetharam et al. [15] presented two techniques to enhance the PEGASIS technique; The first idea that was presented consists to allow each node to become leader for a number Xi = $(d^2_{Bref} / d^2_{Bi}).X_{ref}$, where d_{Bref} is a distance to BS reference, d_{Bi} is the distance between node *i* and the BS and X_{ref} is an arbitrary coefficient to overcome the error by X_i rounding to the nearest integer. The second idea is to use the ant colony optimization to form the network chain. For the first scheme no extension of the network lifetime is observed. A slit enhancement can be observed but not for the first node depletes its residual energy. As the first scheme, the second one presents a slit enhancement of the network lifetime. In this paper we present a new technique for routing data in order to extend the network lifetime. The main object is to equitably distribute the leader role among the network nodes. The remainder of the paper is arranged as follows. Section-2 provides the problem statement. The detail of the proposed technique has been discussed in section-3. Simulation parameters and results have been given in section-4. Based upon the simulation results, conclusions have been drawn and some recommendations for future work have been proposed in section-5.

2 PROBLEM STATEMENT

2.1 PROBLEM DEFINITION

In this work we are interested in WSN composed from N nodes. The major object of this work is to extend the network service duration until the first node in the network has its residual energy depleted which means that the node is failed to play its function in the network. We assume that this network has the features given bellow:

- The nodes are at first distributed randomly in the play field;
- The BS is fixed at a far distance from the sensor nodes;
- The sensor nodes are homogeneous and energy constrained with uniform energy;
- The nodes are able to adjust their transmission radius to reach their destination;
- No mobility of sensor nodes.

In this paper we consider that the data gathering is based on chain. So, all network nodes are organized in chain. At any transmission round, one chain node is elected as leader to collect data in the chain and transmit it to the BS. PEGASIS assumes that each node becomes leader for one transmission round and passes this role for another node. Thus, all network nodes would play leader role equitably. Since nodes in the chain consume different energy when playing leader role, a certain network nodes such as the farthest ones from the BS will die quickly. As idea it is important to take into consideration the energy load and the energy for each chain node to determine for many times a node will be a leader.

2.2 ENERGY DISSIPATION MODEL

We assume a simple model for the radio hardware energy dissipation as discussed in [11] where the transmitter dissipates energy to run the radio electronics and the power amplifier, and the receiver dissipates energy to run the radio electronics, as shown in Fig. (2). For the experiments described here, the free space channel model are used. Thus, to transmit an l-bits message over a distance d, the radio expends (1)

$$E_{TX} = l.(E_{elec} + E_{amp}.d^2) \quad (1)$$

Where E_{elec} is the energy dissipated per bit in the transmitter circuitry (to run the transmitter or receiver circuitry) and Eamp.d2 is the energy dissipated for transmission of a single bit over a distance d. The electronics energy (E_{elec}) depends on many factors such as the digital coding, the modulation, the filtering, and the spreading of the signal, whereas the amplifier energy, $E_{amp}.d^2$, depends on the distance to the receiver and the acceptable bit-error rate. The radios have power control and can expend the minimum required energy to reach the intended recipients. The radios can be turned off to avoid receiving unintended transmissions. To receive an l-bit message, the radio expends (eq2):

$$E_{RX} = l.E_{elec} \quad (2)$$

It is also assumed that the radio channel is symmetric, which means the cost of transmitting a message from A to B is the same as the cost of transmitting a message from B to A.

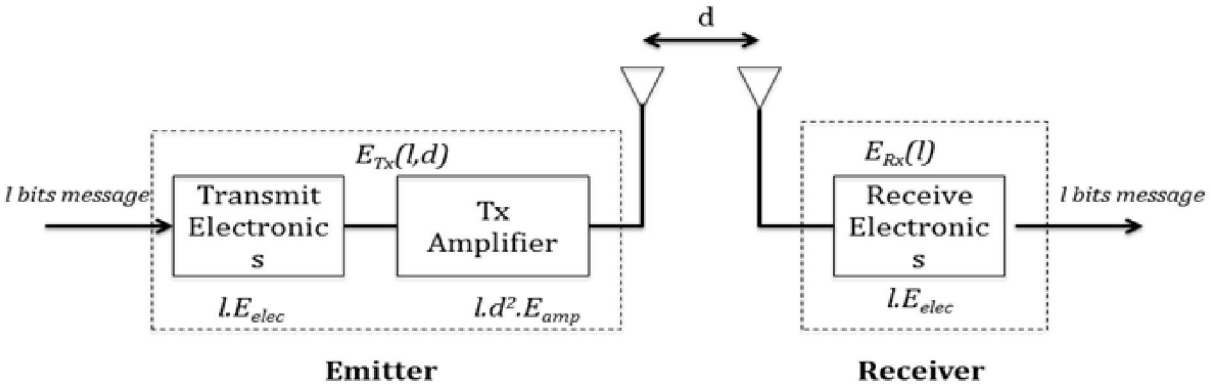

Fig. 2. Radio energy dissipation model

3 ENHANCED POWER EFFICIENT GATHERING IN SENSOR INFORMATION SYSTEM

In this work we aim at developing a system that would provide that the total energy dissipation is distributed equally among all the network nodes. The objective is that the network nodes die equitably. We use a greedy algorithm in order to organize the nodes in the form of a chain. This is an open chain that starts from the farthest node from the base station. We assume that global knowledge of the network is available. An upstream node on the chain searches its downstream node between not chained nodes that is the closest one. This process will continue until all network nodes are chained. Once the chain formation is done, the data gathering process begins. In every data-gathering round, a leader node is selected to receive data from the chain and transmit it to the sink. During a data gathering round each node in the network receives a data packet from its neighboring node, aggregates it with its own data packet and transmits it to its other neighbor in the chain. A simple token passing approach initiated by the leader is used to organize the data transmission. So, the data transmission starts from the chain end-nodes to its next nodes in the chain. This node do data aggregation and so that until the leader. Let us assume that the network is composed from 7 nodes as depicted in Fig. 1. The chain is formed as (1, 3, 2, 6, 5, 7, 4) and the node denoted by 6 is elected as the leader in particular round. The leader elected in a particular round receives the fused data packets of the nodes in the chain from its two neighbors, fuses it with its own data packet and finally this single data packet is transmitted to the base station. Thus, node 1 transmits its data to node 3 that fuses it with its own and transmits it to node 2 and so on until reaching the leader. The same process is done in second part of the chain starting from node 4. Because playing leader is energy consuming, and in order to distribute energy load, PEGASIS ensure that at each transmission round a new node is selected as leader. But, the chain nodes consume different energy when being leader depending on its location in the chain and its distance to the BS, which means that a certain nodes would die quickly.

In this paper we try to let the network nodes play leader depending on its energy capacity to ensure best energy transmission balancing. The proposed method is based on distributing the energy load over all the network nodes. Let a network formed of N chained nodes and E_{i0} is the initial battery energy of the node i. Let E_{iBS} is the required energy for the node i to transmit to the base station, E_{ij} is the energy to transmit from the node i to node j and E_{rec} is the energy cost required for receiving a packet. In this work we use a greedy algorithm to form the transmission chain. This chain is formed from the farthest node from the BS. The node i deployed in the monitored area can do Ti transmissions in its lifetime (until the depletion of its residual energy) in which it is the leader. For notation simplicity, we suppose that the chain nodes are organized as follow: {1, 2, ..., N } and then the end chain nodes are 1 and N. For the node 1, that will be leader for T_1 times, will do T_1 transmission to the BS and $T_2 + T_3 + ... + T_N$ transmissions to the next node in the chain, lets node 2. Then, the equation (3) must be respected.

$$E_{10} = T_1.(E_{1BS} + E_{rec}) + (T_2 + T_3 + ... + T_N).E_{12} \quad (3)$$

For a not end chain node i, this node will do Ti transmission to BS and 2.Erec from the two chain elements when it is a leader and consumes the $(T_1 + T_2 + ... + T_{i-1}).(E_{i-1} + E_{rec})$ for transmitting to the left element of chain and $(TN + T_{N-1} + ... + T_{i+1}).(E_{i+1} + E_{rec})$ to transmit to the right element of the chain. The equation (4) gives the relation between the numbers of becoming leaders for the entire network nodes.

$$\begin{pmatrix} E_{1BS}+E_{rec} & E_{12} & \dots & E_{12} \\ E_{21}+E_{rec} & E_{2BS}+2.E_{rec} & E_{23}+E_{rec} & \dots \\ \dots & \dots & \dots & \dots \\ E_{21} & E_{21} & \dots & E_{NBS}+E_{rec} \end{pmatrix} . \begin{pmatrix} T_1 \\ T_2 \\ \dots \\ T_N \end{pmatrix} = \begin{pmatrix} E_{10} \\ E_{20} \\ \\ E_{N0} \end{pmatrix} \quad (4)$$

As constraint, all T_i must be positives. We solve the equation above to determine how many times a node can be a leader for the chain. If the solution gives negative results, a linear optimization can be used. With this manner the nodes energies would be consumed equitably. Since T_i is given, the node i when it is selected as leader it plays this role pour T_i consecutive transmission rounds rather than one

4 SIMULATION RESULTS

To evaluate the performance of the proposed technique, several Matlab simulations were performed and the represented results are an average. We consider a square network with N nodes deployed randomly in the field. The used parameter values in our work are given in Table 1.

Table 1. Simulation Parameter Values

Description	Symbol	Value
Network dimension	Xm*Ym	100m*100m
Number of network nodes	N	10-200
Data packet length	L	2500 Bits
Electronic Energy	E_{elec}	50nJ/bit
Amplifier Energy	E_{amp}	100pJ/bit.m^2

In WSN literature, several different definitions have been proposed for the lifetime of a network. In this work we define the network lifetime as the time till the first node consumes its residual energy (Noted FND as First Node Dies).

First we run simulation of our scheme and PEGASIS varying the network nodes number from 100 to 600. All the network nodes have the same energy that is 0.5J. The base station is located at (50m, 300m). We are interested at the network lifetime until the first node run out its residual energy. The results are represented in Fig. 3.

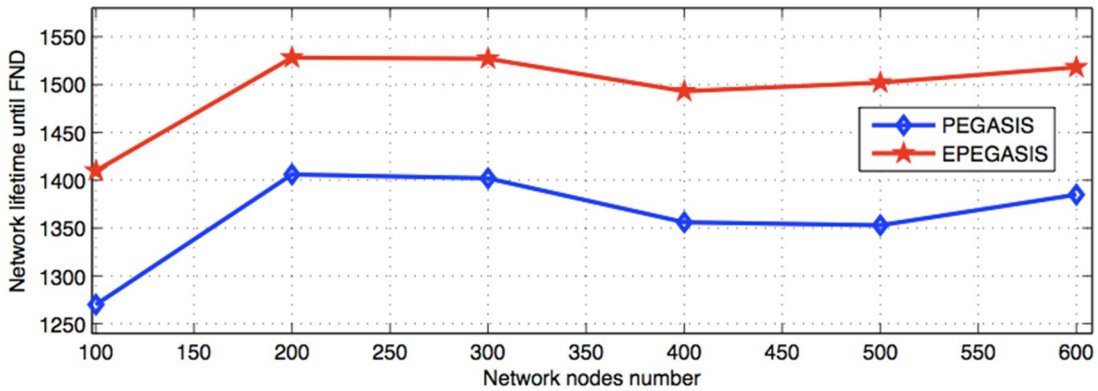

Fig. 3. Network lifetime vs Network nodes number

As depicted, our scheme performs better than PEGASIS since the lifetime extension is up to 11%. In the second situation we aim to investigate the effect of the BS location on the performance of the proposed algorithm. We consider a network of 100 nodes and we vary the base station location from (0.5Xm, 2Ym) to (0.5Xm, 5Ym). The simulation results are presented in Fig. 4. The network lifetime is defined until the first node dies. As depicted, the network lifetime of both the protocols decreases when the BS is far from the network because the needed energy to reach the sink increases with the distance. Table 2 gives the network lifetime for different node initial energy. As we can observe, the network lifetime is extended for all the considered node initial energy. This extension is relevant for the network with nodes initial energies at 0.5 Joule.

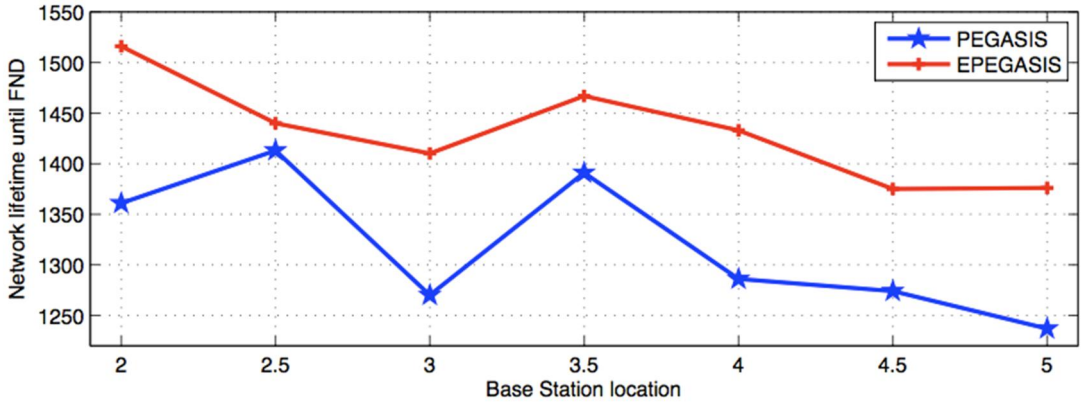

Fig. 4. Network lifetime vs Base station location

Table 2. Network lifetime extension

Initial Energy in J	0.25	0.5	0.75	1
Lifetime extension %	9.19	11.43	4.10	2.43

5 CONCLUSION

The proposed technique allows balancing correctly the transmission energy over the whole network nodes, which leads to network lifetime extension. This extension is guaranteed for different number of network nodes, for different Base station location and for different nodes initial energies. The simulation results clearly show the improvement provided by our technique compared to the well-known protocol for chaining in wireless sensor networks (PEGASIS protocol). In future, we will continue the work investigating the effect of data correlation on the network performance for this kind of routing protocols.

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Investigate the Performance of Various Shapes of Planar Monopole Antenna on Modified Ground Plane Structures for L frequency Band Applications

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ABSTRACT: In this paper, various shapes of planar monopole antenna on different ground plane structures are presented. It is designed for the 1-2 GHz frequency band for L-band application. A monopole of square, circular, triangular and hexagon shape is mounted vertically on the dielectric of glass epoxy (FR4 lossy substrate) with relative permittivity of 4.3, thickness of 1.6 mm above the ground plane through a single feeding strip. Simulation results such as impedance bandwidth, directivity, gain and radiation pattern are also analyzed and compared. The effect of feeding strip is a critical parameter for the performance of antenna, is studied for various shapes of monopole antenna are investigated. The radiation performance is also shown to be acceptable over a wide range of frequency.

KEYWORDS: Monopole Antenna, Planar Square Monopole Antenna, Planar Circular Monopole Antenna, Planar Triangular Monopole Antenna, Impedance bandwidth.

1 INTRODUCTION

With the growth of applications in wireless communication systems, various antenna designs take greater demand [1-7]. One of the most popular antennas employed in mobile and wireless communication systems is the monopole antenna because of satisfactory radiation characteristics over a wideband is achieved.

Antennas, which can work properly in more than one frequency region either for transmitting or receiving electromagnetic (EM) waves, are termed as Multiband antennas. Such antennas are usually tri-band, penta-band etc. Multi-band antennas are much more complex than the single band antennas in their design, structures and operations [1].

In this paper, several planar such as square, circular, triangular and hexagon shaped monopole antenna with single feeding strip above the modified ground plane structure is designed for single band antenna. Their attractive merits such as simple structure, omni-directional radiation pattern, wide impedance bandwidth, compact size and low cost [2]. The proposed planar monopole antenna is a simple configuration fed by 50Ω SMA connector placed under the ground plane of the antenna [3]. Planar monopole antenna can be optimizing to provide extremely wide impedance bandwidths with acceptable radiation performance. They can be developed to cover several operating frequency bands of wireless communication GSM900: 890-960 MHz, DCS: 1.71-1.88 GHz, Personal Communication System (PCS) 1.85-1.99 GHz, and Universal Mobile Telecommunication System (UMTS 1.92-2.17 GHZ) IMT-2000 [4]-[6].

The designs of the proposed configurations are based upon the monopole antenna structure and the ground plane shapes [7] and parameters of the antenna such as return loss S_{11}, directivity and gain are measured with the help of CST (Computer Simulation Technology) Microwave Studio Software.

CST MICROWAVE STUDIO is a fully featured software package for electromagnetic analysis and design in the high frequency range. The software contains a transient solver which can obtain the entire broadband frequency behaviour of the

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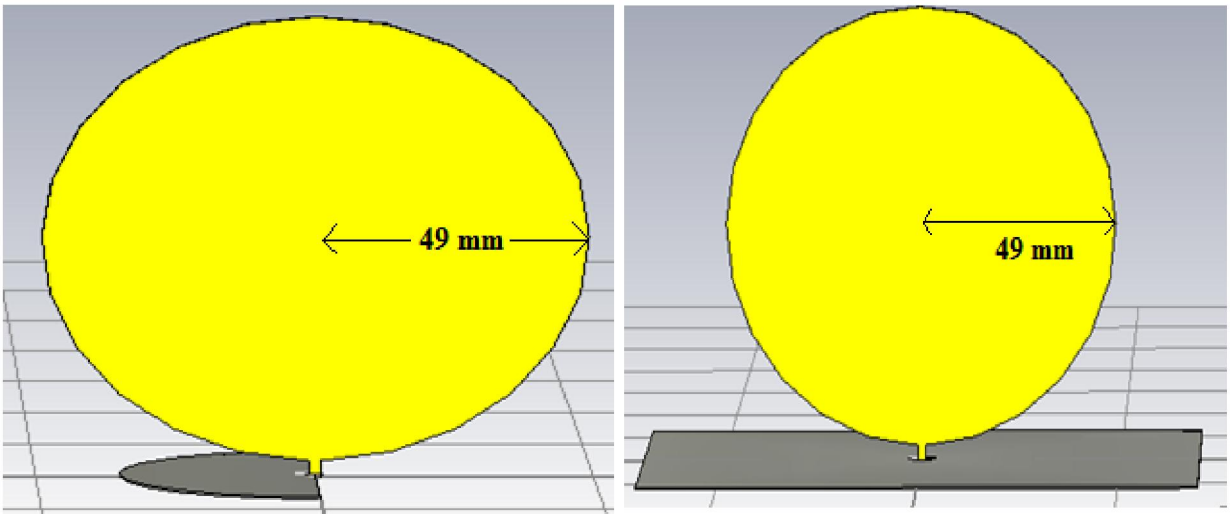
simulated device. This solver is very efficient for most kinds of high frequency applications such as connectors, transmission lines, filters, antennas and many more.

2 ANTENNA DESIGN

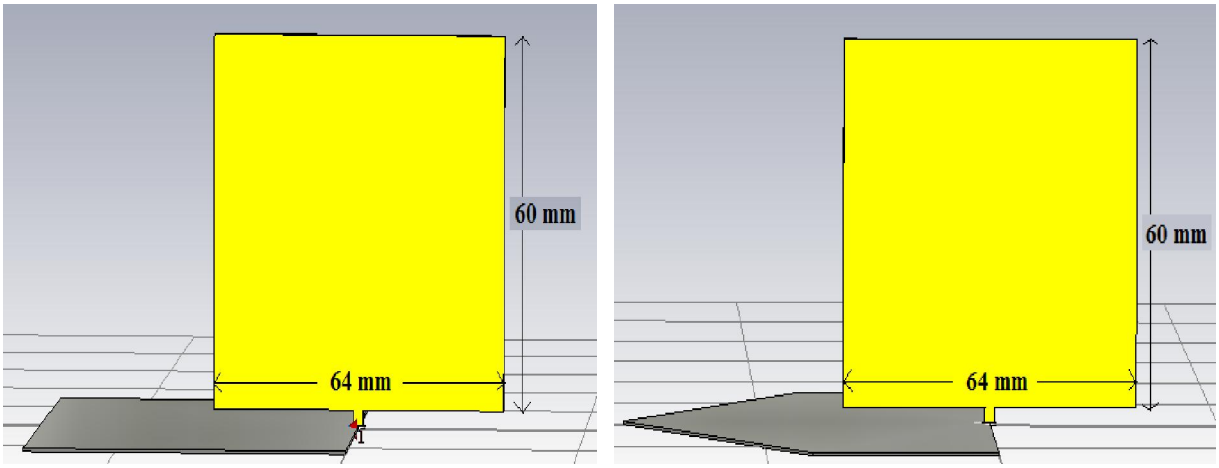
The proposed figure of the planar circular monopole antenna (PCMA-1) with the half circular ground plane on CST [8]-[20] Microwave Studio software is shown in figure 1(a). The proposed PCMA is vertically mounted above a one sided half circular ground plane of radius 35 mm and in the second design, planar circular monopole antenna (PCMA-2) is vertically mounted with the rectangular ground plane structure of size 140 x 120 mm^2 is shown in figure 1(b). The circular monopole and single feeding strip are integrated together and constructed from a single aluminium plate (1 mm thick sheet is used) for both the design of PCMA. In the design of both PCMA structure, feeding strip has a uniform width of 2 mm and a length of 3.5 mm and is connected to a centre of the lower arc of the circular planar monopole.



(a) *(b)*

Fig. 1. Geometry of the proposed planar circular monopole antenna on CST with (a) one sided half circular ground plane (b) rectangular ground plane

The third and fourth design shows the planar rectangular monopole antenna (PRMA-1) and (PRMA-2) with one sided half rectangular ground plane and one side half hexagon ground plane on CST are shown in figure 2(a) and 2(b) respectively. The size of one sided half rectangular ground plane in the PRMA-1 is 70 x 130 mm^2 and the radius of one side half hexagon ground plane radius in the PRMA-2 is 80 mm. In the design of both PRMA structure, feeding strip has a uniform width of 2 mm and a length of 3 mm and is connected to a centre of the bottom side of the rectangular monopole.



(a) *(b)*

Fig. 2. Geometry of the proposed planar rectangular monopole antenna on CST (a) with one sided half rectangular ground plane (b) one side half hexagon ground plane.

Figure 3 shows geometry of proposed planar equilateral triangular monopole antenna (PETMA) above a one sided half rectangular ground plane of size 90 x 105 mm^2. The geometry of proposed figure of Planar Hexagon Monopole Antenna (PHMA) with rectangular ground plane shape of size 140 x 150 mm^2 on CST software is shown in figure 4. The feeding strip in PETMA and PHMA contains a constant width of 2 mm and length of 4.5 mm to achieve the wide bandwidth and is connected to a centre of the bottom side of the monopole structure.

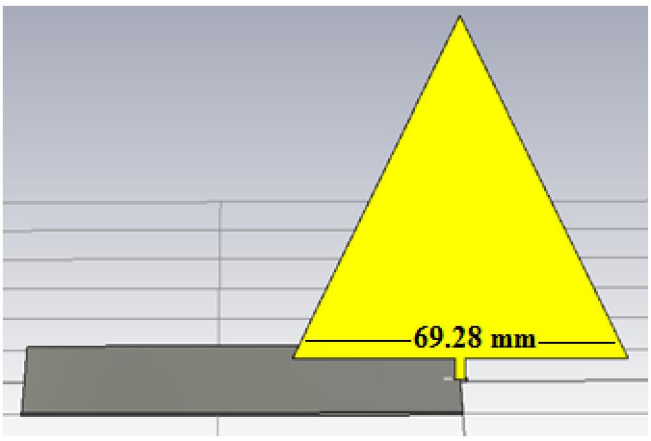


Fig. 3. Geometry of proposed PTMA with one sided half rectangular ground plane on CST

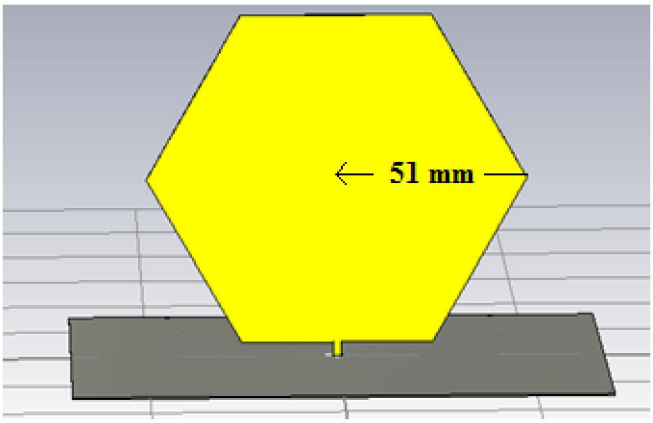


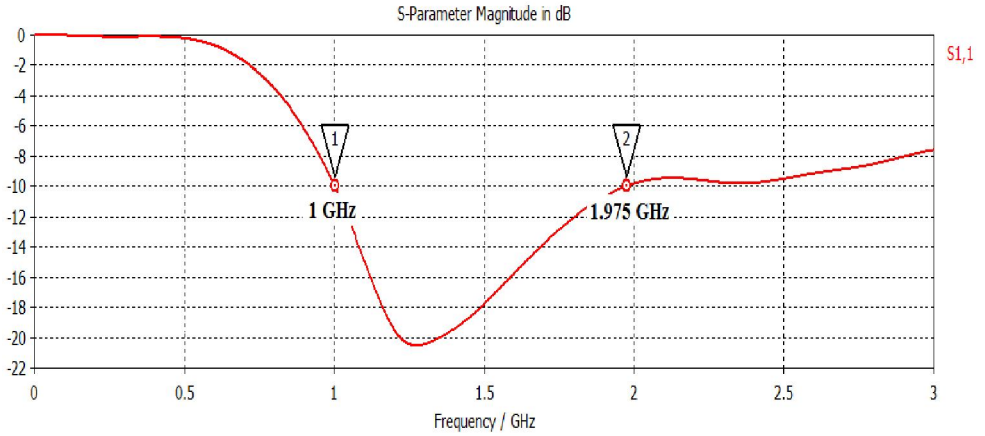
Fig. 4. Geometry of proposed PHMA with rectangular ground plane on CST

3 SIMULATED AND EXPERIMENTAL RESULT'S

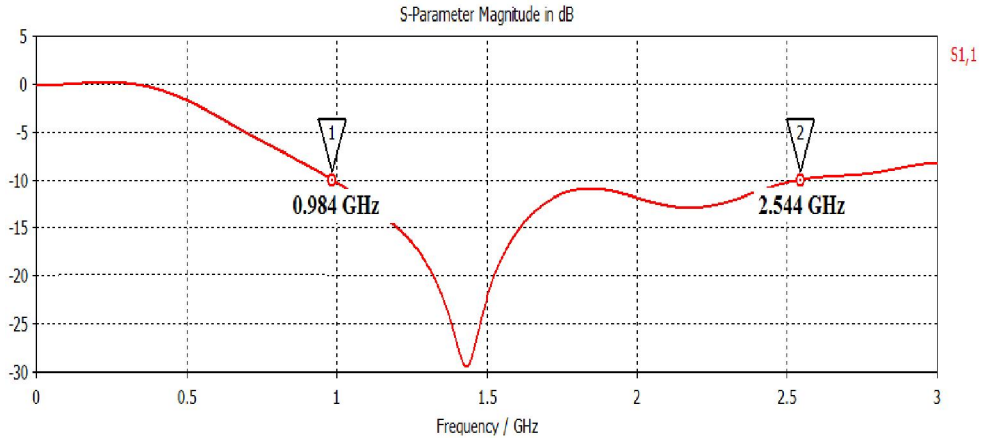
Prototypes of the both proposed PCMA-1 and PCMA-2 with a single feeding strip above the one sided half circular ground plane and rectangular ground plane were simulated and studied. The simulated results are obtained using Computer Simulation Software (CST) Microwave Studio software.

The simulated return loss of PCMA-1 with the one sided half circular ground plane is shown in figure 5(a). The radius of the circular planar monopole is chosen to be 49 mm, which easily makes the obtained impedance bandwidth (10 dB return loss) have a lower frequency (f_L) of 1.0 GHz. Also by selecting the length of feeding strip to be 3.5 mm, the upper frequency (f_U) of the impedance bandwidth is 1.975 GHz and the bandwidth of 975 MHz is achieved.

The simulated return loss for the design of PCMA-2 with the rectangular ground plane is shown in figure 5(b). The radius of circular monopole and feeding strip length are same as the first design to get the wide impedance bandwidth of 1.56 GHz in the frequency range of 0.984 – 2.544 GHz.



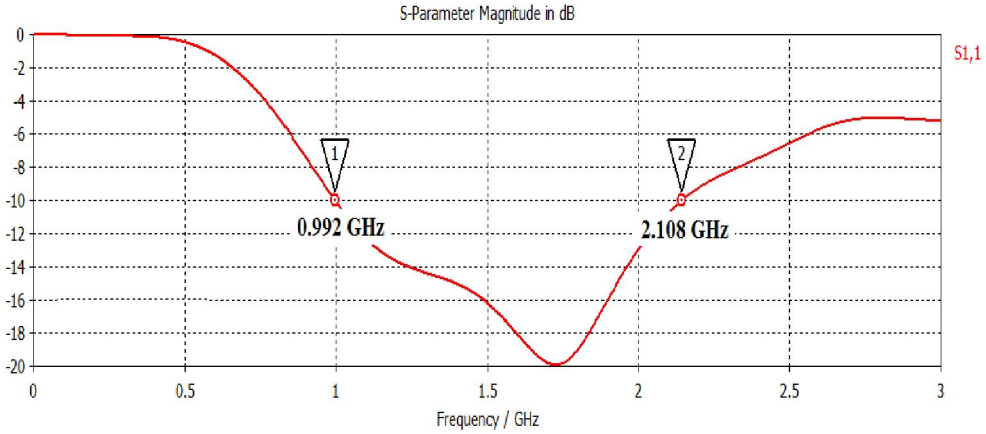
(a)



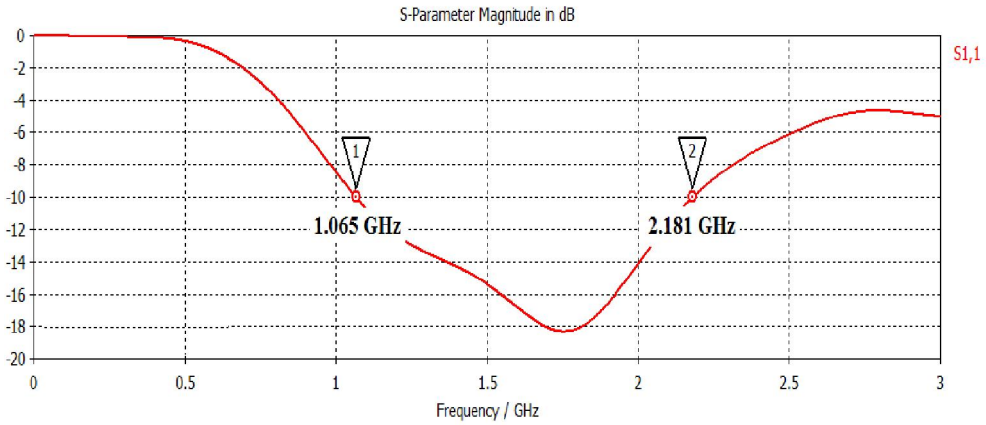
(b)

Fig. 5. Simulated return loss for (a) PCMA-1 and (b) PCMA-2

The simulated return loss for the PRMA-1 with one sided half rectangular ground plane is shown in figure 6(a) and the simulated return loss for the design of PRMA-2 with one sided half hexagon ground plane is shown in figure 6(b). The size of rectangular planar monopole and length of feeding strip in both the design of PRMA-1 and PRMA-2 are set to 64 x 60 mm^2 and 3 mm respectively, to achieve the impedance bandwidth of 1.116 GHz in the frequency range 0.992 - 2.108 and bandwidth of 1.116 GHz in the frequency range of 1.065 - 2.181 GHz respectively.



(a)



(b)

Fig. 6. Simulated return loss for (a) PRMA-1 (b) PRMA-2

The simulated return loss for PETMA with one sided half rectangular ground plane is shown in figure 7. The side of the equilateral triangular planar monopole is 69.28 mm which easily makes the obtained impedance bandwidth of about 1.079 GHz have a lower frequency of 1.025 GHz and upper frequency of 2.104 GHz. The simulated return loss of PHMA with rectangular ground plane is shown in figure 8. The each side of the hexagonal planar monopole is 51 mm which obtained the impedance bandwidth of 1.747 GHz in the frequency range of 0.932 - 2.679 GHz. The feeding strip length of 4.5 mm and width of 2 mm are used for the above PETMA and PHMA design.

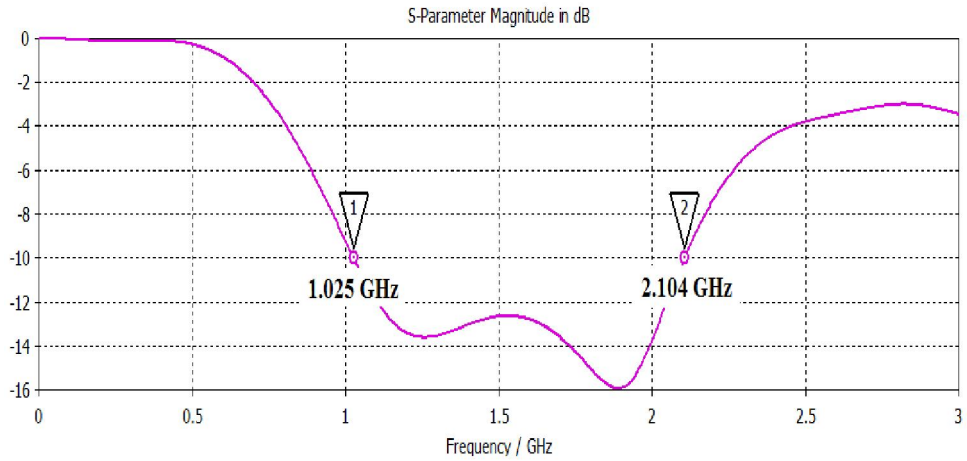


Fig. 7. Simulated result of the proposed PETMA

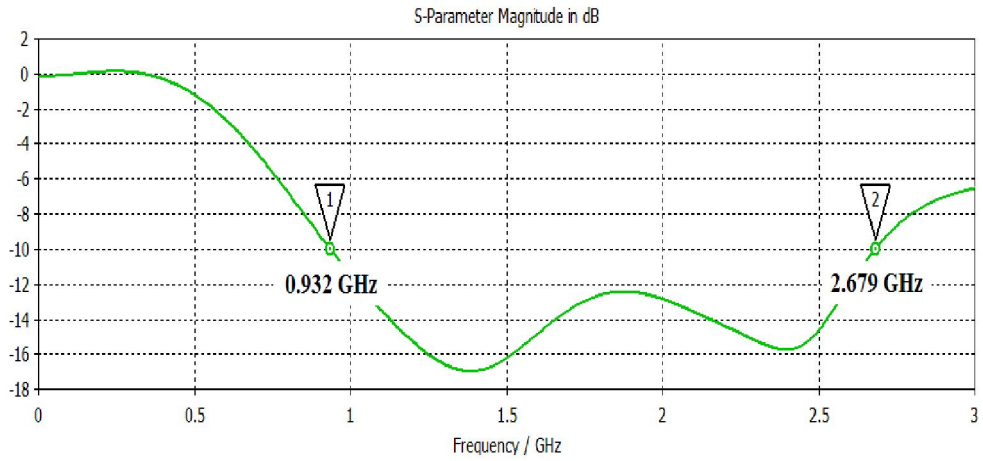


Fig. 8. Simulated result of the proposed PHMA

The corresponding simulated data of the various shapes of monopole antenna with different ground planes are listed in table 1 for comparison.

Table 1. Simulated results of the circular, rectangular, triangular and hexagonal planar monopole antenna on different ground planes structure with different lower and upper frequency.

Configuration	Bandwidth (GHz)	Frequency Ratio (f_U/f_L)
PCMA-1	0.975, (1.0-1.975)	1.97
PCMA-2	1.560, (0.984-2.544)	2.58
PRMA-1	1.122,(0.991-2.113)	2.13
PRMA-2	1.116, (1.065-2.181)	2.04
PETMA	1.079, (1.025-2.104)	2.05
PHMA	1.747,(0.932-2.679)	2.87

It is noticed form the data of Table 1, all configurations given above are designed for the L frequency band applications and the bandwidths of PHMA and PCMA-2 are greater than the remaining design of monopole antennas.

Radiation characteristic of all the proposed planar monopole antennas are also analyzed. Simulated radiation pattern for all the cases of monopole antenna are shown in figure 9.

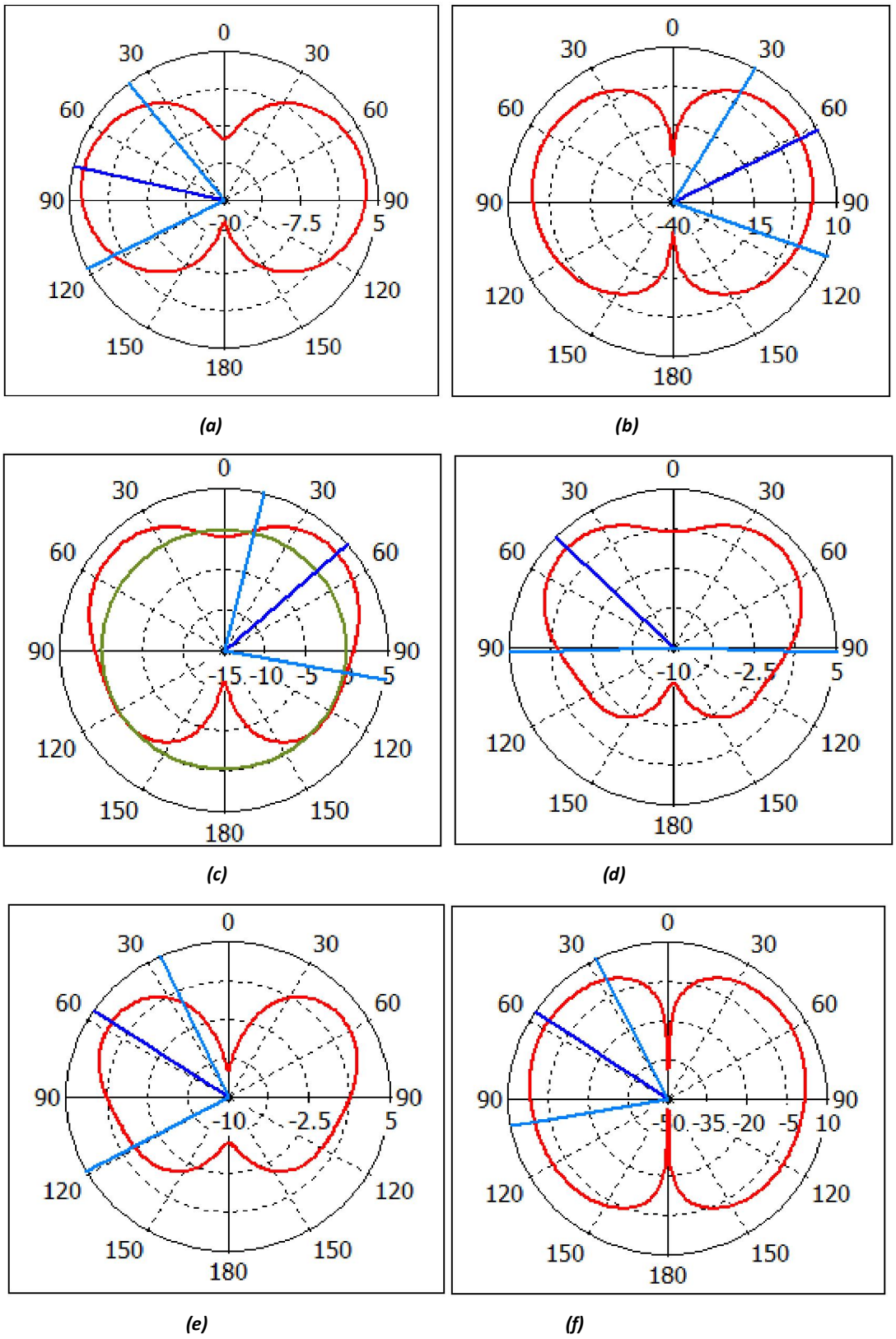


Fig. 9. Simulated radiation pattern of (a) PCMA-1 at 1.28 GHz (b) PCMA-2 at 1.43 GHz (c) PRMA-1 at 1.6 GHz (d) PRMA-2 at 1.75 GHz (e) PETMA at 1.88 GHz (f) PHMA at 1.38 GHz

The radiation efficiency, directivity and gain of all the proposed monopole antennas at different frequencies are shown in Table 2.

Table 2. Radiation efficiency, Directivity and Gain of all proposed monopole antennas at different frequencies

Configuration	Frequency (GHz)	Radiation Efficiency (%)	Directivity (dBi)	Gain (dB)
PCMA-1	1.28	99.36	3.135	3.158
PCMA-2	1.43	98.92	3.503	3.555
PRMA-1	1.60	99.11	3.190	3.197
PRMA-2	1.75	99.67	3.504	3.489
PETMA	1.88	98.88	3.374	3.325
PHMA	1.38	98.18	3.723	3.643

For the comparison point of view, Figure 10 shows a comparison of the simulated return loss of all the design of planar monopole antennas. It is clearly shown in figure 10 and from the data of table 1 that the response and bandwidth of PCMA-2 is better than remaining proposed monopole antenna designs.

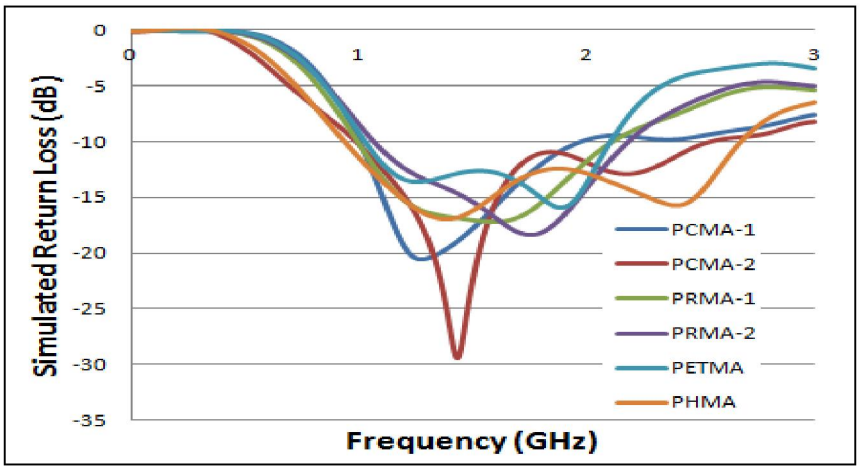


Fig. 10. Comparison of simulated return loss of the all proposed monopole antennas

The antenna gain of all the design of proposed planar monopole antenna are analyzed in the frequency range 0 – 3 GHz. For frequencies upto about 3 GHz, it is seen that the antenna gain of proposed PCMA-1, PRMA-1, PRMA-2 and PETMA monotonically increases with the increases of frecuencies from about 2 to 4.8 dB, 1.6 to 5.5 dB, 1.6 to 6.0, 1.8 to 6.0 respectively. The antenna gain of proposed PCMA-2 and PHMA upto 2.2 GHz frequency is also monotonically increases from about 1.5 to 6.5 dB and 1.4 to 6.3 dB respectively but for higher frequency portion of 2.2 – 3 GHz, the antenna gain decreases from about 6.5 to 5.3 dB and 6.3 to 5.0 dB respectively with the increase of frequency. The antenna gain with frequency in the frequency range 0-3 GHz is also plotted in figure 11 for comparison.

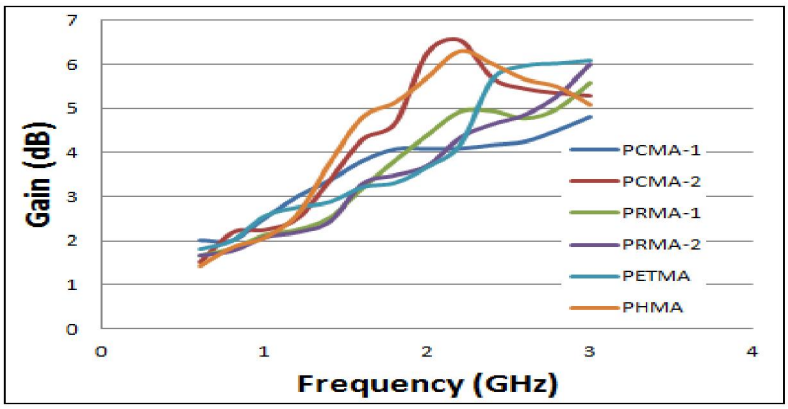


Fig. 11. Comparison of the antenna gain with frequency of all the proposed planar monopole antennas

The lengths of feeding strip, which is the gap between the monopole structure and the ground plane are studied. The corresponding simulated data are listed in table 3 to table 8 of all the design of monopole antennas for comparison, having all the remaining parameters of the proposed antennas are same as design of PCMA-1.

The value of feeding strip length varies from 3 to 4.5 mm for the PCMA-1 is analysed and corresponding simulated data are listed in table 3 with respective simulated return loss as shown in figure 12 which is clearly shows that the response (return loss) of antenna and antenna bandwidth are the function of feeding strip. The antenna bandwidth is decreases with the increment in feeding strip length. The antenna efficiency is also given as per the repsponse of PCMA-1 with variation in feeding strip length. The antenna efficiency is also given for each case of PCMA-1 as per the variation in feeding strip length.

Table 3. Simulated results of the proposed PCMA-1 as a function of feeding strip

Feeding Strip (mm)	Simulated Frequency (GHz)		Bandwidth (GHz)	Antenna Efficiency (%)
	f_L	f_U		
3	1.018	2.663	1.645	99.16
3.5	1.000	1.975	0.975	99.64
4	0.990	1.970	0.980	99.66
4.5	0.970	1.818	0.848	99.70

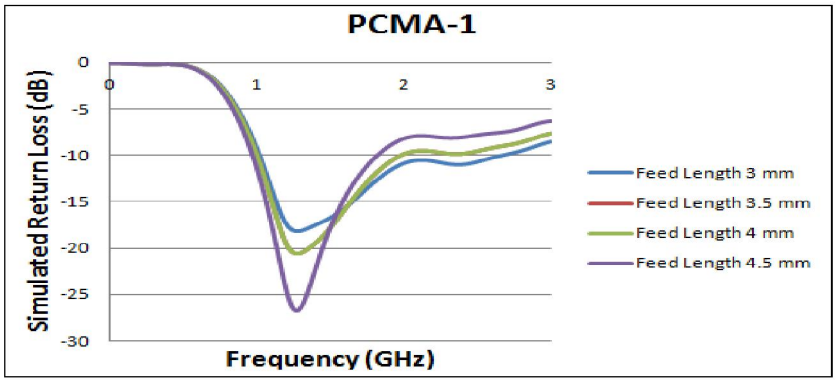


Fig. 12. Simulated return loss of the proposed PCMA-1 as a function of feeding strip

The simulated return loss of the proposed PCMA-2 with the variation in feeding strip varies from 2.5 to 4 mm is shown in figure 13 and the corresponding data (simulated results) is also listed in table 4. All the remaining parameters of the proposed antenna are constant for comparison. The data of the table 3 clearly shows that antenna bandwidth is monotonically decreases with the increment in length of feeding strip. The antenna efficiency is also given as per the repsponse of PCMA-2 with variation in feeding strip length.

Table 4. Simulated results of the proposed PCMA-2 as a function of feeding strip

Feeding Strip (mm)	Simulated Frequency (GHz)		Bandwidth (GHz)	Antenna Efficiency (%)
	f_L	f_U		
2.5	0.929	2.828	1.899	99.53
3	0.955	2.701	1.746	99.67
3.5	0.984	2.544	1.560	98.90
4	1.023	2.480	1.457	99.38

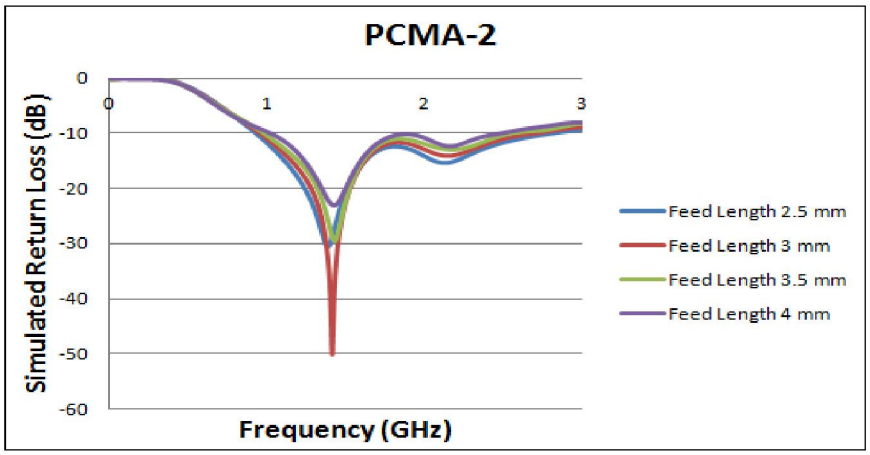


Fig. 13. Simulated return loss of the proposed PCMA-2 as a function of feeding strip

The value of feeding strip length varies from 2.5 to 5 mm for the PRMA-1 is analysed and corresponding simulated data are listed in table 5 and their respective simulated return loss is shown in figure 14 which is clearly shows that the response (return loss) of antenna and antenna bandwidth are the function of feeding strip. The data of the table 3 clearly shows that antenna bandwidth is monotonically increases with the increment in length of feeding strip up to 4 mm and after that if feeding strip length is further increased then antenna of bandwidth is decreases.

Table 5. Simulated results of the proposed PRMA-1 as a function of feeding strip

Feeding Strip (mm)	Simulated Frequency (GHz)		Bandwidth (GHz)	Antenna Efficiency (%)
	f_L	f_U		
2.5	0.991	2.024	1.033	97.79
3	0.992	2.108	1.116	98.26
3.5	0.996	2.143	1.147	98.30
4	1.004	2.156	1.152	99.01
4.5	1.035	2.130	1.095	99.42
5	1.099	2.115	1.016	99.59

The simulated return loss of the proposed PRMA-2 with the variation in feeding strip length varies from 2 to 4.5 mm is shown in figure 15 and the corresponding data (simulated results) is also listed in table 6. All the remaining parameters of the proposed antenna are same as design of PRMA-2 for comparison. The data of the table 3 clearly shows that antenna bandwidth is monotonically increases with the increment in length of feeding strip up to 4 mm and after that if feeding strip length is further increased then antenna of bandwidth is decreases.

Table 6. Simulated results of the proposed PRMA-2 as a function of feeding strip

Feeding Strip (mm)	Simulated Frequency (GHz)		Bandwidth (GHz)	Antenna Efficiency (%)
	f_L	f_U		
2	1.042	1.894	0.852	98.66
2.5	1.053	2.114	1.061	96.35
3	1.065	2.181	1.116	98.2
3.5	1.087	2.210	1.123	99.02
4	1.135	2.218	1.083	99.49
4.5	1.299	2.209	0.910	99.91

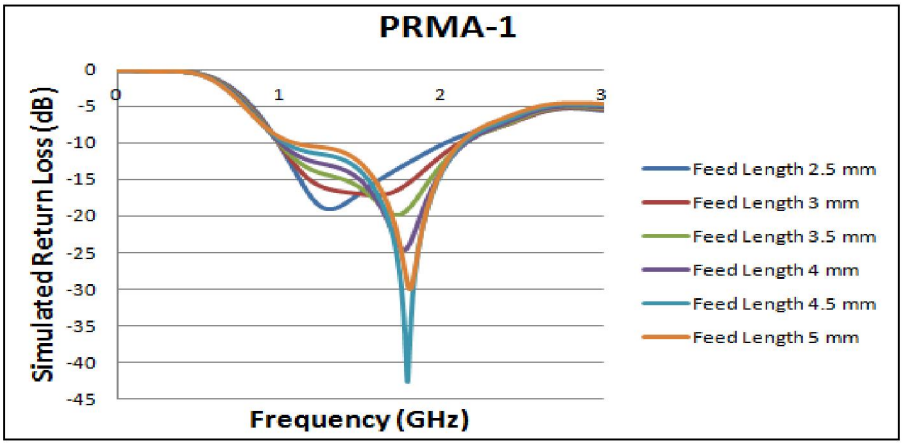


Fig. 14. Simulated return loss of the proposed PRMA-1 as a function of feeding strip

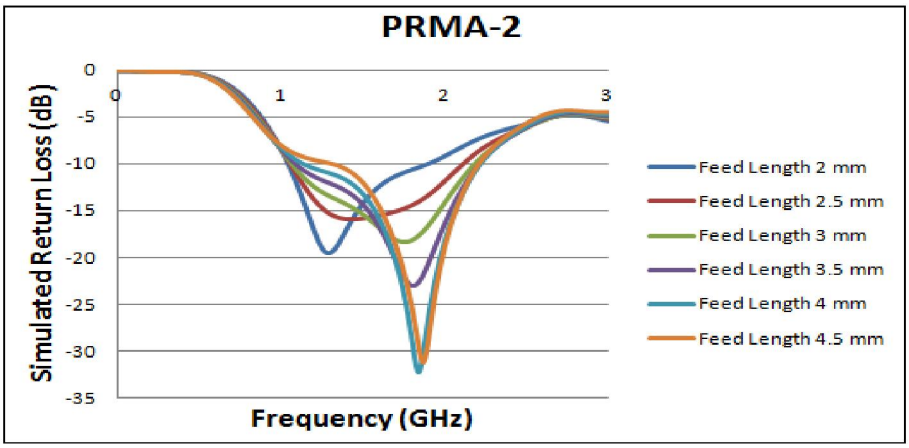


Fig. 15. Simulated return loss of the proposed PRMA-2 as a function of feeding strip

The effects of feeding strip length on the impedance bandwidth of PETMA are studied in table 7 and corresponding simulated return loss is shown in figure 16. For the feeding strip length varies from 3 to 4.5 mm, the antenna bandwidth is monotonically increases with the increment of the length of feeding strip.

Table 7. Simulated results of the proposed PETMA as a function of feeding strip

Feeding Strip (mm)	Simulated Frequency (GHz)		Bandwidth (GHz)	Antenna Efficiency (%)
	f_L	f_U		
3	1.119	2.065	0.946	99.09
3.5	1.076	2.091	1.015	98.65
4	1.049	2.102	1.053	97.74
4.5	1.025	2.104	1.079	96.34

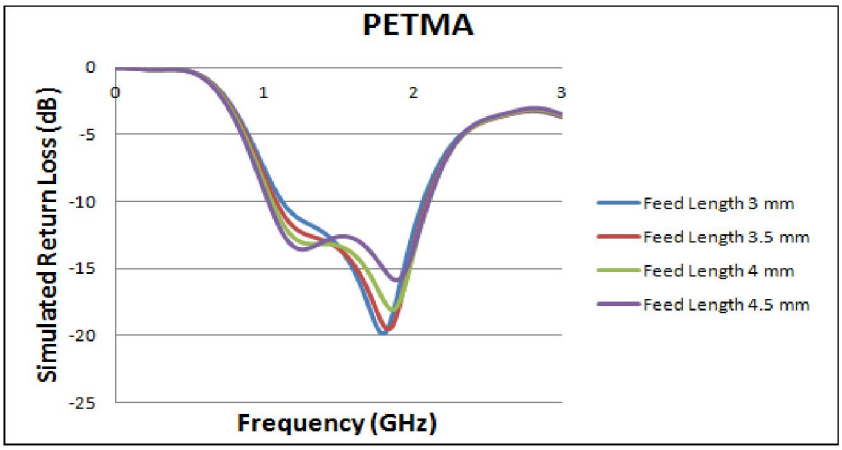


Fig. 16. Simulated return loss of the proposed PETMA as a function of feeding strip

Table 8. Simulated results of the proposed PHMA as a function of feeding strip

Feeding Strip (mm)	Simulated Frequency (GHz)		Bandwidth (GHz)	Antenna Efficiency (%)
	f_L	f_U		
3.5	0.886	2.680	1.794	97.49
4	0.906	2.687	1.781	94.79
4.5	0.939	2.679	1.740	96.21
5	0.960	2.670	1.710	98.06
5.5	0.968	2.657	1.689	98.96
6	1.026	2.622	1.596	99.54

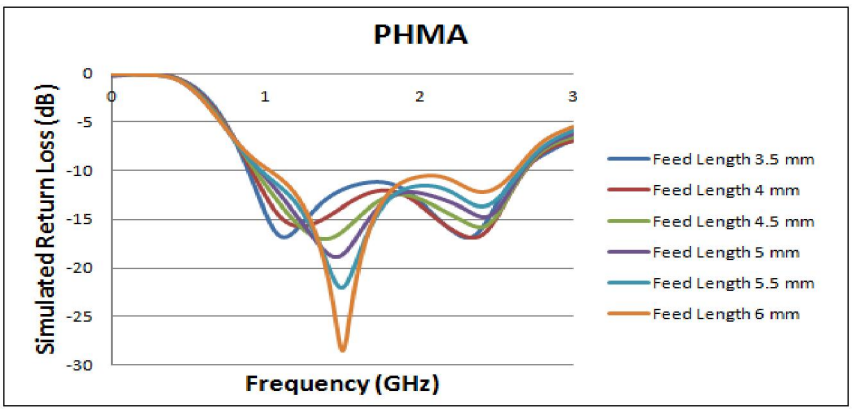


Fig. 17. Simulated return loss of the proposed PHMA as a function of feeding strip

The simulated return loss of the PHMA with the variation of feeding strip varies from 3.5 to 6 mm is shown in figure 17. The corresponding bandwidth (simulated results) is also listed in table 8. It is clearly seen that the antenna bandwidth is monotonically decreases with the increment of the length of feeding strip.

4 CONCLUSION

New configurations of planar circular, square, equilateral triangular and hexagon monopole antenna on the modified ground plane shapes using single feeding strip has been investigated. These proposed antennas can be easily constructed using the aluminum sheet and achieved the bandwidth of 1 GHz and much more in all the design and each cases of monopole antenna structure which is applicable for the L-frequency Band. It is also investigated that feed gap is a frequency dependent parameter which effects the bandwidth of the antenna (antenna bandwidth in each design is either increases or decreases as feeding strip length increases). In each design of proposed planar monopole antenna, the antenna gain is also investigated that the antenna gain is also a frequency dependent parameter (as frequency increases, the antenna gain is increases). Among all these configurations, the PCMA-2 and PHMA were reported maximum bandwidth.

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P-shaped Wearable Antenna for ISM band at 2.45 GHz

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ABSTRACT: A P-shaped wearable antenna is proposed for the application of ISM (Industrial Scientific Medical) band at frequency 2.45 GHz. This proposed antenna is studied using different numerical techniques. Those techniques are Method of Moment (MoM) and Finite Element Method (FEM). This proposed structure is a high directive gain, low-cost, low weight base station antenna. The characteristic analysis such as return loss (RL), VSWR and radiation pattern of this antenna has been investigated numerically. Numerical study has been carried out by using Ansoft HFSS V13 simulating software.

KEYWORDS: Patch antenna, ISM band, Return loss, VSWR, Radiation Pattern.

1 INTRODUCTION

Over the last two decades, microwave resonators have become very important subject of interest. Recent years have observed the demand for reconfigurable antennas, these are used in a variety of applications, including sensors, filters, oscillators, frequency meters and tuned amplifier [1]-[4]. Resonator elements based on microstrip antenna technology are conformable and have minimized shape, low weight and cost. Hence, these are commonly used in many commercial applications in the industry, such as mobile satellite communications or direct broadcast satellite services etc. In this paper, modeling and study of P-shaped wearable antenna is investigated at frequency 2.45 GHz. The geometry of wearable antenna is shown in the Fig.1. For achieving best performance of this antenna, a parametric study has been performed. The antenna parameters, such as length (L), width (W), slot dimensions etc are also shown in the Figure 1. In order to satisfy IEEE 802.11 a standard, the proposed antenna should operate at 2.45 GHz. Therefore, slotted antennas for WLAN applications become a research point in the past decades and many different technologies for miniaturized antenna have been proposed [5]-[22] and also slotted antennas for ISM band become a hot research point in the past decades and many technologies for miniaturized antenna have been proposed. This proposed antenna is simulated by Ansoft HFSS V13 simulating software, based on method of moment (MoM). In this article, a study for optimizing the performance of the proposed wearable antenna has been carried out by varying the slot dimension (P) as illustrated in the Fig.1. The best performance is achieved for P=2mm. The simulated results offer VSWR of 3.5, and return loss (RL) of -17.25dB. To meet the actual design requirements i.e. operating frequency 2.45 GHz, band width and the radiation efficiency, some approximation has been used. The dimension of the wearable antenna has been calculated based on transmission line model. The substrate duroid (tm) of dielectric constant 2.2 has been taken in this design. The low-profile P-shaped wearable antenna is presented in this paper. It is also very helpful to understand the interaction and performance of the antenna and the communication system in ISM band. The results and design details on the antenna presented here, can be chosen as the initial design for professionals interested in utilizing low-profile integrated antenna. A numerical study has been done to find out the exact feed location and it is found that at (-44.59, 1.85, 0). Duroid (tm) substrate with electrical properties, ε_r of 2.2, thickness of 1.52mm have been used. In this paper a new wearable antenna is design and simulates is used in the Industrial, Scientific and Medical ISM band operating at the frequency 2.45 GHz as a P shaped wearable antenna with micro strip line feed.

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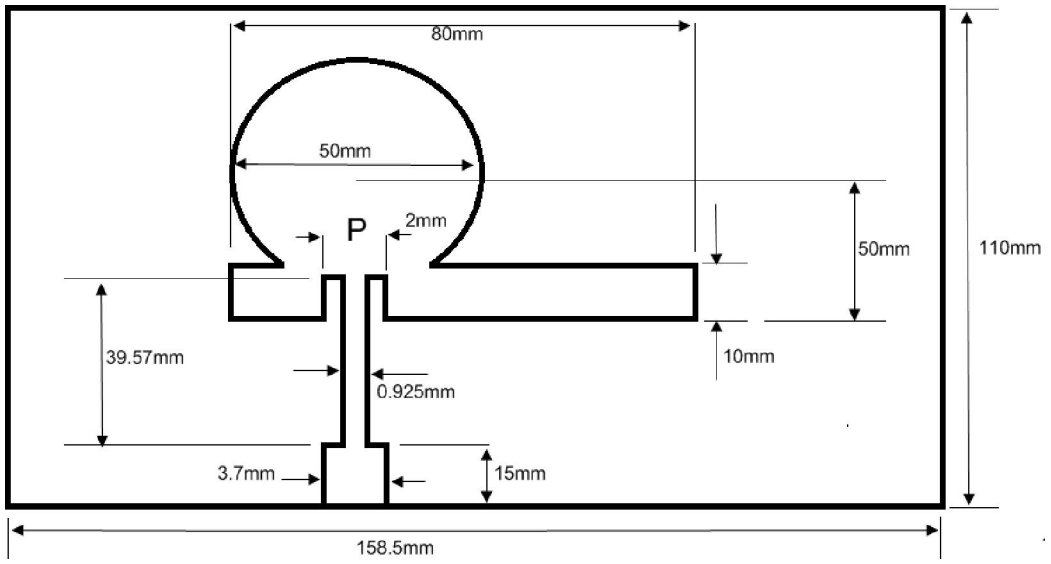

Fig. 1. Geometry of the P-shaped wearable patch antenna

2 SIMULATION RESULTS AND ANALYSIS

2.1 RADIATION PATTERN

This wearable antenna radiates normal to its patch surface. So the elevation pattern for ϕ= 0 and ϕ= 90 degrees are important for measurement. Figure 2 below shows the radiation pattern at 2.45 GHz. The maximum gain is obtained at design frequency for the P-shaped wearable antenna is 6.5 dBi for both ϕ= 0 and ϕ= 90 degrees. The 3D view of the polar plot is shown in Figure 3.

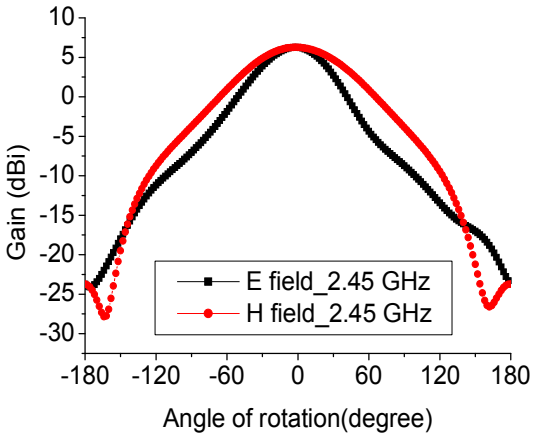

Fig. 2. Simulated result of radiation pattern at 2.45GHz

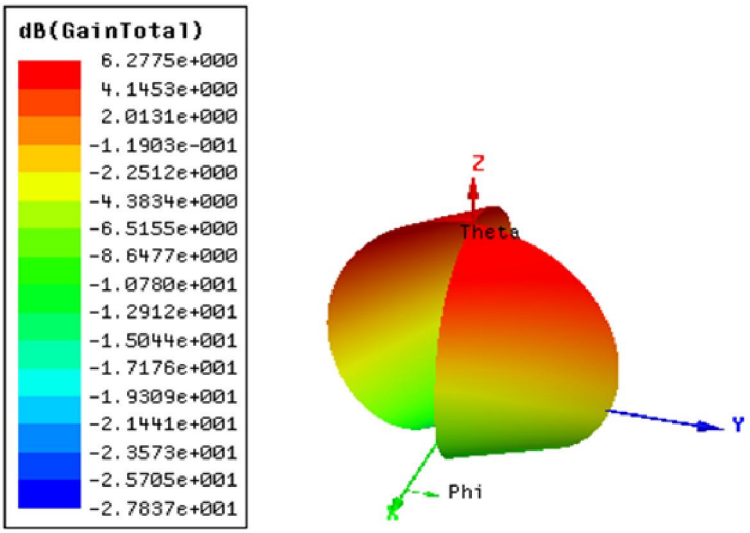

Fig. 3. 3D view of polar plot of the proposed P shaped wearable antenna

2.2 RETURN LOSS AND VSWR

The Return loss characteristics are shown in the Fig. 4. From Return loss (RL) curves it is observed that the optimized RL at 2.45 GHz is -17.25 dB. It has been observed that as the feed location is moved away from designed location, the center frequency deviates slightly but return loss changes noticeably. The optimum VSWR of the proposed antenna at 2.45 GHz is 3.5 as shown in Fig.5.

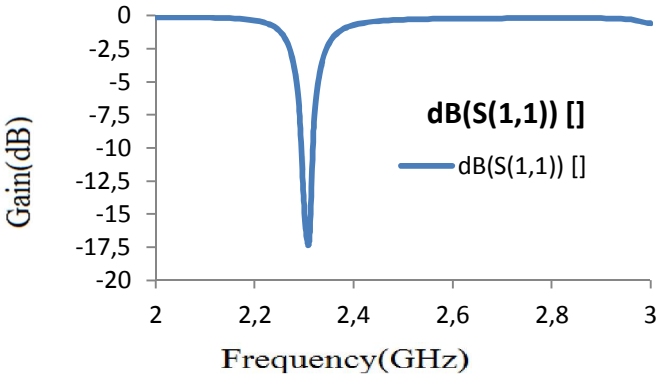

Fig. 4. Simulated result of RL. at 2.45GHz

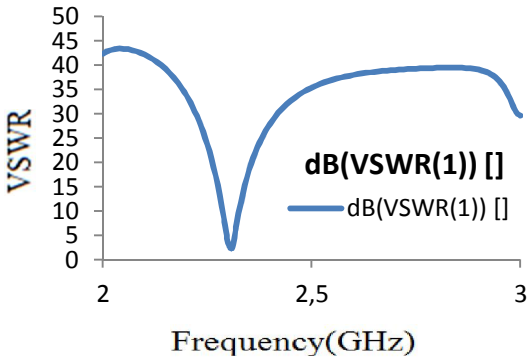

Fig. 5. Simulated result of VSWR at 2.45GHz

2.3 CURRENT DISTRIBUTION

The Current Distribution of proposed antenna is shown in the Fig. 4.

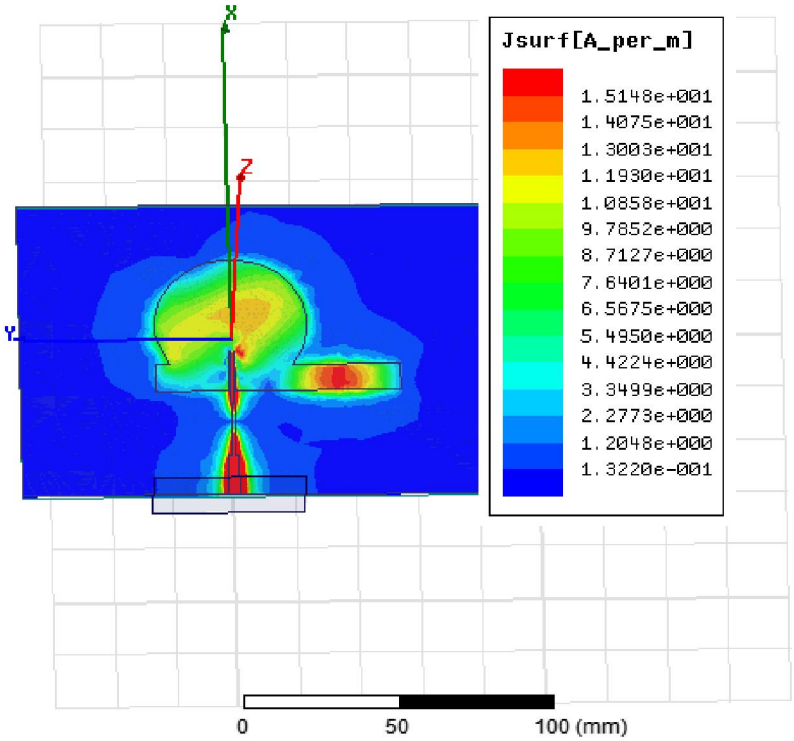

Fig. 6. Simulated Current Distrubution at 2.45GHz

3 CONCLUSION

In this investigation, A new wearable antenna has been design and simulates to use in the ISM band at the center frequency of 2.45 GHz. The proposed slotted antenna is applicable for ISM band. The P-shaped wearable antenna is electrically small and it is suitable to handle easily. If the dielectric constant is high, the electrical length of the antenna will be reduced but the bandwidth would be narrow. It is clearly observed that the bandwidth, radiation efficiency and VSWR improve by introducing P-shaped wearable antenna at the receiver or transmitter ends.

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Pest Rodent Species Composition, Level of Damage and Mechanism of control in Eastern Ethiopia

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ABSTRACT: The assessment on the current information on the species composition of pest rodents and the local communities' perception on their pest status was carried out in Dire Dawa Administration from March 2010 to September 2011. Stratified and multistage random sampling techniques were used to sample representative villages (urban and rural) and respondents (n=150). Both qualitative and quantitative data were gathered through trapping, observation, questionnaire and interview. The collected data were tabulated and organized and appropriate statistical analysis like frequency distribution, percentage and chi-square test were used. For the survey of species composition and relative abundance of pest rodents Sherman live-traps and snap traps were set in the selected standardized and variable trapping grids. Five hundred and nine new individual rodents were captured from the trap nights of 986 Sherman live-traps and 130 snap traps. Twelve species of pest rodents were recorded of which eight were trapped and the four were observed in the study grids. The present result revealed as rodents were the most noxious pests causing substantial damage to agricultural crops, household items and human health through different mechanisms like feeding, discomforting, contaminating and mechanical damage and disease transmission. Techniques like using cat, hunting and trapping, rodenticides and field sanitations were frequently used. The present records of high pest rodent species composition not only indicate as the area is highly infested but it also indicates the existence of a high stock of rodent species diversity that requires an immediate development and application of ecological based rodent pest management strategy.

KEYWORDS: Damage, Dire Dawa Administration, pest, rodents, species composition.

1 INTRODUCTION

In Ethiopia altitudinal variation and other factors are resulted in a very diverse set of ecosystems ranging from humid forest and extensive wetland to the desert [1]. As the consequence the country acquired much diversity of species and endemics [2].

Of all the mammalian orders, the rodents contain the largest number of species which were widely diversified and distributed [3], [4]. They account for near half of the known mammalian species [5], [6]. In East Africa, they account for nearly 28% of mammalian species [7]. Among the 280 mammalian species that occur in Ethiopia, 84 species are rodents forming more than 25% of the total mammalian fauna [2]. Out of these species, 15 are endemic that constitute 50% of the Ethiopian endemic mammalian fauna [2], [8].

Rodents show a great diversity in their morphology, ecology, physiology and behavior. Despite their great species diversity, all rodents share dentition as their common features [3], [9]. They have economical, ecological, social and cultural values and provide major benefits to our environment [6]. Most rodent species play great role in maintaining the ecosystem such as in seed dispersal, pollination, predator-prey relationship and in maintaining ecological balance and habitat modification [10], [11]. They are important food source for predators including the endangered and endemic Ethiopian Wolf (*Canis Semensis*) [11].

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Despite of their ecological benefits some rodent species cause major economical losses in developing country like Ethiopia. In Africa, more than 70 rodent species [12] and in Ethiopia 11 rodent species [8] have been reported to be pest species. The cultivated lands harbor higher numbers of rodent pests and the major ones are *Mastomys natalensis*, *Arvicanthis dembeensis* and *Mus musculus* [13].

In developing countries rodent infestation poses a serious threat for reduction of income and widespread of food shortage by causing substantial damage to food and cash crops worldwide [14]. In East Africa, rodent pest is mainly cause damage on cereal crops [15] and they have been ranked as major crop pest and become threat for national and international food security [16]. In Ethiopia rodents cause a great damage on cereal crops damage [17]. They adversely affect rural communities by damaging their agricultural crop in the field and in the place of storage [18]. Dire Dawa Administration (eastern Ethiopia) also experiences chronic rodent pest problems through the damage of different products and economically loss [19]. Although climate and other pest animals primarily affected the household and agricultural products of the Dire Dawa Administration about 15% of loss is occurred as the consequence of rodent damage [20].

Assessing the farmers' perception on pests status, existing control methods and costs and efficiency of controlling methods facilitate the decision made on the application of successful pest management strategies [21]. Therefore, identification of farmers' gaps in their knowledge to enhance their pest identification and management skills and identifying farm-level constraints in adapting alternative integrated pest management strategies are issues that require immediate attention. In addition to this although rodents known as pest animals in most part of Ethiopia, their economic impact is poorly documented [15]. Furthermore, in most parts of the country local communities or farmers are responsible for their effective control although it is not much surveyed in developing country including Ethiopia. This is also true for the impacts of rodents in Dire Dawa Administration. Thus, the present studies were aimed to collect information on pests of rodent species composition, local communities' perception on their pest status and to establish base line information for policy and pest management strategy development.

2 MATERIALS AND METHODS

2.1 STUDY AREA

The current study was carried out in Dire Dawa Administration. The Administration approximately lay in between 09^0 20' - $09^0$50' N of Latitude and $40^0$50' - $42^0$05'E of Longitude in Eastern Ethiopia. The Dire Dawa town is 515 Km from Addis Ababa the capital city of Ethiopia and 333 Km from Djibouti and at center of Ethio-Djibouti railway. The total area of the administration is 128,802 ha.

Dire Dawa Administration is characterized by three broad traditional Agro-Ecological Zones mainly based on altitude, moisture and physiogeography. The topography of the area constitute from very steep high mountains to flat plains where its altitude ranges from 950 to 2,260 m a.s.l. Ecologically, the Administration is lying in a desert and semi-desert scrub and shrub land ecosystem.

Similar to other low land area of eastern Ethiopia it has arid climate (high temperature and low rain fall) with minor seasonal variation. The monthly mean maximum temperature ranges from 28.1 ^{0}c, which is recorded in the months of December and January, to 34.6 ^{0}c recorded in the month of June. Likewise, the monthly mean minimum temperature varies from 14.5 ^{0}c in December to 21.6 ^{0}c. The region has two rain seasons; that is, a small rain season from March to April, and a big rain season that extends from July to September. The aggregate average annual rainfall that the region gets from these two seasons is about 677 mm.

Most parts of the Dire Dawa Administration is covered with variable vegetation types of arid and semi-arid habitats like cactus scrub, thorn scrub and many wood and sparse grasses. However, most its vegetation is seems to be highly disturbed by anthropogenic and natural factors like overgrazing, deforestation, urbanization and soil erosion. Although the complete assessment is not carried out, the Administration is also known by possessing wildlife in dense shrubs and bushy habitats.

The current modification of natural habitat of species by the anthropogenic activities is increasing the manifestation of pest species. The impact of pest animals like rodents in such highly disturbed habitat is tremendous and requires detail study for their conservation and management.

2.2 METHODS

To select a representative villages and householders or respondents from each stratum a multistage systematic random sampling techniques were used. That means at first stage representative villages were selected then the representative

habitats and respondents were selected from each village. Based on the preliminary survey study result, 14 representative villages (nine from rural and five from urban) and 150 respondents were selected.

The survey studies on species composition of pest rodents were carried intensively by using standardized trap grids in four representative villages where as for remaining villages, grids with different size and trap stations were selected. For the selection of grid size and trap station level of perceived infestation by local community, habitat type, nature of village, type of agriculture field and surrounding habitats were used as selection criteria and four standardized trapping grids and 58 variable trapping grids were selected.

In standardized trap grids (70 m x 70 m), which were square, were used to sample rodent populations from different suitable representative habitats [11]. In each standardized sampling grids, 49 Sherman Live traps at 10 meters interval were laid [22]. To explore the remaining habitats and for the detailed identification of species two to 10 snap traps at an interval of 20 meters were used at least 200 meters away from the live trapping grids.

For the variable trapping (grids with different size and layout), the techniques applied by [23] were used. In most cases, 5 x 5 traps in agricultural field and its surrounding habitats and lines of 1 to 10 Sherman Live Traps were set along adjacent fence lines with 5 to 10 m intervals at each trap station. Sherman Live and Snap traps number ranging from1 to 6 traps were also placed inside resident home, office, shop, storehouse and mill house at different trapping places.

The trap stations were marked with the branches of the tree and by red and yellow color plastic tags tied on tall branches of the tree [11]. The traps were baited with peanut butter mixed with roasted barley flour and replenished each day if rodents or other animals (insect) ate it or dried and lost its smell. The traps were usually visited twice a day early in the morning (7:00 to 9:00 a.m.) and in the late afternoon from (4:30 to 6:30 p.m.).

The live trapped animals were removed from traps and placed in a pre-weighed polythene bag and weighed to the nearest gram. They were marked by toe-clipping and released at the point of capture after recording the location of capture, weight, species, sex and approximate age, reproductive condition. Similarly, for rodents trapped from the snap traps, information on their sex, weight, age, reproductive condition, and standard body measurements (head and body length, hind foot length, ear length and tail length) were recorded for each trapped individuals. Skins (vouchers) of the sample specimen of each species were prepared for further species identification.

The data on the level of damage and pest status of rodents were collected with the help of semi structured open and close-ended questionnaires, interview and focus group discussion, observation, secondary data sources and document analysis. The perceived level of the damage caused by pest rodents was assessed using a four-point scale forwarded by [24] in which no damage for 0% damage, limited damage to up to 25% , for moderate level of damage to between 21-50% and for high level of damage to more than half of items being damaged by rodents. The data were also collected on type of items affected; stage and part in which damage was seem to occur. Furthermore, information on the major controlling methods used and mechanism by which pest rodents cause damage were collected from each respondent.

The collected data were tabulated and organized into tables. Both qualitative and quantitative data were analyzed with appropriate descriptive statistics. All the trapped and observed species were identified to the species level with the help of field guides [3], [4] and comparing the prepared skin voucher with specimens preserved in Zoological Natural History Museum of Addis Ababa University.

3 RESULTS AND DISCUSSIONS

3.1 PEST RODENT SPECIES COMPOSITION AND THEIR RELATIVE ABUNDANCE

A total of 556 individual pest rodents were captured of which 509 individuals were new captures and 47 were recaptures from 986 Sherman live-traps nights and 130 snap traps nights. In different parts of the administrations, 12 species of rodents were recorded as serious pest. From the 12 species of pest rodents recorded eight species namely *Acomys cahirinus*, *Arvicanthis nairobae*, *Arvicanthis somalicus*, *Mastomys erythroleucus*, *Arvicanthis natalensis*, *Mus masculus*, *Rattus rattus*, *Tatera rousta* were trapped and the remaining the four species namely *Heterocephalus glaber*, *Hystrix cristata*, *Tachoryctes splendens* and *Xerus rutilus* were observed in the study grids (*Table 1*).

From the trapped rodents the relative abundance of *A. cahirinus* was 109 (21.41%) and followed by *A. nairobae* 95 (18.66%), *R. Rattus* 80 (15.72%) and *M. natalensis*, 71 (13.95%) and *T. robusta* was the least in abundance (4.91%) (*Table 1*). Thus, *A. cahirinus* was the dominant species of trapped rodents and followed by *A. nairobae* (18.66%) and *R. rattus* (15.72%) and among the live-trapped rodents (*Table 1*).

Out of the four pest rodents (*Heterocephalus glaber, Hystrix cristata, Tachyoryctes splendens* and *Xerus rutilus*) observed by direct or indirect observation in the study grid except *Tachyoryctes splendens* that is only recorded from Halo Busa Peasant Association from one of its village located in high altitude area, relatively the rest were widely distributed. *Xerus rutilus* were attempted to be trapped as they were attracted to the bait that placed in Sherman live-traps. However, Sherman live-traps fail to trap *X. rutilus* due to its larger size when compared with the size of size trap (*Table 1*).

Rattus rattus was the dominant and widely distributed rodent species that trapped from all study grids particularly from human residences whereas *A. somalicus* and *A. nairobae* were most of the time trapped from agricultural field and its surrounding habitats. The *R. rattus* trapped were in three different forms. The two were brown in color distinguished from each other by presence of dusky venter or a creamy-white beneath and the other form is pure black form which it is relatively limited in distribution.

Acomys cahirinus most of the time trapped from field although there is a case in which it was also trapped from human residence during the night trapping sessions. In many occasions two individual rodents of *A. cahirinus* and *A. somalicus* were trapped in a single Sherman live-trap in area where they were highly abundant.

Table 1. Species composition and their relative abundance of pest rodent recorded in the study area (number in the bracket indicates re-captures)

Species	Common name	Abundance	Relative abundance (%)
Acomys cahirinus	Cairo Spiny Mouse	109(9)	21.41
Arvicanthis nairobae	Nairobi Grass Rat	95(7)	18.66
Arvicanthis somalicus	Somali Grass Rat	45(5)	8.84
Mastomys erythroleucus	Multimammate Mouse	55(4)	10.81
Mastomys natalensis	Natal Multimammate Mouse	71(9)	13.95
Mus masculus	House mouse	29(2)	5.70
Rattus rattus	Black rat/Roof rat	80(8)	15.72
Tatera robusta	Fringed tail gerbil	25(3)	4.91
Heterocephalus glaber	Naked (Sand) Mole Rat	*	*
Hystrix cristata	Crested Porcupine	*	*
Tachyoryctes splendens	East African Mole-rat	*	*
Xerus rutilus	Unstrapped Ground Squirrel	*	*
	Total	**509(47)**	**100**

3.2 PEST RODENTS DAMAGE PERCEPTION AND THEIR MANAGEMENT

All respondents replayed as they have pest animals' problem. From these the number one crop pest identified by majority (54%) respondents was rodents and followed by insect 26%, wild animals 16% and birds 4%. Moreover, all respondents that mentioned rodents as their severe pest also mentioned as they least able to control over them.

The majority (76.7%) of respondents believed that the frequency of rodent damage occurrence was 'regular' and 'frequent' whereas a few respondents (3.3%) were either unable to determine the rate of occurrence or consider it as it occur rarely. The rest respondents stated as the rates of occurrence of rodents' damage is 'occasional'. Most respondents claim the seasonal based regular out break of rodents' damage on their household products based on the availability of food in the house or field.

Respondents reported the damage caused by rodents to both standing crops and stored grains. Cereal crops particularly sorghums and maize, which dominantly cultivated, was most susceptible at the seedling, vegetative, matured and storage stage of its development. More than half of the cereal crops were damaged at its storage stages although it also occurs at its matured, seedling and vegetative stage. Particularly the squirrels cause a great damage by eating the seed before and after its germination stage with 1-2 leaves. The damage occurred at this stage forces farmers to replant the field with other seed.

Fruits and cash crops were also affected at their different stage of growth. The major damage on fruits like that of cereals occurrence at their matured stage was stated by 8.7% of respondents. Few of the respondents stated as rodents cause damage on vegetative stage of growth of the plant. Cash crops like chat affected by mole rat whereas groundnut by squirrels

at all of their stages of developments in the field particularly at its seedling stage and after seeding formation and when it is matured before harvest.

In the same way, the occurrences of rodents' damage on vegetables in their vegetative and seedling stage were reported. Like that of cereals, fruits and cash crops the damage occurred on vegetables at matured stage were reported by few respondents. Unlike that of cereals, the damage on vegetables was not perceived as significant at its seedling and storage stages of developments.

As shown in *Table 2* the majority 70 (46.7%) of respondents estimated the moderate loss on cereal crops up to 50% of their product and followed by loss of less than quarter of their product. In addition, 16% of respondents blame rodents for the loss of more than half and by emphasizing on the incidence of a total loss on their agricultural and household products.

Relatively low rates of damage on fruits, legumes and vegetables were recorded although its estimation of the loss was not as such low. Respondents that had pest rodents infestation on these agricultural crops reported as they face a moderate loss (*Table 2*). In Ija Anani and Biyo Awale Peasant Associations, the loss on groundnut by the squirrel was believed to be tremendous. Even some discouraged and stopped cultivation of the groundnut and sorghum crops in fear of the loss by these pest animals.

Table 2. Respondent estimation on the level of loss caused by pest rodents

Crops	Estimated level of damage					
	Low (<25%)		Moderate (25% - 50%)		High (>50%)	
	Frequency	%	Frequency	%	Frequency	%
Cereal	56	37.3	70	46.7	24	16.0
Fruits	4	2.7	7	4.7	-	-
Legumes	5	3.3	15	10	1	0.7
Vegetables	8	5.3	8	5.3	1	0.7
Others	36	24	75	50	39	26

Porcupines were ranked as leading pest rodent for sweet potatoes although other agricultural crops were too affected by them. Respondents reasoned out that in areas that have porcupine infestation the cultivation of potatoes and sweet potatoes was not carried for fright of their damage.

The least mentioned pest rodent group but not least in their level of damage was mole rat. The damage by mole rat was more pronounced on fruits and vegetables (potatoes and sweet potatoes) as they are fossorial and eat their root and become difficult to control. They destroy sweet potato and other root and tuber crops by collecting and storing it in their burrow. Even large plantations planted for shedding and other purposes were also damaged through feeding its root and making the plant dye and dry.

In addition to the loss on agricultural crop products, household materials and equipments, livestock's (goat), poultry and children were also affected. Half of respondents estimated the losses to be from moderate. These results revealed that communal rodents particularly Brown Rat (*Ratttus rattus*) have been observed as causing great loss on poultry by eating egg and chickens. They also eat the hooves and horns of goat and cattle causing difficult to move and to be infected by microorganisms. In the same way *Xerus rutilus* were also notified as it predate chickens by entering into human residence. In general, the local communities blame all rodents including *H. glaber*, *T. splendens* and *H. cristata* as they damage all things available in their home.

3.3 PEST RODENTS MECHANISM OF DAMAGE AND CONTROL

The present result revealed that rodents were the most noxious pests causing substantial damage to agricultural crops, livestock, poultry, household items and human health through different mechanisms like feeding, discomforting, contaminating and mechanical and disease transmission (*Table 3*).

More than 93% of respondents reported that rodents affect them by discomforting and contaminating (*Table 3*). These pest rodents cause discomforts during their feeding, gnawing and sound production. They produce noisy sound in the walls, attics and ceiling during their scampering, running, scratching, gnawing, grooming, playing and fighting that result in discomfort and sleepless particularly during the night time. Furthermore, they were bite and make wound on the palm and fingers of foot of children and adults. These make them to be ferrous and to feel discomfort with them. In addition to direct

consumption, they were also upshot high damage indirectly by contaminating stored crops by their droppings, urine, hairs, oily skin gland secretions and microorganisms. Most respondents perceived as pest rodents fall into drinking water and also ate and spoil the prepared human food. They contaminate the food more than what they eat by making it to be disgust and forcing them to disposed it as waste.

About 81% of respondents face the rodents' problem related to mechanical damage (*Table 3*). They reported as pest rodents cause mechanical damage almost on all household materials and structures.

Local communities were initiated for pest rodent management after noticing the damaged crops in the fields and after noticing rodent movement rather than considering it as part their routine farming practice. They use different controlling methods or mechanisms like using cat and dog, hunting, trapping and scaring, rodenticides and field sanitation. However, their pest rodent management actions were in ad-hoc, one-off uncoordinated and reactive. The majority of them were only initiated for rodent management after noticing damaged.

Table 3. Respondent estimation on the level of loss caused by pest rodents

Damage/Control	Alternative Mechanism	Frequency (n=150)	Percentage (%)
Damage	Feeding	145	96.7
	Discomforting	140	93.3
	Contaminating	140	93.3
	Mechanical damage	122	81.3
	Disease causing and transmission	3	2.0
Controlling	Using cat	122	81.3
	Hunting and trapping	114	76
	Rodenticide	59	39.3
	Field sanitation	22	14.7

The most widely used method to control rodents damage was the use of cat although it only used to control pest rodents in house or human residence. In addition to cat dog was also used to scare porcupine and squirrels although not much effective. The secondly widely used methods or techniques were hunting, trapping and scaring. They use different equipments like spear, stick, pebble of stone and locally prepared traps or purchased snap traps. Some uses a bucket filled with water to kill rodents. Even they use any materials that were strong and used to beat and kill rodents. For instance more than 10 killed individual pest rodents were over one night was observed in Kelicha Peasant Association form one household by using stick. The third widely used controlling method was the use of rodenticides. However, the types of rodenticides they use were insecticides of grain weevil which seems to be inappropriate. The forth method is habitat manipulation. It is used as a management strategy for the control of pest rodent by clearing bushy and scarab habitats that can be used as pest rodents hiding and reproduction site. The habitat manipulation is used to make habitat uneasily accessible for rodents' food and shelter. One of the very important techniques observed is the technique used to avoid the accessibility of food or materials to rodents by hanging on the roof. They were also uses techniques like diverting floods and smoking into the burrows of mole rat to kill them and to make their burrow unfit for their survival.

4 DISCUSSIONS

The present results of pest rodent species composition is slightly higher than the previous studies conducted by [8] that indicated as 11 species were serious pest in the central parts of Ethiopia. According to [25] reported as the damage caused by rodents depends on their population and species. Thus the high stock of pest rodents' species in the administration can be used as an indication for high potential of pest damage.

The pest rodent species recorded in the present study range from small sized house mouse (*Mus masculus*) to large sized African Crested Porcupine (*Hystrix cristata*). Some pest species are found specifically in certain geographical and environmental conditions, while others are widely distributed. Their occurrence in different abundance and distribution make them to cause a wide range of damage and losses on cereals, legumes, vegetables and root crops. For instance the house mouse (*Mus musculus*) is found mostly in urban areas and in some village dwellings [26]. However, the roof rat (*Rattus rattus*) and the multimammate rat (*Mastomys natalensis*) and the Grass rat (*Arvicathis species*) are widely distributed over East Africa [7], thus occupy diversity of habitats including cultivated fields. The most common rodents in sub-Saharan Africa belong to the genus *Mastomys*. They occur all over the continent in natural grasslands, thicket, cultivated areas and human habitations [12].

The seasonal based regular and frequent rodent damage occurrence on household items seems to depend on food availability in the house or field. The damage on household items seems to be high during the summer time when there was no food from agricultural field. Thus except for a few species, many rodent species are forced to migrate from field to human residence depending on the place where food is available [16]. In particular the migration pest rodent from the field to human residence in the Administration is seems to be facilitated since the houses of most respondents who engaged in farming activities are located in the middle of the farm or close to bushes or pile of stone fence.

The majority of the villagers in the Administration use stone bunds for fencing and prevention of soil erosion and water loss and to increase crop production. In the same way, as in [16] indicated the importance of stone bunds made for soil and water conservation in crop fields. However stone bounds become a suitable habitat for breeding and hiding places for rodents, from where the rodents come out and feed on crops and damage household products. In the present study places with stone bounds faces serious pest rodent infestation. Increase in rodent population of epidemic proportion northern Ethiopia, after years of stone bund construction in crop fields. Thus, proper plan needs to be done to assess the relation between stone bunds and rodent dynamics and crop damage in the future.

In variable environments, there need to predict outbreaks of agricultural rodent pests. Rodent populations often increase rapidly in response to periods of unusually high rainfall, presumably due to an increase in the quantity of food available to them or its quality, such that relationships between the likelihood of an outbreak and past rainfall form the basis of a forecasting method [27].

The local communities in the Administration face problems related to pest damage on their products whether they participated on crop cultivation or not. Dominantly pest animals like rodents, insects, wild animals and birds were mentioned as they affect their agricultural or household products of which rodents were the dominant and they least able to control over them. The damage by rodent is an important cause of harvest loss throughout the world-wide and forcing farmers often to list them as one of their most significant crop pests [28].

The different types of crops such as cereals, vegetables and fruits cultivated in study areas were damaged by pest rodents at their different stages of their growth and development. Pest rodents are the most serious and important vertebrate pests of various crops, inflicting damage from sowing onwards until harvesting, storage, distribution and actual consumption of the produce [27]. These crops were most susceptible to pest rodents at different stage of their growth or development. The most serious damage would be the loss of seeds from sawed farm field forcing farmers for the next planting [26].

Almost all respondents believed that rodents cause a significant damage or loss in different items due to their feeding habits of varieties of food items and gnawing nature. Rodents eat on grains, cereals, fruits, seeds, nuts, buds, barks, seedlings, leaves, flowers, roots and invertebrates [29]. Most rodents are opportunistic feeders, capable of changing their feeding habit depending on the availability of food from season to season. Thus, these behavioral traits make them to be the most destructive pest animal.

The present results of the study suggest that as there is a significant variation on the level of damage at different stage of growth on cereal crops with highest during its matured and storage stage. Similar to the previous studies conducted in different counties, pest rodents cause damage on cereal crops from sawed seed predation to the slanting cut of the tiller at its base to the feeding of the matured grain before harvest. They were also dragged the matured grains of cereal crops from the farm field to their burrows. In the farm field although damage was more pronounced around surface openings of their burrows, it was spread all over the field. Most of the rodent damages in agricultural fields occur during the sensitive young seedling stage and just before harvest [26]. The studies made by [28] indicated the cumulative damage occurrence during the dry season reach 54% at the primordial stage, 32% at the booting stage and 16% at the ripening stage. However, farming practice, the change in climatic factors and the intrinsic characteristics of the pest species are among the factors that possibly influence the occurrence and severity of rodent attacks on crops [29].

The level of damage on agricultural crops and other materials were roughly ordered as low for estimation of loss less quarter (>25%), moderate for less than half of loss (<50%) and high indicating for loss greater than half (>50%). However, in some cases during the pilot survey of the current study, the respondents were unable to estimate post-harvest damage. As in [30] stated many countries have a poorly documented on exact losses or damages on agricultural crops and household materials and on their prevalence of rodent-borne disease. They estimated losses on stored cereal crops by merging it with other storage materials and household properties. The estimated amount of crops damage by majority of farmers in the house was higher than in the field. The figure might seem to be small but for such subsistence and small-scale farming community such loss in annual production is hard to tolerate [26].

Rodents are known to damage and destroy 30% of the crops in both pre-harvest and post-harvest conditions worthing of $ 30 billion, globally [31]. In East Africa, they cause considerable economic losses to staple crops, particularly tubers and

cereals. For example, in Tanzania, the loss of cereals by rodents reaches approximately 15% [29] and the damage of maize at sowing and seedling stage is around 40–80% [32]. In western Kenya, as in [33] reported a 20%, 34-100% and 34% loss by rodents out break on maize, wheat and barley, respectively. The studies made in the central Ethiopia have been documented to as rodents consume up to 26% of the cereal crops [8], [17].

The pattern and the extent of damage by pest rodents depend upon the species, the intensity of infestation, type and stage of growth of crop and nature of the surrounding habitat. Most of the estimates of damage related to pre-harvest stages of the crop although they cause damage at almost all stages of the crop from sowing to its harvesting. Knowledge of the mechanism, extent of the damage and the situations vulnerable to attack by rodents in different crops and regions is important in planning management strategies [18].

Among the oil seed crops groundnut often suffers severe (up to 85%) loss by rodents. Although other pest rodent specie like *M. musculus*, *A. somalicus*, *M. natalensis* and *T. robusta* were abundant in groundnut fields and major damage caused on it was by *X. rutilus* [18]. Rodents may damage the whole or the branches of the plant during burrowing. They damage and removal of the pods at the maturity and harvesting stages and take them in to their burrows [18].

Porcupines are among the world's largest rodents and have long been recognized as forest pests in many countries of the New and Old Worlds [3]. However, the old world porcupines of the genus *Hystrix* have been little studied because of their shy nature, nocturnal habits and tendency to live in remote and inaccessible places [34]. Crops of economic importance such as maize, groundnut and potatoes and vegetables like pumpkin and onions are severely damaged. Similarly in Pakistan porcupine is identified as the abundant and widely distributed and serious pest of fruits, vegetables, flowering plants and forage grasses that ranged between 5.7 and 30%, with an average of 17.6% [34].

Rodents cause direct damage to various commodities by gnawing, feeding, and indirectly damage by spoilage, contamination, deterioration and enhancing susceptibility to fungal and bacterial infestations during pre- and post-harvest stages [18], [30]. Rodents gnaw and perforate structural materials and dig burrow into banks, sewers and under roads and buildings cause flooding, soil erosion and collapse of human built structures [5].

Although rodents known as carriers of more than 60 life-threatening diseases [30] in the present study no body claimed as they cause and transmit disease. However, the wound they cause on skin during their bite, feeding on the skin and nail of human and animals and wounds by piercing of quill during the defense were the astonishing damage. Sever health problem incidence was recorded from Biyo Awale Peasant Association that occurred due to attach of porcupine by its quill.

Even if the majority of respondents know the use of cat for pest rodent control, some are not much interested to use it. The reasons forwarded were the current change of cat's food preference for foods for human consumption rather than feeding on rat and mice meat. This change in food preference of the cats might be a reason for the less interest in trapping and capturing rats and mice. The second reason is the rise of milk cost and meat that is assumed to be natural supplementary food for cat. Thirdly, some rats are beyond the capacity of the cat and they defend well not to be preyed or captured.

Although rodenticides widely used current use of insecticides for pest rodents' management seem to be inappropriate. The unwise and inappropriate use of rodenticides results in genetic resistance, behavioral avoidance, non-target animal poisoning and environmental pollution [28].

Rodents show preferences for habitats with high amount of vegetation cover [35], which is closely related with predation risk. The selection of thick vegetation is considered to be an anti predatory strategy against both aerial and terrestrial predators. Various means of cover removal have resulted in depletion of rodent populations [36]. The composition and abundance of rodents at given habitat depends on microhabitat features, which provide food and shelter against predators [37]. Thus as reported by [38], the habitat manipulation techniques recorded in this study can be considered as cost-effective and is a viable strategy for the control of rodent damage.

5 CONCLUSION

The present high records of major pest rodent species not only indicate us as the area is highly infested with pest rodent species but also indicated us the existence of a high stock of rodents' species composition. Although rodents were listed as number one pest animal and make them to be least able to control additionally insects, wild animals and birds were also perceived as pest. The regular and frequent occurrences of rodents out break can be used as an indication for the extents of pest rodents' problem that seek urgent application of pest management plan and strategy development. Agricultural crops were most susceptible to pest rodents at different stages of their growth. Mostly cereals were damaged by the pest rodents at their storage and matured stage that can be used as an indication on their time of managing the loss. Rodents cause damage on different items through feeding, causing discomfort and mechanical damage. However, to prevent or minimize of

pest rodents infestations different methods like using cat and dog, hunting, trapping and scaring, rodenticides and field sanitation were mostly used. The current local communities' ad-hoc, one-off, and uncoordinated, actions of rodent management actions needs to be improved and ecological based rodent management strategy need to developed and used through education and extension programs that strongly focus on demonstration and community participation.

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Insights on cholesterol nutrition: shift to a new paradigm for better cardiovascular health

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ABSTRACT: Cholesterol is an extremely important biological molecule involved in a multitude of biological processes regarded as vital for our survival. Yet, the function that has attracted more attention is its contribution to the development of atherosclerosis, a chronic inflammatory disease of blood vessels, which constitutes an underlying cause of coronary heart disease. Atherosclerosis is the principal cause of myocardial and cerebral infarction and remains the chief cause of death across many parts of the globe. Shockingly, despite its extreme physiological importance, cholesterol remains the most controversial nutrient ever. Misconception continues to exist not only among the people lacking knowledge in nutrition, but also among many nutrition researchers. The misconceptions surrounding cholesterol have been so pronounced and persistent that its beneficial effects are hardly heard of. Pharmaceutical companies are using this mass (cholesterolphobia) to flourish their business. However, recent studies demonstrate that cholesterol plays a minor role in cardiovascular disease. The objectives of this article are twofold. Firstly we review research articles to analyze the existing ideas regarding the link between heart diseases and cholesterol. Then we provide an up-to-date information about some health impacts of cholesterol and highlight the effects of anti-cholesterol drugs based on the researches performed to date.

KEYWORDS: Cholesterol, Cardiovascular disease, Atherosclerosis, Inflammation, Anti-cholesterol drugs.

1 INTRODUCTION

Cholesterol ($C_{27}H_{45}OH$) is an extremely important biological molecule that plays major roles in membrane structure and serves as the sole precursor for the synthesis of the steroid hormones and bile acids. Cholesterol is a type of sterol, a class of lipid molecules, waxy substance found in all parts of the body. Body gets cholesterol from two different sources, dietary and from synthesis in liver. Biosynthesis in the liver accounts for approximately 75% of the amount produced each day [29]. Both dietary cholesterol and that synthesized de novo are transported to the target cells to be used in the manufacture of hormones and cell membranes through the circulation in lipoprotein particles known as LDLs and HDLs. A low level of LDLs and high level of HDLs are believed to lower the risk of heart disease. In general, healthy adults synthesize cholesterol at a

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rate of about 100mg/day and consume approximately 300mg/day and blood maintains a relatively constant level of cholesterol of 150–200 mg/dL primarily by controlling the level of de novo synthesis [1]. The greatest proportion of cholesterol is used in bile acid synthesis. The medical establishment commonly incriminates cholesterol for everything from all types of cardiovascular diseases (CVD) disease to neurodegenerative diseases such as Alzheimer's. But recent epidemiological and clinical studies show that high cholesterol level is not the main cause of CHD. On the contrary it has proved to be beneficial in the normal regulation of many biological pathways. For example cholesterol is indispensable in the brain for its significant role in the process of memory formation and optimal functioning of neurotransmitters. Though cholesterol has involvement to the development of arthrosclerosis, many cardiologists now beginning to believe that it's a minor contributor to CHD and the most deleterious cause is actually inflammation. Inflammation is body's innate immune response to injuries resulting from infection and/or other physical injuries. Various kinds of anti-cholesterol drugs are presently available on the market. But it appears that doctors are prescribing such drugs before their safety measures are tested on all target population. Drug companies are more mindful in disseminating their products and hiding many side effects that occur on long-term use of these drugs. Thus it appears that by avoiding cholesterol in diet and by taking medication to keep blood-cholesterol level low, people are engendering greater health hazards. We need to avoid the misconceptions about this vital nutrient and have to maintain proper dieting that is conducive to cardiovascular health.

2 CHOLESTEROL AND CARDIOVASCULAR DISEASE

It's been few decades now since the executive board of the World Health Organization declared coronary heart disease as 'Mankind's greatest epidemic'[33]. Still today cardiovascular disease (CVD) is responsible for approximately one-third of deaths worldwide [34]. Cholesterol has historically been incriminated as an accomplice of all types of cardiovascular diseases. According to a recent WHO report, high blood-cholesterol is estimated to cause 18% of global cerebrovascular disease and 56% of global ischaemic heart disease. Together this amounts to about 4.4 million deaths (7.9% of total) and 40.4 million DALYs (2.8% of total) [36]. It was after the research by a mid-nineteenth century German pathologist Rudolph Carl Virchow (13/10/1821 – 5/9/1902) when cholesterol entered the picture, who first theorized that high blood-cholesterol level leads to the formation of plaques in arterial walls. Since then the link between cholesterol and heart disease has been a very popular venue for many medical studies. Almost a hundred researches and studies have been conducted just to find out how cholesterol's contributes to heart diseases. To date, the most widely accepted underlying pathology of most clinical manifestations of CHD is atherosclerosis. However, whether or not cholesterol contributes to atherosclerosis has always remained controversial [53]. A group of researchers at the Saint Louis University School of Medicine once hypothesized that cholesterol contributes to atherosclerosis by suppressing the activity of a key protein that protects the heart and blood vessels. Some other studies revealed that excess cellular cholesterol induces apoptosis in macrophages, an event likely to induce the development of atherosclerosis. Development of atherosclerosis is associated with the induction of the endoplasmic reticulum stress pathway known as the unfolded protein response (UPR) [31]. It was subsequently proposed that cholesterol channeling to endoplasmic reticulum membranes, resulting in activation of the CHOP (A stress-inducible nuclear protein, also called GADD153) arm of the UPR, is the key signaling step in cholesterol-induced apoptosis in macrophages, which by a certain way influences formation of plaques [32]. However, many epidemiological surveys indicated that the majority of CHD events occur in people who show moderate or low blood cholesterol levels. High levels of blood-cholesterol have consistently been shown to be associated with coronary heart disease risk [41]-[45], [55]. On the other hand, low levels of blood-cholesterol have shown to be associated with marked increase in mortality in advanced heart failure [40], [54]. Lowering blood-cholesterol levels reduced rate of death from coronary disease related causes in both who had coronary complications as well as in those who didn't have [46]- [51]. Thus the relationship between cholesterol and heart failure remains clouded till today. However, in the light of some recent and more comprehensive studies, which focused more on the activity of cholesterol carriers(LDLs and HDLs) rather than cholesterol itself, researcher are slowly coming to accord with the fact that cholesterol itself has no particular link to the development of CVD whatsoever. It is worthy of mentioning that, in all likelihood, the mystery roots not in cholesterol, but somewhere else. The exterior of LDL molecule is made up mainly of lipoproteins and cholesterol. When it becomes deficient in cholesterol, the fatty part in the lipoprotein become more vulnerable to attack by oxygen and also the protein (apoB) part becomes vulnerable to attack by blood sugars, especially glucose and fructose. During a state of increased blood-sugar, more and more sugar molecules get stuck to the protein part which results in relatively less efficient LDL particles as they fail to transport the contents to target cells. Consequently they begin to travel longer in the bloodstream resulting thus evident that blood cholesterol/LDL/HDL level alone is a relatively poor determinant of individual CHD risk. Furthermore, now we know that there are at least five different types of LDL and HDL particles and there is growing evidence that only the small LDL particles are able to squeeze through the artery linings and can do potentials harm when oxidized(turning rancid). There is a natural tendency among many researchers to highlight the most positive findings in their study, particularly where commercial sponsorship is involved. The fact of the matter is that, since there are sufficient evidences both qualifying and rejecting cholesterol to be a

genuine contributor to CVD, it provokes a need for more pragmatic clinical trials based on more personalized treatment rather than randomized trials which involves homogenized sample population. Moreover, risk factors are capable of greatly altering the profile of CVD events in different individuals. *Hence, it is assumable that cholesterol screening is unlikely to reduce mortality and can be misleading or even harmful.*

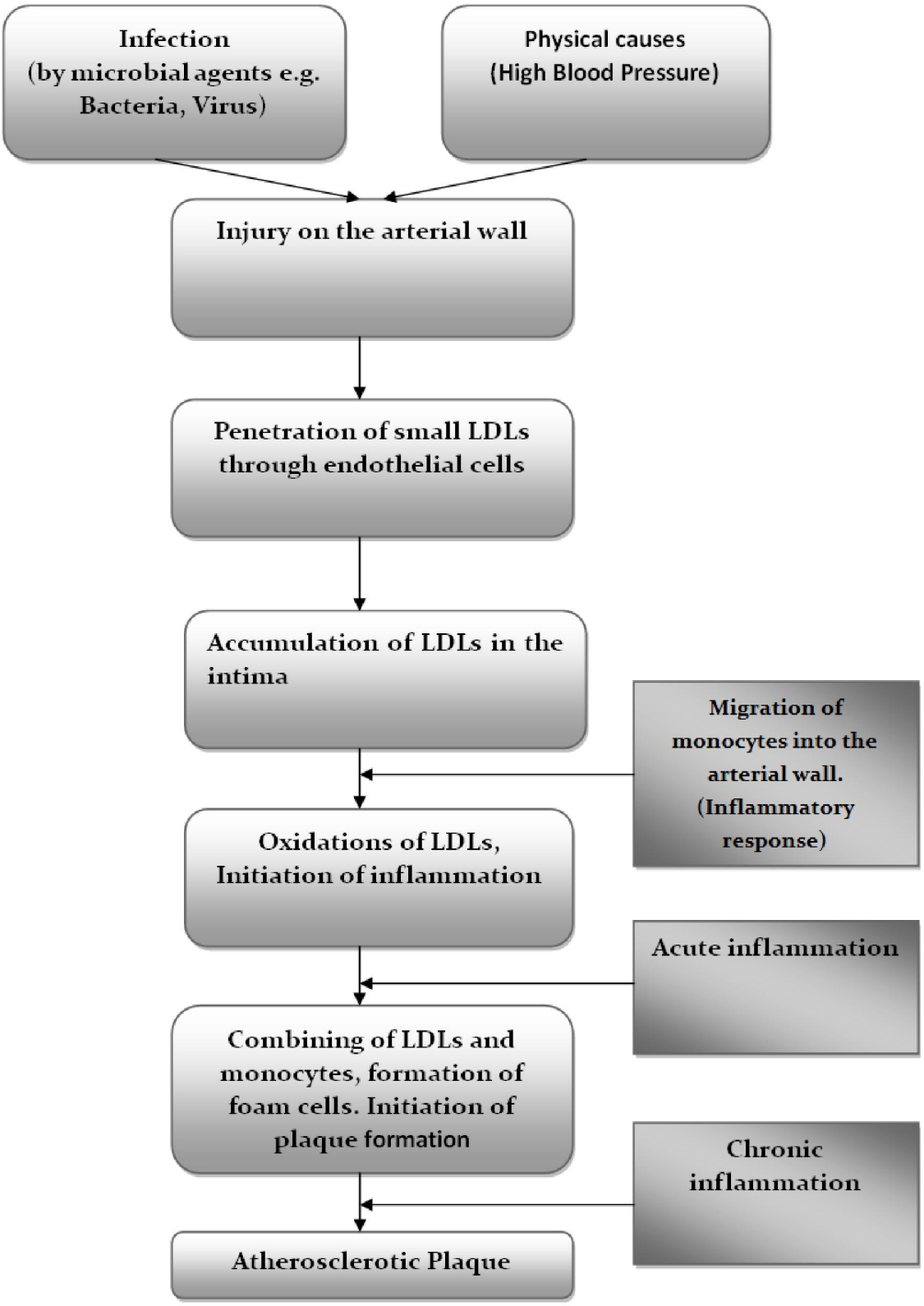

Fig. 1. Steps of the development of atherosclerosis

3 NEUROLOGICAL IMPLICATIONS OF CHOLESTEROL

Cholesterol is an extremely important molecule for maintaining a healthy brain where it functions as an antioxidant, as a structural scaffold for the neural network and a functional component of all membranes. Scientists in the early 19th century regarded it as 'a principal element' for the nervous system [83]. The central nervous system accounts for only 2% of the whole body mass but contains almost a quarter of the unesterified cholesterol present in the whole body [20]. Around 95% of the cholesterol content in the brain can be accounted for by de novo synthesis ([92], [93]). The cerebral production appears to be relatively constant, although the hepatic metabolism varies with age. Cholesterol helps in the formation of memory and vital for neurological function. The brain's dry weight is 60% fat and cholesterol plays a vital role in neuron signaling and brain structure. Brain signaling is all about membranes, and cell membranes contain a good amount of cholesterol. Cholesterol is required for myelination, dendrite differentiation, and synaptic activity. It has been estimated that up to 70% of the brain cholesterol is associated with myelin. The brain has an independent and isolated pool of cholesterol which reflects a high need for constancy in the cholesterol content of membrane and myelin. Patients with defected 7-dehydrocholesterol-7-reductase in the brain show mental retardation, most likely caused by a deficiency in myelin function [84]- [85]. The blood-brain barrier effectively prevents it from exchange with cholesterol in the circulation [86]- [88]. Brain Cholesterol homeostasis is regulated through *de novo* synthesis by the action of 24S-hydroxycholesterol, most of which are found in brain [89]. Some researchers showed that Oxysterol, an oxidized form of cholesterol, is necessary for the formation of dopamine-producing neurons during brain development. The process requires the activation of a specific receptor in the brain which is mediated by Oxysterol. Cholesterol is also known be an important chemical in dopamine transporter function [90]. Disturbances in central nervous system cholesterol homeostasis are implicated in neurodegenerative disorders, including Alzheimer and Huntington diseases [84]. Recent results indicate that both cholesterol synthesis and degradation are active in the adult brain as well and that alteration in these mechanisms profoundly effects higher-order brain functions [91]. Some studies found that individuals with type 2 diabetes (who tend to run raised blood sugar levels) have a 2- to 5-fold enhanced risk of Alzheimer's disease (AD) due to impaired cholesterol availability to the brain [94]. Brain cholesterol homeostasis misregulation causes the key AD feature of learning and memory failure as a result of the impairment of neuronal function, neurotransmission and synaptic plasticity [22]. The normal functioning of serotonin in the brain is profoundly influenced by the availability of cholesterol in the central nervous system [17-19]. Though brain appears to be independent in its own cholesterol supply, several epidemiological and clinical studies have demonstrated that low serum cholesterol reflects reduced cholesterol content in the brain, specifically in brain cell membranes which affect the serotonergic system, due to the lowering of the lipid microviscosity of the brain cell membranes [10]. Cholesterol and the omega-3 fatty acids are two most important molecules for normal synaptic transmission. Depleting cholesterol impairs the function of the serotonin 1A receptor and the serotonin 7 receptor, and reduces the ability of the membrane serotonin transporter. Reduction of serotonergic function profoundly affects brains natural performance and causes severe mood disorders, mixed-anxiety and depression. Low serum cholesterol has been linked in numerous scientific papers to suicide, accidents, impulsive acts, hostility, aggression and violence [2]-[11].

4 ROLE OF IMMUNITY AND INFLAMMATION IN ATHEROSCLEROSIS

Cholesterol is vital for immune function. It is a precursor to vitamin D which is essential for immune system function. It is also a precursor to corticosteroids, hormones that support immune system by protecting the body against stress. Many researchers have suggested that the blood lipids play a key role in the immune defense system [68]-[73]. Immune system plays an important role in the development, progression, and the complications associated with atherosclerosis [75]. High cholesterol is believed to be protective against infections and atherosclerosis [77]. Apparently, microorganisms play a role in cardiovascular disease. A large number of studies have reported on the associations between of coronary heart disease and various bacterial and viral agents and clarified the role of chronic infection and inflammation in CHD. Some studies have mentioned that during the weeks preceding an acute cardiovascular attack many patients have had a bacterial or viral infection [78]. They may be one of the factors that start the process by injuring the arterial endothelium. A secondary role may be inferred from the association between acute cardiovascular disease and infection. Infectious disease causes deleterious effects on blood clotting with sludgy blood flow which promotes vascular occlusion. During infections an inflammatory infectious reaction may be occurring in the arteries. Inflammation is a natural protective response intended to eliminate the initial cause of cell injury and thus it is intimately associated with the repair process which include clogging of the injured area, regeneration of tissues and scarring. But chronic inflammation is associated with the risk of excessive plaque formations and subsequent coronary complications. Evidence of bacterial and viral infections in the walls of arteries have been found by electron microscopy and immunoflourescence microscopy in many patients [80]. Infection is caused by a bacterium, virus or fungus, while inflammation is the body's response to it and a part of body's innate immunity. A medical

team in Germany found that the strongest predictor for death in a patient with heart failure was the concentration of cytokines type of hormones secreted from white blood cells in response to inflammatory process in the body [79].

5 IN SEARCH OF THE REAL CULPRIT

The most apparent link between CVD and cholesterol is atherosclerosis. Atherosclerosis, sometimes called hardening of the arteries, which is a condition that causes the arteries of the heart and other tissues to become hardened and narrowed, preventing normal flow of blood and increasing the risk of heart attack. In Greek the term 'Arthero' means the building up of fatty gunk in arterial walls which is also known as plaques and 'sclerosis' means hardening or thickening. Generally it takes years to for atherosclerotic plaques to become bulky enough to hinder normal flow of blood. When there is damage to the arterial wall initiated by certain causes, small LDLs penetrate the endothelium and begin to accumulate in the intima (the innermost layer of arterial wall). In the intima the LDLs gets oxidized which is harmful for health and causes inflammation. In response to this inflammation liver begins to release more cholesterol in the blood stream. Problem arises if inflammation is prolonged which causes more cellular damage and liver starts to send out more cholesterol to take part in tissue repairing process. Were there no inflammatory damage, no extra cholesterol would have released in bloodstream by liver. Thus a rise in blood-cholesterol level indicates the occurrence of an inflammation. Thus, raised blood-cholesterol actually serves as a symptom of the underlying problems. Atherosclerosis, which manifests itself as acute coronary syndrome, stroke, and peripheral arterial diseases, is a chronic inflammatory disease of the arterial wall [62], [76]. The atherosclerotic plaque is characterized by an accumulation of lipids in the artery wall, together with infiltration of immunocytes [81]. The defense of the normal artery depends on innate immuneresponses of endothelial cells and, which after an inflammatory signal, by macrophages and other cells of the immune response that are recruited to the artery wall. Such innate immune responses also have a major role in the initiation of atherosclerosis [82]. Cholesterol is body's natural response to inflammations. Therefore it is INFLAMMATION, which is the real culprit behind heart disease, while we've been obsessed with cholesterol for around a century. Inflammation is triggered when innate immune cells detect infection or tissue injury. Chronic inflammation as measured by high sensitivity C-reactive protein which predicts future risk of acute coronary syndrome independent of traditional cardiovascular risk factors. *Inflammation*, not high *cholesterol*, is the primary cause of heart disease. Harvard researchers have discovered that a high blood level of C-reactive protein, a marker of inflammation, is more predictive of heart disease than cholesterol. More recent studies claim that stem cells also play a certain role of in the development of Atherosclerosis, which are able to produce various types of cells including adipocytes and osteocytes. So the deal is to avoid foods that causes inflammation (e.g. trans-fat, omega-6, refined sugar rich food) rather than cholesterol-rich foods(e.g. egg, butter, red meat, organ meat). The typical American, however, consumes 15 times more Omega 6 fats than Omega 3s. This imbalance creates the path for increased inflammation and accounts for the high morbidity and mortality from CHD.

6 FACTS ABOUT ANTI-CHOLESTEROL DRUGS AND PHARMACEUTICAL COMPANIES

With anti-cholesterol drugs begins the second chapter of cholesterol-cardiovascular tragedy. Nowadays there are around hundreds of different types of anti-cholesterol drugs on the market. Statins and Lipitors are regarded as some of the greatest triumphs of modern medicine. Statins are potent cholesterol-lowering drugs and claiming them very effective in the prevention of coronary heart disease. It's no surprise that Statins constitute one of the most important sectors of the pharmaceutical industry, with total revenues exceeding $25 billion in 2009. There's no question about their efficacy in lowering cholesterol. Yet there remains something to ask- *does lowering cholesterol actually benefit patients with coronary artery disease*? These drugs have a range of well-documented negative effects. The evidence of the adverse effects of statins in the treatment of stable coronary heart disease continues to grow. Besides that, Statin treatment has found to be effective only when the initial LDL level is high. Large-scale, randomized, secondary-prevention trials involving patients with CHD have shown that statins reduce the clinical consequences of atherosclerosis, including death from cardiovascular causes, nonfatal myocardial infarction, nonfatal stroke, hospitalization for unstable angina pectoris and heart failure, as well as the need for coronary revascularization. But almost all of those studies were short lived, and/or weren't carried out for long enough to observe the long-term effects. Statin therapy is associated with excess risk of developing diabetes mellitus [39]. Besides that, cholesterol-lowering drugs are also lipid-lowering drugs which cause myopathy, even rhabdomyolysis. Few Studies have also shown that Statin drugs exert their anti-cholesterol properties by inhibiting the function of HMG coenzyme-A reductase(3-hydroxy-3-methylglutaryl-coenzyme A), which catalyses an early step in the biosynthesis of cholesterol. This step also generates few other vital biological substances (for example Coenzyme Q10, also known as CoQ10) that are required for normal functioning of cells. CoQ10 is a fat-soluble antioxidant present in almost all cell membranes, required for the proper functioning of Vitamin E. It is also an essential component of the mitochondria. CoQ10 is known to prevent arteriosclerosis by reducing the accumulation of oxidized fats in blood vessels. Several studies revealed that the function of the heart may be

improved after major heart surgeries if CoQ10 is given to patients before or during surgery [38]. It is even found to be necessary for brain functioning. Statin drugs inhibit not only cholesterol biosynthesis, but also that of CoQ10, as they are synthesized from the same precursor (mevalonate). The loss of CoQ10 leads to loss of cell energy and increased free radicals which in turn can damage mitochondrial DNA and sets the way for farther cellular damages. Gradual depletion of CoQ10 causes fatigue, muscle weakness and soreness, and eventually heart failure. Thus while lowering blood-cholesterol; Statins also decrease energy supply to nerves, muscle and heart by lowering CoQ10. However, anyone who has no choice but taking statin must also consume sufficient CoQ10 supplements to avoid the consequences of depletion of CoQ10. Another important substance whose synthesis is blocked by Statin is Dolichol, which plays a crucial role in the endoplasmic reticulum.

Table 1. Most widely used Anti-cholesterol drugs

Active ingredient	Example	Efficacy (percent)	Potential Side Effects	Mode of action
Statins	Atorvastatin, Fluvastatin, Lovastatin, Mevastatin, Pitavastatin, Pravastatin, Rosuvastatin, Simvastatin.	Lower LDL-C by 30-50%, triglycerides by 20-40% Raises HDL-C by 10%	Rhabdomolysis, Insomnia, Headache, GI problems, Memory loss, mental confusion, high blood sugar, Renal impairment, Liver disfunction, pregnancy complication.	Inhibit the activity of HMG CoA reductase
Fibrates	Lopid, Tricor, Lopid.	Lower LDL-C by 10%, triglycerides by 40-60% Raises HDL-C by 10-20%	indigestion, headache, muscle weakness and/or pain.	decreases the formation of VLDL, very low-density lipoproteins
Bile acid sequestrants	Questran, Welchol, Cholestagel, Colestid	Lower LDL-C by 20% Raises HDL-C by 10%	constipation, abdominal pain, bloating and gas.	binding to bile acids in the intestine, resulting in their elimination from your body.
Nicotinic acid	Niaspan	Lowers LDL-C by 15% Raises HDL-C by 15-30%	Flushing, itching, rash and high blood sugar.	blocking the formation of LDL, the bad cholesterol, and decreasing the production of VLDL in the liver.
Intestinal absorption blockers (Ezetimibe)	Zetia	Lowers LDL-C by 20%	muscle pain and abdominal pain.	blocking the absorption of dietary cholesterol in the intestine

Moreover, since most anti-cholesterol drugs also lower LDL, which is a carrier of all other fat-like nutrients including fatty acids, fat-soluble vitamins, fat-soluble antioxidants; the bioavailability of these nutrients are significantly decreased and body becomes exposed to the risks which are protected by these nutrients. Consequently liver begins to produce low quality LDL particles, containing insufficient protective cholesterol, which results in increased vulnerability of the LDL particles to the free blood sugars. Several studies showed that people who have extremely low levels of blood-cholesterol have a greater risk to dying in later years from a variety of causes, including suicide, homicide, strokes, certain cancers, liver disease and lung disease. However, there is no controlled study yet to demonstrate the benefit of Statin drugs on women, children, and men over 65. There lipid-lowering statins should not be prescribed for women of any age and for men older than 69 years [63]. In fact, some reviews of clinical studies on cholesterol-lowering drugs suggest that the survival rate is not improved because the observed reduction of deaths from coronary heart disease is offset by a noticeable increase in non-cardiac mortality, including cancer and violent deaths. A recent WHO report says Thanks to population-wide policies and individual risk

management in the past 30 years CV disease has decreased by more than 50% in many developed countries. It doesn't indicate that it is due to the advent anti-cholesterol drugs. One meta-analysis showed that in healthy patients Statin reduced the rate of mortality only by 0.6% [64]. People are beginning to realize that they are actually inviting more serious evils in exchange of a minor one. Heart diseases have many risk factors. Hence the treatment can't be as simple as taking a pill, no matter how effective it is. Emphasis should be given on controlling risk factors too. The fact of the matter is that, people have become overly obsessed about drugs to cure our health problems rather than taking measures to prevent it. Drugs are barely healing patients and at the same time generating other indirect yet serious aftermaths, thereby increasing the necessity for more drugs. And this type of necessity has made drug industry the most lucrative sector of modern day economy. In USA no other industry makes as much profit as the drug industry does. Billions of dollars are being spent to invent new drugs, billions of dollars being spent to advertise them and billions of dollars are being spent to offer free samples. No doubt there are many more billions spent to manipulate the knowledge and data acquired by researchers, doctors, pharmacists and health officers from the experience of their consumers. The ready money serves as a strong deterrent against any legislative proposal that would lower costs for consumers and profits for the drug makers [67]. Prosperity and goodwill of the drug companies are rooted on not only inventing new drugs, but also new diseases. No drug has ever been able to cure any chronic disease, yet drugs for chronic disease remains the most sold ones ever. Lipitor was the highest selling drug for about a decade. Last year Crestor was the third most sold drug worldwide. As is the case with anti-cholesterol drugs, drug companies are targeting to bring more diseases than cures and scam patients for vast amounts of money, by treating the symptoms but not addressing the cause. As a matter of fact, treating high blood-cholesterol is nothing but treating the symptoms, and not necessarily the disease. Not only the anti-cholesterol drugs are being manufactured, but also many unscientific information which are bringing welfare for drug companies, and severe threats to public health. Not surprising, anti-cholesterol and anti-depressant drugs are always on the top selling list. Statin use has increased in recent years as high cholesterol, heart disease, and diabetes are being diagnosed more frequently. Physicians are increasingly influenced to prescribe these drugs. Patients are also becoming increasingly dependent on drugs and in most cases neglecting the fact that life style has a greater effect on health and disease than these magic drugs. Since cholesterol is needed for maintain good memory and brain health, the more there are patients taking anti-cholesterol drugs, the more there is need for anti-depressant drugs. More and more young people are taking anti-depressant drugs nowadays. CVD provides a very lucrative ground for pharmaceutical industry as it's one of the most feared diseases in the world. The guidelines that create the clinical imperative for physicians are manipulated by experts who have financial ties to drug companies. It has been repeatedly shown that doctors prescribing practices are influenced by interaction with industry representatives and attendance at events sponsored by drug companies [66]. In a meta-analysis of statins in *Lancet*, 13 out of 14 studies were commercially sponsored. The industry also maintains a war chest for advertising and grassroots lobbying aimed at altering public opinion. The worst part of the story is that the ordinary folk are kept away from the light of scientific truth and they are bound to obey their physicians' prescriptions, which are in some way other manipulated by the drug industry itself. Once someone is found with high blood-cholesterol, he/she is somehow sentenced for a lifetime use of anti-cholesterol drugs. Patients who already had a heart attack are prescribed to continue these drugs to maintain a constantly low level. And according to the prevailing trend, the level has no lower threshold, the lower the better. The consequences of such medical malpractices are borne mostly by healthy people is more and more people are at risk of falling sick. Heart diseases have become a matter of regular checkups, blood tests and taking costly medicines. These drugs are not only depriving us of our wealth, but also our health. More and more we're falling sick before we really fall sick. More than ever we're dying from drugs than from diseases. It's the high time for a paradigm shift now. Health is a global issue and it exiges for a global approach to bring forth a sustainable healthcare system, and improvement of corporate ethics of the healthcare industry.

7 CONTROLLING THE CONTROVERSIES

Ancient pharmacological knowledge tells us that everything is toxic; it is only the dose that draws the differentiating line between the toxic and the non-toxic. So must be true for cholesterol too. If cholesterol were really so harmful then how come liver goes on producing it every day beginning from birth and not all of us die from heart disease! It's a vital nutrient and body is capable of producing by itself. It does make no sense to cut its dietary intake or inhibiting body's natural ability of producing it by taking medications. Furthermore, absorption rate of cholesterol from diet is relatively low and by removing all cholesterol from the diet the blood cholesterol will only fall by about 20% to 25%. So cholesterol in food may matter, but not nearly as much as we are used to believe. Chronic excessive intake of any nutrient above threshold would cause toxicity. Vitamin and mineral toxicity is well known fact. Even water consumed in an excessive volume (known as Water intoxication) in a short time can cause death [28]. But cholesterol has never found reach toxic level in human body as body has its own mechanism to discard the excess the surplus amount. Besides that, almost 80% of body's cholesterol is finally converted to bile acid which has no such influence on heart diseases. The fact remains that, humans preside over the plant kingdom by virtue of two elements- conscience and cholesterol, and even the first one would go inert without cholesterol. We are

supposed to have cholesterol in our body and not depriving body from the functions it exerts. Life wouldn't be possible if cholesterol were not present in sufficient amount in our body. Cholesterol is the long misunderstood molecule that plays critical roles in human develop and survival. People with high blood-cholesterol are suggested to avoid cholesterol rich food. But unfortunately most cholesterol rich food are also very good source of other vital nutrients. Egg, red meat, organ meat are ideal sources of protein, and many other important nutrients such as Zn, Cu, Fe and CoQ10. Increased consumption of PUFA induces an increased rate of cholesterol synthesis to maintain their stability and proper fluidity in the cell membranes [21]. But almost all of these foods are prohibited by many dieticians due to their high cholesterol content. Such faulty ideas can lead to serious health problems. Blood cholesterol might serve as an important risk factor for CHD but should be considered in the context of other risk factors such as smoking, high blood pressure (HBP), physical inactivity, hypertension, obesity, [51]- [52]. Newly emerging CVD risk factors, such as low birth weight, folate deficiency, and infections, are also more frequent among the poorest segments of the population in low and middle-income countries [35]. Infants require plenty of cholesterol for proper brain development and cholesterol content of breast milk gives a clear evidence of that. Infant formulas are usually made free of cholesterol due to lack of adequate knowledge about the necessity of cholesterol. Avoiding cholesterol rich food is associated with the risk of being deficient in very low cholesterol levels, which make death from other causes more likely. The issue of cholesterol has long been clouded by debate because large-scale studies of people with high cholesterol levels have shown that lowering their cholesterol levels reduces their rate of fatal heart disease, but, paradoxically, no overall reduction in mortality has been seen. Normally people who are at risk of developing heart disease are advised to lower their cholesterol level even if it is already low enough due to the belief that the lower the level of blood-cholesterol, the lesser is the risk of heart diseases. According to certain studies that address the link between cholesterol and heart disease, the best way to reduce cholesterol and prevent heart disease is to adopt a healthy diet rather than avoiding cholesterol in foods and that the link between the two is made possible only with poor diet.

Table 2. Major Risk factors of atherosclerosis

Age	Male: ≥45 years Female: ≥55 years
smoking	Highly associated with smoking habit
Genetic factors	Myocardial infarction or sudden death before 55 years or 65 years of age in parent or first-degree relative, male or female, respectively
Family history of hypercholesterolemia	Individuals with family history of hypercholesterolemia are more likely to develop atherosclerosis
Hypertension	Blood pressure equal or above ≥140/90mmHg
Diabetes Mellitus	Individuals with diabetes frequently have what is commonly referred to as an atherogenic lipoprotein profile: low HDL cholesterol levels and elevated triglyceride levels.
Low LDL	Low high-density lipoprotein (HDL) cholesterol (<40mg dl/1 (1.0mmol l/1))
Obesity, physical inactivity	Increased body weight for height is associated with various primary risk factors for atherosclerosis. These include hypertension, elevated LDL cholesterol levels, and low HDL cholesterol levels.

8 CONCLUSIONS

This article reveals that cholesterol plays a minor role in the development of atherosclerosis and the correlation between cholesterol and CVD is very narrow. On the contrary low blood-cholesterol is likely to increase the risk of mortality from other causes. Furthermore, blood-cholesterol fluctuates depending on a wide range of factors and not everyone respond in the same manner to dietary cholesterol, and hence in no way blood-cholesterol can serve as a suitable predictor for increased risk of heart disease. It is also an unscientific idea that everyone must have or has to maintain exactly the same amount of cholesterol in their blood. The war on cholesterol need to be terminated and its beneficial sides must be emphasized instead to promote health. Cardiologists are slowly realizing that it is inflammation of arterial tissue that leads to heart disease and most strokes, but not cholesterol. Safety tests of anti-cholesterol drugs have not yet been performed on all age and sex groups and have proved to have a multitude of adverse effects on many.

ABBREVIATIONS

AD: Alzheimer's disease
HD: Heart disease
HDL: High density lipoprotein
CHD: Coronary heart disease
CVD: Cardiovascular disease
HBP: High blood pressure
LDL: Low density lipoprotein
UPR: Unfolded protein response
WHO: World health organization

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CONFLICT OF INTERESTS

The authors declare that no conflict of interest exists.

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Study on Phosphate Solubilization of Salt Tolerant Soil Yeast Isolates and Effects on Maize Germination and Growth

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ABSTRACT: Among 12 isolated soil yeasts, four isolates were selected according to their salt tolerance and these four isolates tolerated 14% NaCl. Moreover, they can tolerant to KCl, $MgCl_2$ and $CaCl_2$. Phosphate solubilization of selected soil yeast isolates were detected in Pikovskaya's broth supplemented with various NaCl concentrations (ranging from 0% to 10%). They can solubilize insoluble phosphate at all NaCl concentrations. But with increasing NaCl concentration, phosphate solubilization was decreased and the best solubilization was occurred at 6 days incubation period. Above 10% NaCl concentration, these isolates cannot solubilize insoluble phosphate, $Ca_3(PO_4)_2$. On maize germination under NaCl stressed conditions, it was found that soil yeast isolates enhanced maize germination when compared with uninoculated treatment. Above 0.5% NaCl concentration, germination percentage of maize was obviously different between inoculated and uninoculated treatments. Like in phosphate solubilization, germination percentage was decreased with increasing NaCl concentration. At 2% NaCl concentration, germination was not found. So these isolates tolerated to some degree of NaCl, there is limited range for their functioning. After treating salt affected soils with soil yeast isolates for four weeks, salinity of treated soils was slightly decreased but total nitrogen content, K^+, and available nutrients (P and K_2O) were slightly increased when compared with those of untreated soil.

KEYWORDS: NaCl, Phosphate solubilization, Pikovskaya's broth, Soil yeasts, Maize germination.

1 INTRODUCTION

Nearly 40% of world's surface has salinity problems [1]. Salinization of soil is a serious problem and is increasing gradually in many parts of the world, particularly in arid and semiarid areas. The phosphorus deficiency frequently compounds the problems of saline soils of the tropics [2]. High salinity affects plant growth through, (i) the osmotic effects; (ii) toxicity of salt ions; and (iii) the changes in the physical and chemical properties of soil [3]. It also suppresses the phosphorus uptake by plant roots and reduces the available phosphorus by sorption processes and low solubility of Ca-P minerals [4]. Since phosphorus is a critical nutrient limiting plant growth [5].

A wide variety of heterotrophic fungi and bacteria have been shown to be capable of solubilizing insoluble phosphate ([6], [7]). In fact, the ability of fungi and heterotrophic bacteria to solubilize insoluble phosphate is well documented ([6], [7], [8], [9], [10]). Although soils are known to contain yeasts, little is known about their ecology and the role which they play in mineral cycling. This lack of interest probably reflects the low population density and relatively small biomass of yeasts in most soils ([11], [12]).

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Yeast are ubiquitous unicellular microorganisms in the natural environments (including aquatic systems) as well as industrial effluents where they are exposed to a variety of conditions with respect to nutrient availability, temperature, pH, osmotic pressure, access to oxygen and water activity, all of which induce stress responses [13]. They offer the advantages of having cell wall materials which show excellent metal binding properties [14].

Data on phosphate solubilization *in vitro* by soil yeasts are scarce or lacking. Reference [15] isolated soils yeasts and studied phosphate solubilizing of thes soil yeasts. It was reported that isolated soil yeasts solubilized insoluble phosphate *in vitro* leading to the formation of large amounts of soluble phosphate. Moreover, Reference [16] studied phosphate solubilization of a species of Candida isolated from soil. It has been found that the soil yeast *Williopsis califurnica* is able to oxidize ammonium sulphate to nitrate via nitrite and it could also solubilize insoluble phosphate [17].

The present investigation was undertaken to study the role of selected soil yeasts, isolated from Myanma Agricultural Soils, on salt tolerance, the solubilization of insoluble phosphate, $Ca_3(PO_4)_2$, effectss on germination and growth of maize.

Application of yeast produced the highest spike number irrespective of salinity level and cultivar type [18].

An improved salinity and tolerance of crop plants by using bio-fertilizers was investigated in several studies. Reference [19] studied the effect of of biofertilization of yeast (*Rhodotorula glutinis*) on four Egyptian maize varities (Giza 2, One Way Cross 10, One Way Cross 129 and Three Way Cross 352) grown under different salinity levels. From their study, they reported that bio-fertilization alleviated adverse effects of high levels of salinity and plants accumulated more polyamines than those, which received no bio-fertilizer, especially at high salinity levels.

2 MATERIALS AND METHODS

2.1 SOIL SAMPLING AND ISOLATION OF SOIL YEAST

Soil samples were collected from around Yangon Region, Kyaukse Twonship, Patheingyi Township in Mandalay Region. Soil yeasts were isolated on PYG media (peptone - 2 %, yeast extract - 1%, and glucose - 2%) containing 0.05 % Chloramphenicol. The culture plates were incubated at 37ºC for overnight. After overnight incubation, growth of yeast colonies on PYG media was observed and pure strains were obtained by subculturing.

2.2 SCREENING OF SALT TOLERANCE OF SOIL YEAST ISOLATES

The cultures obtained on PYG media were further screened for their salt-tolerance. For this purpose, PYG broth supplemented with various concentrations of NaCl (ranging from 1-14%) was used for inoculation of soil yeast isolates and PYG broth without NaCl was used as a control and incubation was carried at 37ºC. Total viable count of all cultures was determined on PYG media. The isolates showing high salt-tolerance were selected for further study.

Salt tolerance of soil yeast isolates were also screened on other salts ($MgCl_2$, $CaCl_2$, and KCl) using PYG media.

2.3 CONVENTIONAL IDENTIFICATION OF SOIL YEAST ISOLATES

Isolates soil yeasts were identified through colonial and microscopic morphology, sugar assimilation and fermentation abilities, some biochemical characteristics.

2.4 PHOSPHATE SOLUBILIZATION OF SOIL YEAST ISOLATES UNDER SALT-STRESS CONDITIONS

Phosphate solubilization of soil yeast isolates under salt stressed conditions was determined in Pikovskaya' broth [20] by Spectrophotometric method [21]. Pikovskaya's broth with $Ca_3(PO_4)_2$ was used and Pikovskaya's broth (30 ml) with different NaCl concentrations (0%, 2%, 4%, 6%, 8%, and 10%) was prepared for salt induced phosphate solubilization. Sample (10 ml) from each flask was withdrawn aseptically at 3 days, 6 days and 9 days. Phosphate solubilization in Pikovaskaia's broth media was quantified in a flask (10 ml) and incubated in water batch shaker at 37ºC for five days. Uninoculated medium served as control. After incubation, the culture broth was passed through the cation exchange resin and $(PO_4)^{3-}$ solution was reacted with color forming reagent. After color development, phosphate solubilizing activity was measured by UV-vis spectrophotometric method at 830 nm.

2.5 Effects of Soil yeast Isolates on Maize Germination under Salt Stressed Conditions

Maize seeds were surface disinfected by immersion in 70% ethanol for 1 min followed by 10 min in 2% sodium hypochlorite. They were then washed three times with sterile distilled water. An inoculum of soil yeast isolates was prepared in PYG broth. The disinfected seeds were immersed in either the inoculums or in PYG broth without any yeast isolates for one hour and were used as inoculated and uninoculated treatments. Germination was assayed according to International Seed Testing Association [22]. Four replicates of 25 seeds were germinated in Sterile Petri dishes containing two sheets of filter papers moistened initially with 4 ml of sterilized tricalcium phosphate solution supplemented with NaCl at 0%, 0.5%, 1%, 1.5%, and 2%. The Petri dishes were then placed in room temperature and germination was assayed daily and recorded.

2.6 Treatment of Salt Affected Soils with Isolated Soil Yeasts

Salt affected soils were obtained from Myitthar Township, Mandalay Region Myanmar. Agricultural land of this area was affected by salinity and so this has been left without cultivation. Growth of plants in this soil was tested (Figure 1). 10 kg of soil samples were separately placed. An inoculum was prepared by preculturing the yeast isolates in PYG broth at 37ºC. 50 ml of PYG medium was inoculated with exponentially growing yeast isolates of inoculums (5 ml). After two days incubation at 37ºC, 50 ml of PYG broth culture solution of each isolate was poured to soil samples and mixed well. Moisture of soil samples was maintained enough to grow the soil yeast isolates. Yeast broth culture solution was poured weekly. In order to compare the soil salinity and some mineral contents of treated and untreated soils, untreated soil was used as control. After four week treatment, treated soil samples were analysed for electricial conductivity (EC), and total nitrogen by the Kjeldahl method [23], available phosphorus (P) by the Olsen method [24] and the potassium by flame photometry mineral contents.

2.7 Growth of Maize in Treated Salt Affected Soils

After four weeks treatment of salt affected soils with soil yeast isolates, maize seeds were sown in pot trial and growth of maize were studied. Pot experiment was carried out by sowing five seeds of maize per pot containing 1 kg of treated soil sample. After sowing, yeast broth culture of each isolate (OD – 0.5) was poured to each pot at every weekend and pots were also watered. After four weeks, growth of maize was studied and the height of maize was measured.

3 Results and Discussion

A total of 12 soil yeasts were isolated on PYG medium from collected soil samples. After purifying isolated soil yeasts on PYG media, salt tolerance of soil yeasts were screened on PYG media supplemented with various NaCl concentrations (ranging 1-14%). Among 12 isolates, four isolates (I1, I2, I3 and I4) tolerated NaCl to 14% (Table 1) and selected after plate screening. TAKAKUW [25] selected yeast strains that tolerated at 10% NaCl for study of Glucosylcramide. Besides NaCl tolerance, tolerance of selected four soil yeast isolates were screened on other salts (KCl, $CaCl_2$ and $MgCl_2$). Among three types of salts, they can tolerant to these salts, but growth rates of soil yeast isolates on PYG media supplemented with $MgCl_2$ were less when compared with the growth on other media.

3.1 Sugar Assimilation and Fermentation Abilities and Biochemical Characteristics

Sugar assimilation and fermentation abilities of selected soil yeast isolates were shown in Table (2). Some biochemical characteristics were shown in Table (3).

3.2 Phosphate Solubilization of Soil Yeast Isolates under Salt Stressed Conditions

Phosphate solubilization of soil yeast isolates were evaluated in Pikovskaya's broth supplemented with different NaCl concentrations. This study revealed that all four yeast isolates solubilized insoluble $Ca_3(PO_4)_2$ under NaCl stressed conditions. Therefore, it seemed that they had been well adapted to the salt stressed conditions and they have genetic potential to solubilize the insoluble phosphate at high salt concentration. Stress induced phosphate solubilization has been studied by several researchers ([26], [27], [28]). The insoluble phosphate solubilizing of isolated soil yeasts was increased at 6 days incubation period and soluble phosphate concentrations were almost the same between 0% and 2% NaCl concentration (Figure 2). With increasing NaCl concentration, insoluble phosphate solubilizing activity was drastically decreased. These results could be due to influence of NaCl on their growth. It was also said that halotolerant microorganisms have limited degree of salt tolerance. It was also reported that solubilization in presence of 10% sodium chloride but there is a general trend of decrease in solubilization activity with the increase of sodium chloride concentration. This might have two reasons

either two stresses at the same time may harm cell growth and proliferation which result in less efficiency of solubilization or it might be possible that too much chloride ions may chelate or neutralize proton ions or acid produced in the medium ([29], [30], [31], [32]).

3.3 Effects of Soil Yeast Isolates on Maize Germination

To study the effects of isolated soil yeasts on maize germination under saline conditions, the suspension of soil yeast isolates was used to inoculate maize seeds prior to germinate under saline conditions supplemented with 0%, 0.5%, 1%, 1.5% and 2% NaCl concentrations. The germination percentage of inoculated with soil yeast isolates and uninoculated seeds were compared (Figure 3). Uninoculated treatments were conducted at all NaCl concentrations along with the inoculated treatments. This study was found that germination percentage of inoculated and uninoculated treatments was decreased with increasing NaCl concentrations. But germination percentage of inoculated treatments was higher than uninoculated treatments. Germination percentage of inoculated and uninoculated treatments was not significantly different between 0% and 0.5% NaCl concentration, but above 0.5% NaCl, germination percentage was obviously different between inoculated and uninoculated treatments. Salinity affect on germination by interfering with the uptake of essential nutrients and the direct toxicity effects of salt ions and prevention of weed water uptake in the first phase of germination ([33], [34]). In this study, it was also seen that decreasing of germination percentage of uninoculated treatment was due to salinity effects and might be due to the lack of soluble phosphorus supply from microbial activity. Maize germination inoculated with soil yeasts was obviously higher than those of uninoculated treatment. This might be a result of inoculation of maize seeds with salt tolerant soil yeast isolates and increasing available phosphorus from activity of yeasts. Seed or soil inoculations with phosphate solubilizing microbes (PSM) have largely been used to improve crop growth and production by solubilizing of fixed and applied phosphates [27].The inoculation of bean seeds with yeast under saline conditions increased the percentage of germination compared to non inoculated seeds [19].

3.4 Treatment of Salt Affected Soils by Soil Yeast Isolates

Collected salt affected soils were treated with soil yeast in order to study the tolerance of soils yeasts and to promote soil fertility. After four weeks treatment, salinity was measured. According to this study, salinity of treated soils was slightly decreased but not obvious, and some mineral contents (total N_2, available P and K, P_2O_5) were slightly increased (Table 4). Before treatment of salt affected soils (initial soil), total nitrogen content, K^+, available nutrients (P and K_2O) were lower than those of treated soils with salt tolerant soil yeasts. But increasing of some mineral contents was not obvious. It may be due to treatment duration in this study. Nitrogen fixing and potassium decomposing activities of soil yeast were not detected, so it was not known whether these isolates have the above activities. But increasing of total nitrogen content and potassium in soils might be due to the supply of soil yeasts to the growth of other beneficial microorganisms in soils. But from this study, it is believed that isolated salt tolerant yeasts can contribute positive effects when they are applied in salt affected soils. At high salinity level, it was found that treatments supplied by biofertilization with yeast decreased the adverse effect of salinity. Halophilic microorganisms are already in use for some biotechnological processes, such as commercial production of carotene, polymers, enzymes, compatible solutes [1]. Reference [19] also said that bio-fertilization of four Egyptian maize varieties grown in saline conditions with *Rhoditorula glutinis* influenced the plant K-content.

After four weeks treatment of salt affected soils with soil yeast isolates, maize were grown in these treated and untreated soils. At first, germination of maize was first seen from treated soils. In untreated soil, germination took more time than those in treated soils. The growth of maize from all treatments was measured in height. After four weeks, height of maize from treated soils was higher than those of untreated soil (Table 5). An enhancement of growth of maize might be a result of increasing available phosphorus from microbial activity and promotion of soil yeasts to growth of other beneficial microbes in soils. Similar finding was also proposed in [35]. The use of micro-organisms to increase the salt tolerance of maize was also studied in [36]. A growing number of studies indicate that plant root growth may be directly or indirectly enhanced by yeasts in the rhizosphere ([37], [38], [39]). A wide diversity of soil yeasts have been researched for their potential as bio-fertilizers ([40], [41]).

4 TABLES AND FIGURES

4.1 TABLES

Table 1. NaCl Tolerance of Isolated Yeast Strains on PYG Media Supplemented with Different NaCl Concentrations

Isolates	*NaCl concentrations*					
	0%	3%	6%	9%	12%	14%
I1	+++	+++	+++	++++	++	+
I2	+++	+++	+++	+++	++	+
I3	+++	+++	+++	+++	++	+
I4	+++	+++	+++	+++	++	+
I5	+	+	-	-	-	-
I6	+	+	+	-	-	-
I7	+	+	-	-	-	-
I8	+	+	-	-	-	-
I9	+	+	+	-	-	-
I10	+	+	-	-	-	-
I11	+	+	+	-	-	-
I12	+	+	-	-	-	-

Table 2. Sugar Assimilation and Fermentation Abilities of Selected Yeast Isolates

Sugars	I1		I2		I3		I4	
	SA	SF	SA	SF	SA	SF	SA	SF
Fructose	+	+	+	+	+	+	+	+
Lactose	+ (WG)	+	-	-	-	-	+(WG)	+
Mannitol	+	+	+	+	+	-	+	-
Maltose	+	+	+	+	+	+	+	+
Glucose	+	+	+	+	+	+	+	+
Xylose	+	-	+	-	+	-	+	-
Sucrose	+	+	+	+	+	+	+	+
Dextrose	+	+	+	+	+	+	+	+

SA – Sugar Assimilation, SF – Sugar Fermentation, WG – Weak Growth

Table 3. Some biochemical characteristics of soil yeast isolates

Isolates	Urease	Utilizing of citrate	Utilizing of methanol	Utilizing of ethanol	Utilizing of glycerol
I1	+	+	-	+	+
I2	+	+	-	+	+
I3	-	+	-	+	+
I4	-	+	-	+	+

Table 4. Salinity (EC ms/cm), Total N_2 (%), K^+, and available nutrients (P and K_2O) of treated and untreated soils after four weeks treatment

Samples	EC ms/cm	Total N2 %	K^+ meg/100gm	Available Nutrients	
				P(ppm)	K_2O mg/100
T1 (I1)	0.95	0.183	1.56	16.42	73.27
T2 (I2)	1.06	0.183	1.64	18.94	77.35
T3 (I3)	0.96	0.202	1.40	16.57	66.10
T4 (I4)	1.07	0.183	1.44	16.84	67.78
T5 (Initial soil)	1.89	0.181	1.38	15.66	65.08

Table 5. Growth of maize biofertilized with salt tolerant soil yeasts after four weeks

Treatment	Plant heights(cm)
T1 (I1)	32
T2 (I2)	25.33
T3 (I3)	34.44
T4 (4)	26.44
T5 (Initial soil)	24.11

4.2 Figures

(i) (ii) (iii)

Fig. 1. Growth of mustard and maize in collected salt affected soils and normal cultivated agricultural soils;(i) growth of mustard, (ii) growth of maize in normal cultivated agricultural soil, and (iii) growth of maize in collected salt affected soil

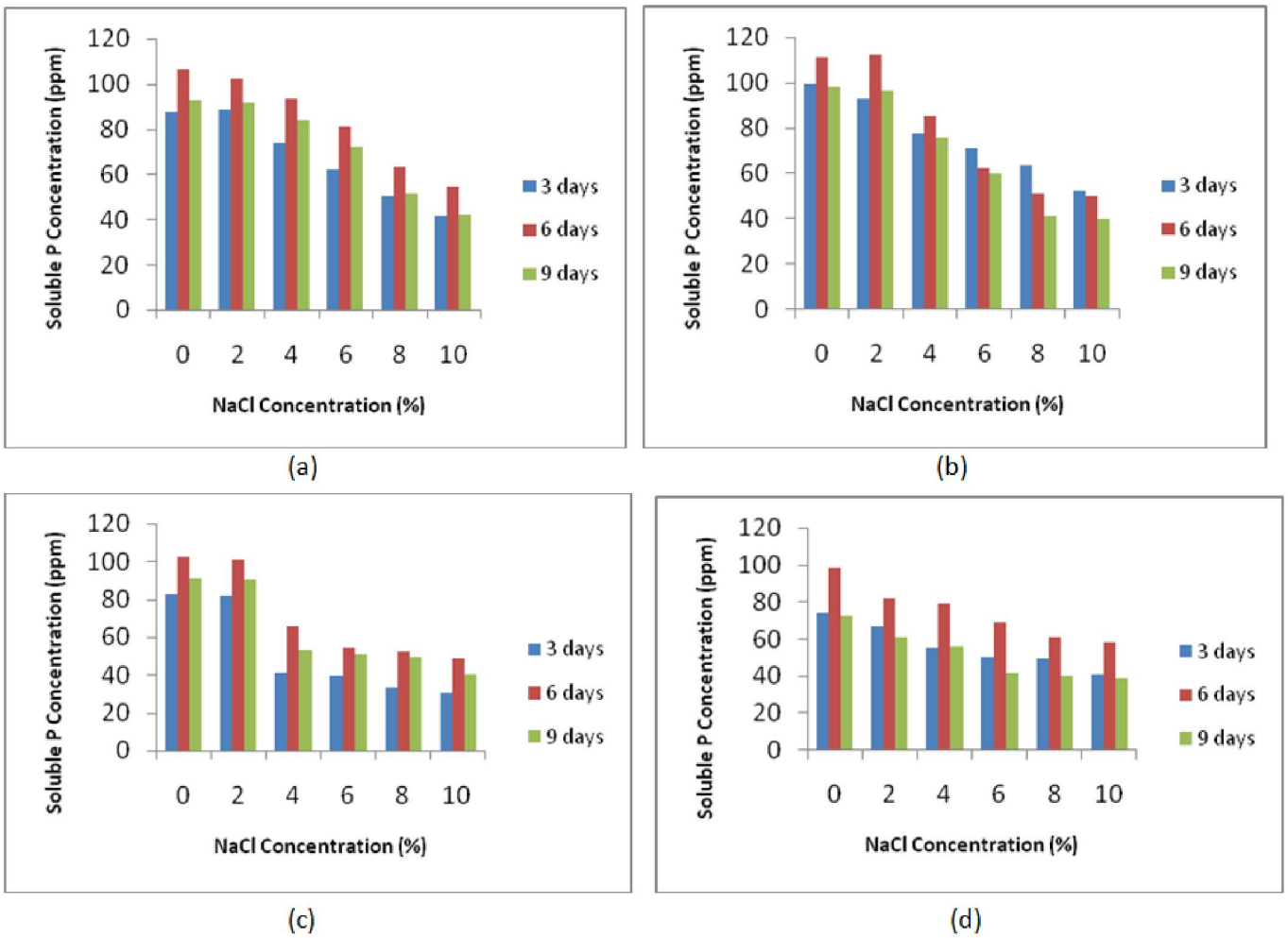

Fig. 2. Soluble phosphate (ppm) solubilized by four soil yeast isolates in Pikovskaya's broth containing tricalcium phosphate at various NaCl concentration: (a) I1 isolate, (b) I2 isolate, (c) I3 isolate and (d) I4 isolate

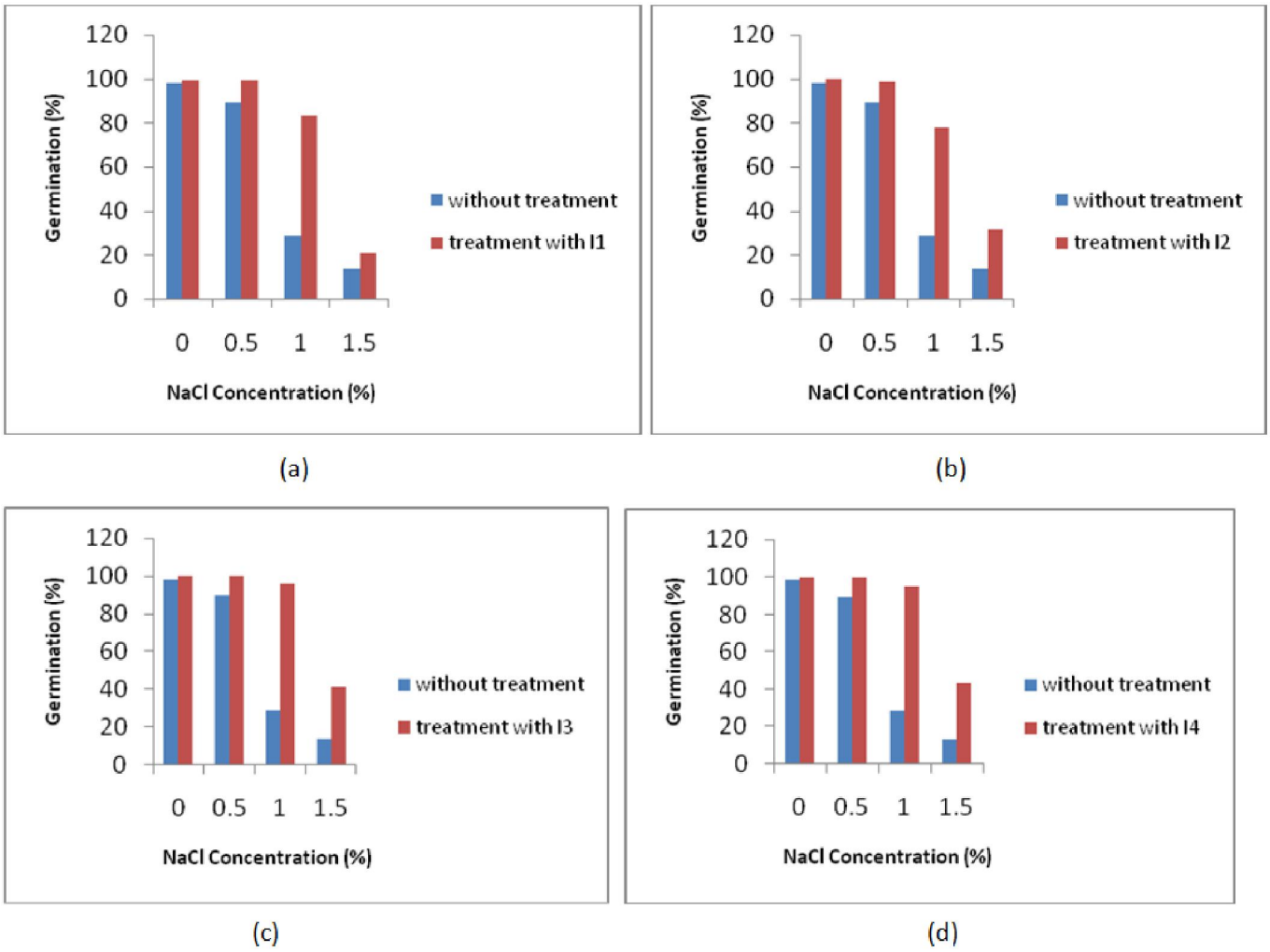

Fig. 3. Effects of soil yeast isolates on maize germination under NaCl stressed conditions; (a) I1, (b) I2, (c) I3 and (d) I4

5 CONCLUSION

Four soil yeast isolates were obtained. These four yeast isolates tolerated to NaCl at 14% and to $MgCl_2$, KCl and $CaCl_2$. Phosphate solubilization of soils yeast isolates was decreased with increasing NaCl concentration. Above 10% NaCl concentration, soluble phosphorus solubilized by soil yeasts was not detected. Although they can solubilize insoluble phosphate at 10% NaCl concentration, germination of maize grown in 2% NaCl concentration was not enhanced. So these isolates limited range of NaCl tolerance for their function. Treatment of salt affected soils by these isolates, some mineral contents in soils were slightly increased but not obvious. Growths of maize in treated soils were slightly higher than those of untreated soils.

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Preparation and Characterization of Sodium Alginate Nanoparticles Containing ICD-85 (Venom Derived Peptides)

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ABSTRACT: Sodium alginate is one of such biodegradable polymers, which has been extensively exploited for the preparation of nanoparticles (NPs) for controlled delivery of several therapeutic agents. ICD-85 (venom derived peptides) has been shown to exhibit anti-cancer activity. In this report sodium alginate nanoparticles employed to improve upon its effectiveness. ICD-85 loaded NPs were prepared by ionic gelation method and were characterized by the particle size, zeta potential, transmission electron microscopy, FT-IR spectroscopy and in vitro release studies. The in vitro cytotoxicity was evaluated by MTT assay. TEM revealed ICD-85 loaded NPs to have spherical shapes with a size of approximately 200 nm. The zeta potential of the ICD-85 loaded NPs was estimated as –16.1 mV. Loading capacity and encapsulation efficiency were 90.48% (w/w) and 90.24% (w/w), respectively. The in vitro release profile exhibited sustained release patterns with relatively initial burst release, followed by a subsequent slower release. Cytotoxicity assay showed that ICD-85 loaded NPs is more potent than free ICD-85 in suppressing proliferation of HEp-2 cells. In conclusion the ICD-85 loaded NPs presented high loading capacity and sustained release profile which effectively inhibit the proliferation of HEp-2 cell line in vitro, and may be a beneficial agent against human carcinoma.

KEYWORDS: ICD-85, Nanoparticles, Encapsulation, Sodium alginate, Ionic gelation, HEp-2 cell line.

1 INTRODUCTION

Nanoparticles (NPs) have become a focus of attention in the field of biomedicine owing to their capacity to deliver various drugs [1]. Much research has been focused on the preparation of nanoparticles using biodegradable hydrophilic polymers such as alginate and chitosan [2], [3]. Alginate has been found increasing biotechnological and biomedical applications in view of its several advantages, such as high biocompatibility, biodegradability, non-toxicity, non-immunogenicity, chelating ability, and the possibility of chemical modification [4], [5], [6], [7]. Moreover, alginate has been widely used for encapsulation of cells [8], [9], proteins [10], DNA [11], venoms [12] and vaccines [13]. Recently, alginate was developed as a nanoparticle for the oral delivery of insulin [14]. On the other hand, alginate has already acclaimed permission from US FDA [4].

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Nanoparticles have been prepared using several different methods [15]. One method for preparing nanoparticles based on polysaccharides is the ionic gelation method [16]. This method offer many advantages such as simple and mild preparation method without the use of organic solvent or high shear force [17], [18], [19].

One of the major problems facing cancer chemotherapy is the achievement of the required concentration of the drug at the tumor site for a desired period of time, since tumors usually present resistances to treatment, and high dosages are frequently toxic [20], [21]. Thus, one of the main goals of nanomedicine is to develop safe and effective drug carriers that are systemically applied but will selectively deliver cytotoxic drugs to tumor cells without harming normal cells [22], [23]. Polysaccharide-based NPs play an important role and their use with some anti-cancer drugs show promising results [24], [25], [26], [27].

Our previous studies revealed an inhibitory effect of ICD-85 (venom derived peptides) on MDA-MB231 and HL-60 cancer cell lines through induction of apoptosis [28], [29]. ICD-85 was also confirmed by in vivo studies to suppress the breast tumor in mice [30].

In this study we attempt, to prepare sodium alginate NPs and encapsulated ICD-85 as cytotoxic agent to evaluate the usefulness of nanoparticles as a carrier of ICD-85 by measuring the in vitro cytotoxicity of nanoparticles on the proliferation of HEp-2 cell line.

2 MATERIALS AND METHODS

2.1 MATERIALS

The active fraction of ICD-85 is a combination of three peptides, ranging from 10,000 to 30,000 Da, derived from the venoms of snake (*Agkistrodon halys*) and scorpion (*Hemiscorpius lepturus*) was obtained from Razi Vaccine and Serum Research Institute (Karaj, Iran). The cell culture medium (RPMI 1640), fetal calf serum (FCS), trypsin–EDTA, penicillin and streptomycin were provided by Gibco (USA). Sodium alginate and poly-L-lysine (PLL) were purchased from Sigma-Aldrich Chemical (Germany). Calcium chloride, dimethyl sulfoxide (DMSO) and 3-(4, 5-dimethyl-thiazol-2-yl)-2, 5-diphenyltetrazolium bromide (MTT) were purchased from Merck (Darmstadt, Germany). All other chemicals used in this study were of analytical grade.

2.2 PREPARATION OF NANOPARTICLES

2.2.1 PREPARATION OF SODIUM ALGINATE NPS

Sodium alginate NPs were prepared by ionic gelation method adapted from Rajaonarivony's method of preparing alginate–poly-L-lysine nanoparticles [16]. Initially, 1 ml of calcium chloride was added to 19 ml of sodium alginate solution to induce gellification. Then 8 ml of poly-L-lysine was added in order to condensation of nanoparticles. The nanoparticles suspension obtained was stirred for 2 h and kept overnight for stabilization. The nanoparticles were separated by centrifugation (Sigma, USA) at 13000 rpm for 30 minutes, freeze-dried and stored at 4°C. The weights of freeze-dried nanoparticles were also measured.

2.2.2 PREPARATION OF SODIUM ALGINATE NPS CONTAINING ICD-85

The concentration of sodium alginate was fixed at 0.3 mg ml^{-1}, whereas the concentration of calcium chloride was 0.2 mg ml^{-1}. The ICD-85 loading nanoparticles were prepared with incorporation of sodium alginate solution into calcium chloride solution containing 334 µg ml^{-1} of ICD-85.

2.3 CHARACTERIZATION OF NANOPARTICLES

2.3.1 PARTICLE SIZE ANALYSIS AND ZETA POTENTIAL MEASUREMENT

The average particle size and size distribution of ICD-85 loaded NPs were determined by dynamic light scattering (DLS), using Malvern Zetasizer (Malvern Instruments, UK) with a wavelength of 532 nm at 25°C with an angle detection of 90°. In brief, 1 mg ml^{-1} of nanoparticulate suspension was prepared in double distilled water and sonicated for 1 min over an ice

bath. Then, 0.1 ml of the above NPs suspension was diluted to 1 ml in water and then subjected to particle size measurement.

The zeta potential was measured by the same instrument. Measurements were made at 25°C without sample dilution or any salt addition. All measurements were performed in triplicate.

2.3.2 TRANSMISSION ELECTRON MICROSCOPY (TEM)

Specimens were prepared by dropping the sample solution onto a copper grid. The grids were subsequently negatively stained with 2% phosphotungstic acid solution. The grid was then allowed to stand for 30 s to 1 min before the excess staining solution was removed by draining. The specimens were air-dried and examined using a Philips 400 transmission electron microscope (Netherlands) at an accelerating voltage of 80 kV.

2.3.3 FT-IR SPECTRUM ANALYSIS

ICD-85 loaded NPs were separated from the suspension by centrifugation at 13,000 rpm and 14°C for 30 min and lyophilized. These dried nanoparticles were mixed with KBr and pressed to the plate for measurements. FT-IR spectra were recorded on FT-IR spectrometer (FTIR- 410® Jasco Colchester, UK).

2.3.4 ENCAPSULATION EFFICIENCY AND LOADING CAPACITY

ICD-85 loaded NPs were separated from aqueous suspension by centrifugation at 20,000 rpm and 14°C for 30 minutes. The supernatant was collected and protein content (ICD-85) in supernatant was determined by the Bradford protein assay spectrophotometric method at 595 nm [31]. The ICD-85 encapsulation efficiency (*EE*) and loading capacity (*LC*) of nanoparticles were calculated by using following equation:

$$\%EE = [(A-B)/A] \times 100$$

$$\%LC = [(A-B)/C] \times 100$$

A = total amount of ICD-85 in added solution; *B* = total amount of ICD-85 in supernatant after centrifugation; and *C* = weight of the nanoparticles measured after freeze-drying [32].

2.4 IN-VITRO RELEASE STUDY

In-vitro release of ICD-85 from NPs was carried out by dispersing 100 mg of NPs in 10 ml of PBS (0.01 M, pH 7.4). The nanoparticulate suspension was equally divided in ten tubes. 1 ml in each and kept in a shaker at 37°C and 300 rpm. At particular time intervals (2, 4, 6, 12, 24, 36, 48, 60 hours) one tube was removed and the sample was centrifuged at 13,000 rpm and 14°C for 30 minutes. The amount of ICD-85 released in the supernatant was measured.

2.5 CELL CULTURE AND TREATMENT

The human larynx carcinoma cell line (HEp-2) obtained from cell bank of Razi Vaccine and Serum Research Institute (Karaj, Iran). Cells were cultured in RPMI 1640 medium supplemented with 10% FCS, streptomycin (100 µg ml^{-1}) and penicillin (100 IU ml^{-1}) in 25 cm^2 culture flasks (Nunc, Denmark) at 37°C in 5% humidified CO2 incubator (Memmert, Germany). For subculture, cells at 80–90% confluence were passaged at a ratio of 1:3 after detachment with 0.25% trypsin containing 0.02% EDTA [33].

Experiments were carried out 24 h after cells were seeded. The cultured cells were treated with free ICD-85 and ICD-85 loaded NPs and examined their effects in different concentrations. The cells were evaluated after 72 h of the treatment.

2.6 IN VITRO CYTOTOXICITY ASSAY

Cell proliferation was determined by MTT colorimetric assay [34]. MTT-based in vitro cytotoxicity assay was performed to compare anti-cancer effects of ICD-85 loaded NPs versus free form of ICD-85 on HEp-2 cell lines. Briefly, cells in logarithmic growth were seeded at a density of 5×10^5 cells ml^{-1} in 96-well culture plates (Nunc, Denmark) in 0.2 ml^{-1} volume media. After an overnight incubation, cells were then treated with different concentrations of free ICD-85 and ICD-85 loaded NPs (0, 1, 5, 10, 20 and 30 µg ml^{-1}). After 72 h of the treatment, 0.02 ml^{-1} of MTT solution (5 mg ml^{-1} in PBS) was added into each well and

cells were incubated at 37ºC for 4 h allowing the MTT to be metabolized. After incubation, purple crystals were observed and the media was removed from each well by aspiration. The crystals were then dissolved by adding 0.2 ml^{-1} of DMSO to each well. DMSO was also added to the wells designated as reference blanks. Then, the optical density of 96-well plates was measured using an ELISA reader (Dynex MRX II, USA) at 570 nm. The optical density of untreated control cells was taken as 100% of viability. Statistical analysis was done to determine the means ± SD of cell viability. The percentage of surviving cells was calculated as the percentage of MTT absorption according to the following formula:

% Survival = (mean experimental absorbance/mean control absorbance×100).

2.7 STATISTICAL ANALYSIS

Computer program (Graph Pad Prism) was used to calculate the IC_{50} (50% inhibition of cell proliferation) values. All experiments were repeated at least three times. Statistical analyses were performed using a Student's t-test and the results were presented as mean ± SD. Statistical significance was accepted at a level of $p<0.05$.

3 RESULTS

3.1 PHYSICOCHEMICAL CHARACTERIZATION OF NANOPARTICLES

The morphological characteristics of nanoparticles were examined using TEM. The TEM image of nanoparticles was shown in figure 1, which revealed relatively smooth and spherical nanoparticle structures. The mean hydrodynamic diameter of particle was approximately 300 nm having polydispersity index (PDI) 0.432.

The zeta potential of the sodium alginate NPs was estimated –21.9 mV and changed to –16.1 mV after loading with ICD-85.

The FT-IR spectroscopy was carried out to study the possibility of chemical interaction between ICD-85 and sodium alginate was shown in figure 2. The band around 3300–3400 cm^{-1} range in the spectrum contributes O–H stretching and intermolecular hydrogen bonding. The peaks observed at 1400–1700 cm^{-1} in the spectra represent peaks belong to the C=O stretching (amide). The characteristic peak observed around 1600 cm^{-1} (salt of carboxyl group) in the FT-IR spectrum of nanoparticles was attributed to the ionic interaction between these two reactive groups.

Loading capacity and encapsulation efficiency were 90.48% (w/w) and 90.24% (w/w), respectively.

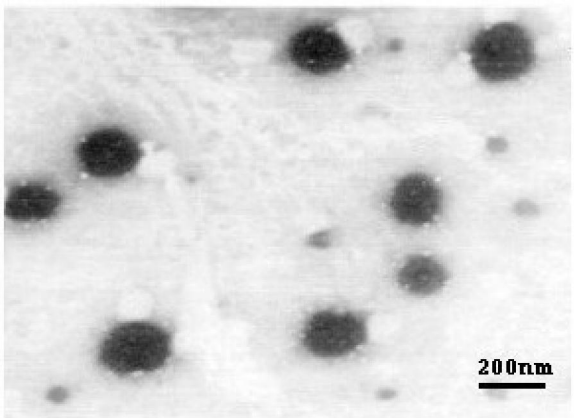

Fig. 1. TEM image of ICD-85 loaded sodium alginate NPs

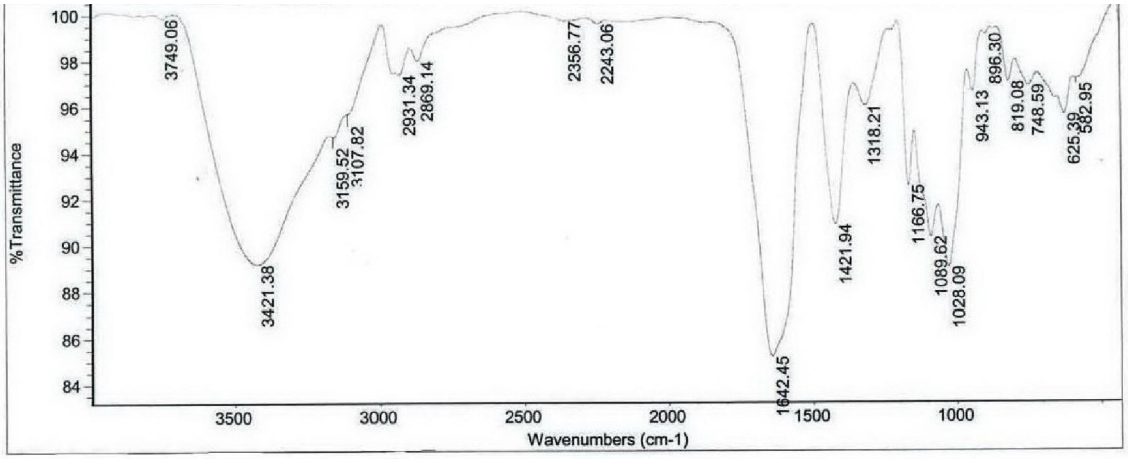

Fig. 2. FT-IR of ICD-85 loaded sodium alginate NPs

3.2 In Vitro Release Study

The in vitro ICD-85 release data are presented in figure 3. ICD-85 loaded NPs showed 7% and 31% release of ICD-85 in 2 h and 24 h, respectively. As shown in the ICD-85 loaded NPs release profile after 60 h, about 90% of the ICD-85 released from the nanoparticles.

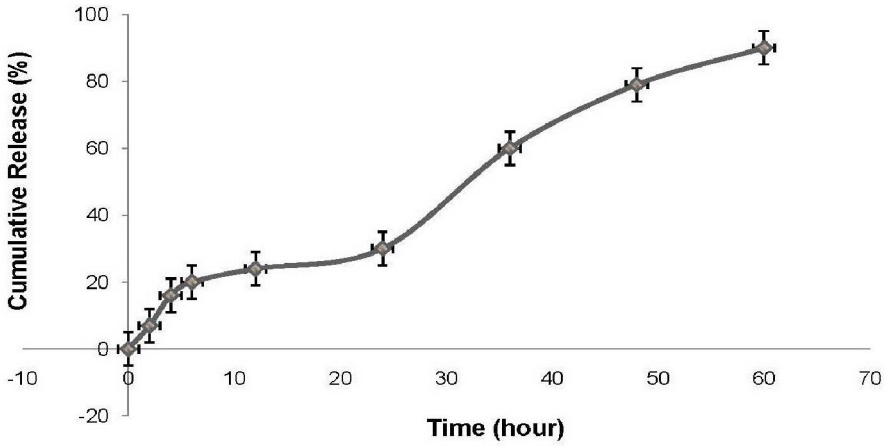

Fig. 3. In vitro release profile of ICD-85 loaded sodium alginate NPs

3.3 In Vitro Cytotoxicity

Figure 4 shows the cell viability treated with free nanoparticles, free ICD-85 and ICD-85 loaded NPs at various concentrations for 72 h incubation time. The free nanoparticles did not demonstrate any significant effect on the viability of HEp-2 cells. The viability of cells treated with free ICD-85 and ICD-85 loaded NPs decreased with increasing concentration. We compared the ability of free ICD-85 and ICD-85 loaded NPs to inhibit the proliferation of HEp-2 cells. ICD-85 loaded NPs inhibited the proliferation of HEp-2 cells in a dose-dependent manner with an IC_{50} value of 5.2 µg ml^{-1} as compared to IC_{50} of 11.1 µg ml^{-1} for free ICD-85.

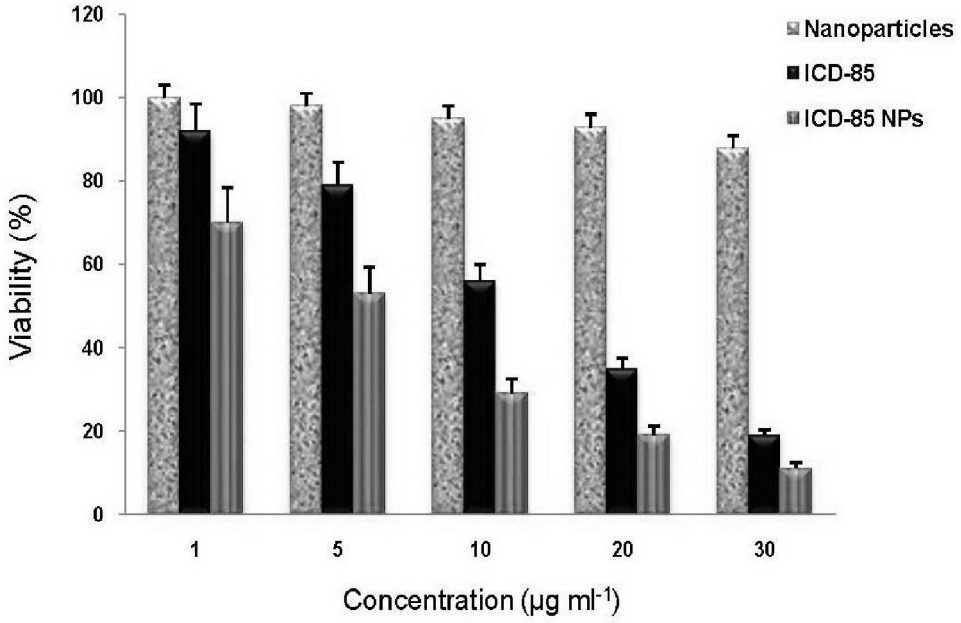

Fig. 4. Viability HEp-2 cells exposed to free nanoparticles, free ICD-85 and ICD-85 NPs at 72 h and measured by MTT assay

Viability of untreated cells (0µg) was taken as 100%. The measurements of the treated cells were normalized to the control measurement (100%). Results are expressed as mean ± SD (n=3 experiments, six replicates per experiment at each test concentration). Significant difference ($P<0.05$, Student's t-test) in proliferation of HEp-2 cells was observed between free ICD-85 and ICD-85 loaded NPs.

4 DISCUSSION

In recent years, a large number of studies have been conducted on polysaccharides and their derivatives for their potential application as nanoparticle drug delivery systems [24], [25], [26], [27]. Modern developments in polymeric nano-formulations for the treatment of cancer have reported for sustained and controlled delivery of anti-cancer agents [35], [36], [37], [38].

The current studies were designed to prepare ICD-85 loaded sodium alginate NPs and investigate their ability to inhibit proliferation of cancer cells. ICD-85 used in the present study is combination of 3 peptides isolated partially from two different venoms [28]. The combination of these peptides used because they work together synergistically having anti-proliferative activity along with anti-angiogenic activity [39]. The natural polymer alginate was chosen in the present study as the best candidate for drug carrier owing to its biocompatibility, biodegradability, easily obtained at a low cost and non-toxic [4], [7].

The ability of the ionic gelation process to form ICD-85 loaded NPs was assessed by employing FT-IR to determine ICD-85 and sodium alginate interactions. Based on the FT–IR spectra, the strong and broad peaks in the 3421 cm^{-1} ranges correspond to O–H stretching and intermolecular hydrogen bonding. We can see carboxyl peaks near 1642 cm^{-1} (symmetric – COO^- stretching vibration) and 1421 cm^{-1} (asymmetric COO^- stretching vibration).

The DLS analysis revealed that the ICD-85 loaded NPs had a mean hydrodynamic diameter of 300 nm. However, TEM revealed the ICD-85 loaded NPs to have a size of approximately 200 nm. The mean nanoparticle diameter measured using TEM is significantly smaller than the mean diameter obtained with the DLS method. Nanoparticles appeared to be considerably smaller when viewed with TEM as compared to the average particle size observed with DLS [40]. On the other hand DLS measures the apparent size (hydrodynamic radius) of a particle, including hydrodynamic layers that form around hydrophilic particles, leading to an overestimation of nanoparticles size [41]. Hence the discrepancy in the size of nanoparticles is because the DLS method gives the hydrodynamic diameter rather than the actual diameter of hydrophilic nanoparticles [41].

Zeta potential is quite important for colloids and nanoparticles in suspension. Its value is closely related to suspension stability and particle surface morphology [42], [43]. The zeta potential of the sodium alginate NPs was –21.9 mV and changed to –16.1 mV after loading with ICD-85. The negative surface charge of sodium alginate NPs may be attributed to the presence of ionized carboxyl groups of alginate segments on the nanoparticles surface. These results indicate that the loading of ICD-85 decreased the surface potential of ICD-85 loaded NPs. High absolute value of the zeta potential suggests high surface charge of the nanoparticles, which leads to strong repellent interactions among the nanoparticles in dispersion [44]. Thus, this change in the zeta potential of sodium alginate NPs is indicative of successful loading with ICD-85.

Our nanoparticulate formulation solely exhibited a sustained release phenomenon, under in vitro conditions as depicted in figure 3. Alginates offer an inert environment ideal for control drug release at a desirable rate [45]. The main release mechanism in encapsulated drugs from alginate pellets is by diffusional processes through pores and the release is facilitated by the degradation of the polymeric network [45]. Relatively initial burst release should be owed to the presence of free ICD-85 absorbed on the surface of NPs, while the sustained release was attributed to the cleavage of the chemical bond between ICD-85 and sodium alginate particles [32]. Even after 60 h, about 10% of the ICD-85 still remained in the NPs, which were found to suitable sustained release phenomenon of ICD-85 NPs. Our previous study revealed that ICD-85 is stable throughout the 24 hours in the culture medium [28]. ICD-85 loaded NPs had high loading capacity (90.48%) and suitable sustained release profile. These results indicated another advantage of the ICD-85 loaded NPs versus free form of ICD-85, which were found to release the ICD-85 too slowly from NPS form as compared to free ICD-85.

When examined for its ability to suppress the growth of human larynx carcinoma cells, we found that ICD-85 loaded NPs significantly more potent than free ICD-85. Numerous investigations have shown that nanoparticulate drug delivery systems can increase anti-tumor efficacy while reducing side effects [46], [47]. Therapeutic potentiality of the ICD-85 loaded NPs was investigated by MTT based cell proliferation assay. MTT results showed a sharp discrimination in cell inhibition between free ICD-85 and ICD-85 loaded NPs, thus stressing the key role of NPs binding and internalization in enhancement of cytotoxic activity [32]. Our results are in accordance to Zhang *et al*. [48] who demonstrated that the 10-hydroxycamptothecin-loaded NPs developed a higher in vitro cytotoxicity and superior in vivo anti-tumor activity in mice than the free drug. Similar results have been also obtained by Hong *et al*. [49] who indicated that the HCPT loaded NPs exhibited anti-tumor effects enhancement as compared to free HCPT.

In the cell cytotoxicity assay, free NPs did not significantly affect the viability of HEp-2 cells. These results indicated that free NPs itself did not affect the proliferation of tumor cells. Therefore, the interference of the carrier itself was negligible in this study and hence, we can anticipate that ICD-85 loaded NPs show significant cytotoxicity on HEp-2 cell line compared to free form of ICD-85. Our results are in accordance to Ravindran *et al.* [50] who showed that Thymoquinone loaded NPs was able to reduce the IC_{50} value in KBM-5 cancer cells from 3.85 µM for free Thymoquinone to 1.9 µM for Thymoquinone loaded NPs. Similar results have been also obtained by Li *et al.* [51] who indicated that the cisplatin-loaded NPs exhibited a superior anti-tumor effect against cancer cell lines compared to free drug.

5 CONCLUSION

We have developed a natural polymer based nanoparticle delivery system for ICD-85 as cytotoxic agent. ICD-85 was easily loaded to the sodium alginate NPs with high loading capacity and sustained release phenomenon. Considering the negligible interference of sodium alginate NPs on cytotoxicity of HEp-2 cells, we can anticipate that ICD-85 loaded NPs has significant cytotoxicity on HEp-2 cell line compared to free form of ICD-85 which indicate the potential of the nano-encapsulation to improve the cytotoxicity of ICD-85. The simplicity of preparation, the high drug loading capacity and improved efficacy, encourage further evaluation of the nano-formulation in animal model.

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Various Culture Media Effect on T4 Phage Lysis and Production

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ABSTRACT: Studies on bacteriophage growth and its development played a vital role in the history of molecular biology which in turn helped in clarification of many points. Most of the previous studies on bacteriophage development and growth have been performed under optimal conditions for the host cell. While On the other hand these conditions may not be optimal for the T4 bacteriophage. As a matter of fact in nature E. coli faces many unfavorable growth conditions, good example are those conditions prevailing in the human gut in which E.coli manages to survive well. This study characterizes the effects and influences of well-defined physiological conditions on T4 bacteriophage growth and development. In addition to this, T4 bacteriophage interactions with its bacterial host have also been demonstrated.

In our present study we observed that the maximum growth and lysis of T4 bacteriophage was on luria-bertani (LB) and nutrient media (NM). Moreover the T4 bacteriophage production and lysis was also good in luria-bertani plus glucose (LB+G) media but when compared with its production in luria-bertani (LB) and nutrient media it was found to be less than these medium. Our study results also showed that in minimal media (MM) rate of growth and lysis activity of T4 bacteriophage was lowest as compared to other mentioned medium.

KEYWORDS: T4 Bacteriophage, E.Coli, Media, Lysis, Production.

1 INTRODUCTION

Studies about growth and development of bacteriophage played important role in the molecular biological history [1]. The information, particularly with the model species T4 bacteriophage was accumulated during the 1940s and this placed the base of the evolving field [2]. Ellis & Delbruck [3] performed classical one-step growth experiment which defined the latent period, rise time, burst size and the eclipse period. Eclipse period was discovered by the effective procedure planned to disrupt infected bacteria before their lysis to occur spontaneously and the mature phages were not damaged [4].

There is a highly specific binding of phage to one of the cell envelope layers of bacteria which initiates phage-host interaction. Fibers of the phage tail attach to specific receptors present in the bacterial envelope [5]. This process is called as adsorption and depends on various factors present in the environment [6].

Lysis of the bacterial host is the last event in lytic bacteriophage infection cycle [7] but standardization of media is very important factor for phage lytic cycle and its production. The ultimate solution to this issue would be to have a synthetic medium which is chemically defined but preserving the sensitivity [8]. The culture media composition is also very important [9]. Apart from the nature of the culture medium, plaque formation also depends on the medium from which the culture is obtained [10]. Plaque formation depends on solid media while the lysis in liquid media is even more dependent on the cultures history [10].

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2 MATERIALS AND METHODS

2.1 BACTERIA AND PHAGE

For conducting the study, the E.coli BL21 strain was used as the primary host for lysis activity of the bacteriophage named Escherichia coli bacteriophage (ATCC11303-B4). The E. coli BL21 was obtained from the American Type Culture Collection (ATCC). All bacterial stock cultures prepared/obtained were stored at -80 ^{0}C in various broths containing 50% (v/v) glycerol. The frozen cultures were plated onto various agars on the need basis. For looking at the effect of various culture media, first an overnight culture of E. coli BL21 was prepared by inoculating broth with a single isolated E. coli BL21 colony from an plate and incubating it in a 37°C until the OD_{600} reached 1.

2.2 CULTURE MEDIA

Luria-Bertani (LB) medium consisted of 10 g tryptone, 5 g yeast extract and 10 g sodium chloride per 1,000 ml of water (pH 7).

Luria-Bertani (LB+G) pulse 0.8% glucose medium consisted of 10 g tryptone, 5 g yeast extract and 10 g sodium chloride per 1,000 ml of water (pH 7).

Minimal Media contains M9 minimal salts solution (5X concentrate) (64g sodium phosphate, penta-hydrate -- Na_2HPO_4-$7H_2O$,15g potassium phosphate (dibasic) -- KH_2PO_4, 2.5g table salt – NaCl and 5.0g ammonium chloride -- NH_4Cl per 1,000 ml of distilled water) 1M solution of magnesium sulfate ($MgSO_4$), 20% solution wt/wt of glucose and 1M solution of calcium chloride ($CaCl_2$) (pH 7).

Nutrient medium consisted of peptone 5 g, sodium chloride 5 g, beef extract 1.5 g, yeast extract 1.5 g per 1,000 ml of water (pH 7).

For phage-plaque formation semi solid medium containing 1.5 and 0.5% agar was used for the upper layer, respectively [11], [12].

The various medium effect on the lysis activity and production of T4 phage (10^9 pfu/ml) against E.coli BL21 was checked by plaque count assays and the MOI was 3. The pH of media was obtained by using HCl and NaOH and then the lysis activity and production were checked against E.coli BL21 by double agar overlay method similar to that of Adams [13].

2.3 STATISTICAL ANALYSIS

Statistical analysis included t test for the comparison of change in outcome variables in response to various culture medium with methods described by sigma stat (Fig. 1). The analysis was carried out with Graph Pad Prism 5 software.

3 RESULT

An ideal medium would be one on which maximal bacterial growth occurs and on which the phage has optimal activity. Some factors favoring growth of the bacteria may have a tendency to inhibit phage action and some factors favoring phage activity may tend to limit growth of the bacterial host. A balance may be reached however in which both activities are maintained at a high level [14].

E. coli cells grow faster and larger cells are obtained in richer media, because a higher proportion of their mass is included in the protein-synthesizing system (PSS) [15]-[16].

In present study we observed that the maximum growth and lysis of T4 phage was on LB and nutrient media. T4 phage production and lysis was also good in LB plus glucose media but a little less than LB and nutrient media while in minimal media rate of growth and lysis activity was lowest as compared to other mentioned medium as showed in fig. 1.

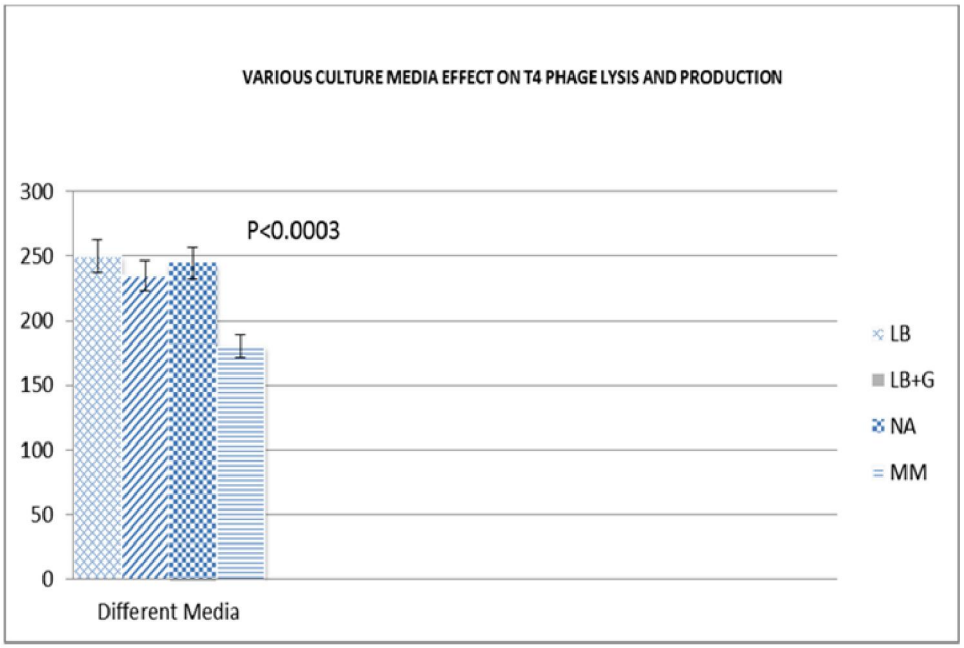

Fig. 1. Various media effect on T4 phage lysis and production

4 DISCUSSION

Most of the previous studies on bacteriophage development have been performed under optimal conditions for the host cell but these conditions may not be optimal for the phage. In nature E. coli faces unfavorable growth conditions such as those prevailing in the human gut [17]. The rate of phage production is proportional to the amount per cell of the PSS at the time of infection and the increased rate of phage production results in larger burst sizes in the bigger cells [18].

This study characterizes the effects of well-defined physiological conditions on T4 phage growth and also its interactions with the bacterial host. In the present study we observed that the maximum growth and lysis of T4 phage was on LB and nutrient media. T4 phage production and lysis was also good in LB plus glucose media but a little less than LB and nutrient media while in minimal media rate of growth and lysis activity was lowest as compared to other mentioned medium as Sula and Sulova [8] reported that media can affect phage lysis activity.

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Mathematical model for Quay Crane Scheduling Problem with spatial constraints

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ABSTRACT: In the last decades, competition between port container terminals, especially between geographically close one, is rapidly increasing. To improve this competitiveness, terminal managers try to achieve rapid container vessel loading and unloading, that corresponds to a reduction of the time in port for vessels. In this paper, we focus our attention on the operational decision problem related to the seaside area of maritime container terminals. In particular, we study The Quay Crane Scheduling Problem (QCSP) which is considered as a core task of managing maritime container terminals and the optimization of these operations affects significantly the time spent by vessels at berth. The main goal behind this planning problem is to find the optimized sequence of loading and unloading tasks on a set of deployed quay cranes in order to exploit the full performances of port's resources while reducing the berth's total time occupation by vessels. In this paper, we provide a rich model for quay crane scheduling problem that covers important parameters such as ready time and due dates of Quay cranes (QCs), safety margin in order to avoid congestion between QCs and precedence relations among tasks. The proposed model seeks for a more compact mathematical formulation that can be easily solved by a standard optimization solver. Thus, we formulated the Quay Crane Scheduling Problem as a mixed-integer linear model that minimizes the sum of the QCs holding cost and tardiness penalty cost.

KEYWORDS: Transportation, Quay crane, Scheduling, Container terminal, Mixed-integer programming.

1 INTRODUCTION

Container terminals are strongly complex logistics systems because they allow transshipment between various modes of transport. They play an important role in the international logistics. As a consequence, the success of the supply chain depends on how efficient are terminal operations. The productivity of container terminals can be measured in terms of vessel turn time which represent the time spent by a vessel at berth. Many studies have investigated on improving the vessel turn time dealing with berth scheduling, quay crane scheduling, stowage planning and sequencing.

We focus our study on Quay Crane Scheduling Problem (QCSP) which is one of several operational planning problems found at container terminals. We organize the paper as follow. In Section 2, we describe in detail the QCSP. Section 3 presents a survey of previous work on QCSP. In section 4, we formulate the problem as a linear mathematical problem. Finally; we give some conclusions and perspectives in Section 5.

2 PROBLEM DESCRIPTION

As shown in Fig. 1, the container terminal operations can be divided into three main categories, cf. [1]:

- The first includes operations related to loading and unloading of ships and barges that are made in the seaside area.
- The second contains the storage operations and container handling. These operations are performed in the storage area (yard) of the terminal.
- The last category concerns the transfer of containers to ground transportation. These operations take place in the landside area.

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In the seaside area, we find three different decisions problems that affect on each other. When a vessel arrives at the port, we have to find a quay space to this vessel. So the first issue treated in the terminal container is berth allocation problem (BAP).It consists of the assignment of incoming vessels to berth positions. Next the containers are transferred from vessel to the quay by using QCs. Hence, the second problem which appears is quay crane assignment problem (QCAP) .It defines how many Quay Cranes (QCs) should be assigned to each berthing ship. Finally, we find the problem that interests our study. It concerns quay crane scheduling problem (QCSP).

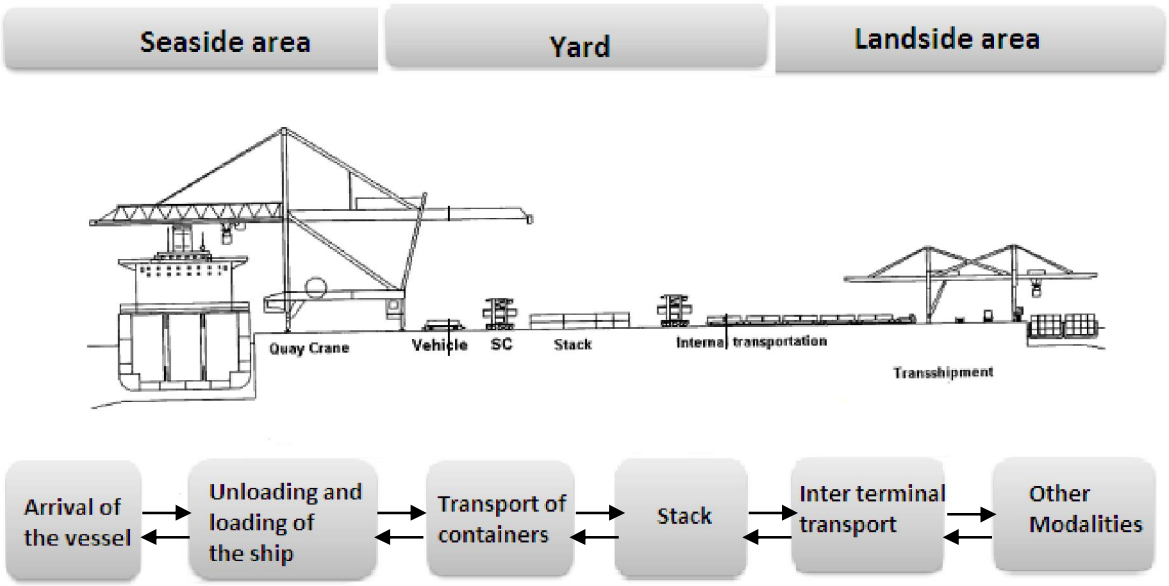

Fig. 1. Processes at a container terminal

This paper discusses the problem of scheduling quay cranes (QCs) which are considered as the most important equipment in port terminals. QCs are used at the seaside of a terminal for loading and unloading containers into and from vessels. They have direct impact on the throughput of container terminal. As a result, the efficient use of these equipments lead to short vessel turn time. Therefore, the scheduling of QCs is one of the most significant issues treated in container terminal. It consists of finding the sequence of charging and discharging containers such that the overall handling time is minimized.

According to Meisel and Bierwirth [2], there are five different classes of QCSP problem. QCSP of bay areas, QCSP of complete bays, QCSP of stack, QCSP of container groups and QCSP of container. The first category, QCSP of bay areas, consider a task as the workload of different bays. Whereas, in the QCSP of complete bays, tasks refer to the loading and unloading operations in a single bay. It means that every bay is served exclusively by one QC. The third category concern the QCSP of stack .It means that the tasks refer to the transshipment of all containers in a stack .The fourth category, QCSP of container groups, defines tasks as loading and unloading operations for a group of container that are stored in adjacent slots of a bay. Finally, in the QCSP of container, tasks refer to the handling of one container.

In practice, the scheduling target is often to complete all the jobs with respect to certain criteria. In our problem, these criteria can be measured according to the completion time of tasks, the makespan of a schedule which corresponds to the maximum completion time among all tasks and the throughput of cranes. Like any scheduling problem, QCSP must satisfy some constraints. The first one concerns interference constraints which mean that the QC scheduling models respect that the cranes cannot cross each other. Because they are mounted on a single rail track alongside the quay. Thus, to ensure the non-crossing constraint, we have to take into consideration a safety margin which has to be kept between adjacent cranes at all time. The second constraint deals with precedence relations among tasks. It allows ensuring that unloading precedes loading for the tasks in the same ship bay and to represent stacking of containers as defined by stowage plan. When unloading operations are performed in a ship bay, tasks on a deck must be performed before tasks in the hold.Conversely, for the loading operation, tasks in the hold must be fulfilled before tasks on the deck.

3 SURVEY OF QCSP

The quay crane scheduling problem for container terminals was first highlighted by Daganzo [3]. He studied the static quay crane scheduling problem with the objective of minimizing the aggregate cost of ship delay with berth length limitations. Furthermore, Peterkofsky and Daganzo [4] developed a branch and bound solution method for the static quay crane scheduling problem. Nevertheless, both of them did not consider non-crossing constraints, which did not reflect the practical cases. Kim and Park [5] defined a QCSP with container groups. They considered a non-crossing and precedence constraints and formulated the problem as MIP model. Additionally, they provided a branch and bound method to resolve the problem.Bierwirth and Meisel [2] gave a classification scheme for QCSP, and outlined a comprehensive review of this problem.

In term of interference constraints, they are taken into consideration in many studies. Thus, Lee et al [6] studied QCSP with interference constraints and proposed a genetic algorithm. Evenly, Choo et al [7] investigated the QCSP with specific constraints to prevent congestion in the yard. They proposed MIP as a model to the problem and resolve it with heuristic algorithm based on lagrangian relaxation.Lim et al [8] further considered the non-crossing spatial constraint for QC.

Regarding criteria, Lim et al [8] considered the latest completion time for all jobs, which is widely used in practice. Also Kim et park [5] had as a goal the minimization of the weighted sum of the makespan of the container vessel and the total completion time of all quay cranes. Recently, Kaveshgar et al [9] has studied the quay crane scheduling problem based on the model of Kim and Park [5] and they proposed the use of GA to solve the proposed problem.

4 MATHEMATICAL FORMULATION

This section proposes a mathematical formulation for the QC scheduling problem. This model must satisfy the constraints below:

- A task is defined as the handling operations of one bay.
- Only one quay crane can work on a ship bay at a time until it completes the ship bay.
- Each QC can operate after its earliest available time.

We use the following notations for the mathematical formulation.

4.1 INDICES

i,j Tasks indices which are ordered in an increasing order according to their locations on the ship-bay.

k QCs where k=1,…,K. QCs are also ordered in an increasing order of their relative locations in the direction of increasing ship-bay numbers.

4.2 PROBLEM DATA

P_i^k Processing time of task i on QC k.

β_k Fixed cost of using QC k.

α_k Variable cost of using QC k.

w_j Tardiness cost of task j.

d_j Due date of task j.

r_k Release time of QC k.

l_i Bay position of task i.

t_{ij} The travel time of a QC from bay position l_i of task i to bay position l_j of task j.

M A sufficiently large constant.

4.3 SETS OF INDICES

Ω The set of all tasks.

ψ The set of pairs of tasks that cannot be performed simultaneously. When tasks i and j cannot be performs simultaneously, $(i,j) \in \psi$.

ϕ The set of ordered pairs of tasks between which there is a precedence relationship. When task i must precede task j , $(i,j) \in \phi$.

4.4 DECISIONS VARIABLES

X_{ij}^k 1, if task j immediately follows task i on QC k; 0, otherwise. Tasks 0 and T will be considered to be the initial and final states of each QC, respectively.Thus when task j is the first task of QC k, $X_{0j}^k = 1$. Also, when task j is the last of QC k , $X_{jT}^k = 1$.

Y_{ij} 1, if task j start later than the completion time of task i; 0, otherwise.

Z_k 1, if QC k is selected; 0, otherwise.

Q_k Completion time of QC k.

C_i Completion time of task i.

$C_{\max}$ Makespan.

The QC scheduling problem can be formulated as follows:

Minimize $\sum_{k=1}^{K}(\alpha_k Q_k + \beta_k Z_k) + \sum_{i=1}^{N} w_i \max\{0, C_i - d_i\}$ (1)

Subject to

$C_k \le C_{\max}$ $\forall k = 1,...,\mathrm{K}$ (2)

$\sum_{j\in\Omega} X_{0j}^k = 1$ $\forall k = 1,...,\mathrm{K}$ (3)

$\sum_{i\in\Omega} X_{iT}^k = 1$ $\forall k = 1,...,\mathrm{K}$ (4)

$\sum_k \sum_{i\in\Omega} X_{ij}^k = 1$ $\forall j \in \Omega$ (5)

$C_i + t_{ij} + p_j - C_j \le M(1 - X_{ij}^k)$ $\forall i, j \in \Omega,\ \forall k = 1,...,\mathrm{K}$ (6)

$C_i + P_j \le C_j$ $\forall (i,j) \in \phi$ (7)

$C_j + t_{jT}^k - Q_k \le M(1 - X_{jT}^k)$ $\forall i \in \Omega,\ \forall k = 1,...,\mathrm{K}$ (8)

$r_k - C_j + t_{0j}^k + p_j \le M(1 - X_{0j}^k)$ $\forall i \in \Omega,\ \forall k = 1,...,\mathrm{K}$ (9)

$X_{ij}^k = 0 \text{ or } 1$ $\forall i, j \in \Omega,\ \forall k = 1,...,\mathrm{K}$ (10)

$Q_k, C_i \ge 0$ $\forall i \in \Omega,\ \forall k = 1,...,\mathrm{K}$ (11)

In this model, the objective function is composed of two terms. The first term is the QC holding cost and the second term is the total cost of tardiness penalties. This objective function reflects the balance between the system cost and the cost related to the job tardiness penalties. Constraint (2) determines the makespan which corresponds to the completion time of all tasks. Constraints (3) and (4) define the first and the last tasks for each QC, respectively. Constraint (5) ensures that every

task must be completed by exactly one crane. Constraint (6) determines the completion time for each task. Constraint (12) defines the completion time of each QC. Constraint (13) ensures that the first task of a crane is not started before the crane is ready. Finally, (14) and (15) define the domains of the decision variables.

5 CONCLUSION

Our study has been focused on the QCs scheduling problem, which is an important problem in the operation of port container terminal. Thus, we proposed a mixed-integer programming model that minimize the cost of tardiness penalties and the cost of using QCs as criterion and take into account constraints of precedence between tasks and non-crossing constraint. As perspective, we are looking forward to resolve this problem with the Genetic Algorithm method. And compare between the optimal solutions found by the LINGO and the proposed algorithm based on Genetic Algorithm in term of the objective function value.

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Land Ownership and its Impact on Adoption of Agroforestry Practices among Rural Households in Kenya: A Case of Busia County

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ABSTRACT: The practice of agroforestry can be much beneficial in the African communities where there are harsh environmental conditions, low technologies of agricultural production, fragmented land tenure system, unreliable livelihoods and chronic food insecurity. This paper is an outcome of a descriptive survey study that was conducted in Nambale division, Busia County in Kenya, which partly examined the factors influencing adoption of agroforestry practices among rural households. The adoption of agroforestry has not been very successful due to land ownership and land rights aspects that have adversely affected its adoption to the larger extent. In Kenya, land ownership remains exceedingly skewed in many rural parts of the country. The authors argue that when land ownership is extremely unequal, agroforestry activities and its growth delivers fewer paybacks for the poor rural households. Land tenure problems have been exacerbated by continuous fragmentation of land, land inheritance, gender imbalance in land ownership and the rights to land use. The paper concludes that the decision to adopt agroforestry was partly influenced by land and tree tenure, size of land and gender equity (women's rights to property and recognition of co-ownership). Additionally, rural households' investments in agroforestry increase with increasing in land tenure. The important policy recommendation made is that laws affecting adoption of agroforestry practices should be updated and harmonized in-order to achieve the 10% tree cover and for farmers and households to achieve the maximum benefits of agroforestry.

KEYWORDS: Land Tenure System, Land Rights, Land Fragmentation, Decision Making, Gender, Agroforestry.

1 INTRODUCTION

In Africa, sustainable use of agricultural land is becoming increasingly important for maintaining capacity for the food supply and livelihood of the agricultural sector. The increased food demand due to the rapidly growing population has increased the importance of improving productivity of land [1]. Agroforestry is a long-established farming practice in many parts of the world. Broadly defined, agroforestry refers to a land-use system in which trees are grown simultaneously, sequentially, or in conjunction with annual crops or livestock. The trees are cultivated primarily for agricultural use, for example, to protect or enrich top soils for the benefit of crops or to provide browse and fodder for livestock [1]. Agroforestry is a collective name for all land-use systems and practices where woody perennial plants are deliberately grown on the same land management unit as agricultural crops and/or animals, either in spatial mixture or in temporal sequence and there must be significant ecological and economic interactions between the woody and non-woody components[2].

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Agroforestry is a dynamic, ecologically based, natural resource management system, which involves the integration of trees on farms and in the agricultural landscape that seeks to diversify and sustain production for increased social, economic and environmental benefits for land users at all levels [34]. This is a definition that considers agroforestry as justified for being beneficial to the environment, household income, productivity, and sustained development of the community. Ideally, agroforestry systems, capable of providing substantial net economic and ecological benefits to households and communities, should be readily adopted by farmers. Despite this, many attempts to promote agroforestry have resulted in poor rates of adoption [3]. According to studies done by [4] and [5], there are higher Net Present Values (NPVs) for agroforestry systems when compared to monoculture systems, yet farmers in developing countries show low rates of adoption. Burley (1982) in FAO [5] has suggested that the major conditions which must be satisfied before rural people will plant trees are economic, socio-cultural, environmental and land ownership.

One of the critical factors that have been given consideration in determining the potential acceptability and viability of agroforestry is land fragmentation, land tenure systems and tree ownership. Land fragmentation at generational transfers has become a more important tendency in nearly all types of holdings. Rules of inheritance of land by all sons in a family and a larger family size inevitably imply a rapid fragmentation of family land. In areas already heavily populated with average land holdings of less than 2 hectares such as parts of western Kenya, the land fragmentation continues much below the limits of capacity to reproduce a family. This fragmentation has continued in spite of the legal instructions against sub-divisions below a minimum for reproducing a family [6].This has reduced land sizes among families leaving only small pieces of land for food production.

“Reference [7], gave the assertion that patterns of technology adoption will be shaped by the structure of opportunities and constraints presented by the rules of tenure.” In the study of Agroforestry adoption and risk perception by farmers in Senegal, [8] established that land ownership was one of the two predominant factors (the other was labour) affecting the adoption of agroforestry practices. For instance, women worldwide have been at the centre-stage of economic production, including agricultural, livestock and business sectors. In Africa, where the mainstay of most economies is farming or agriculture and livestock production, women contribute to 80% of the workforce. In most parts of Africa, women are closely associated with production of food and raw materials for the industrial sector. Indeed, women are also more directly involved in small-scale crafts and localized industries, trade and general business. However, women who comprise over half of the world’s population, rarely own any reasonable forms of property; do not have adequate access to the same, and do not even make major decisions pertaining to allocation and use of such property. Among farming communities where the basic property is land, women's access to it is determined by men as a matter of patriarchy cultural tradition. According to a study carried out by Women and Law in East Africa in 1995 on Inheritance Laws and Practices in Kenya, women only own land to the extent that they perceive or believe this is the case especially within marriage or other cohabitation relationships [9].

Among various Kenyan communities, women do not traditionally own land or other immovable properties. At best, they have usufruct rights, which are hinged on the nature of the relationship obtaining between them and men either as husbands, fathers, brothers or such other male relatives. Such access can be denied, as it is dependent on the whims of such male benefactors. This situation does not only place women in a precarious position in terms of their survival and livelihoods, but stifles their effective role and contribution to national development. With agriculture and other land based natural resources being the main sources of livelihood, the consequences for women not owning, controlling or accessing land are grave [9].

Agroforestry depends on people’s rights to plant and use trees, rights which in turn depend on the prevailing systems of land tenure and tree tenure. Tree tenure is often distinct from land tenure, but they affect each other. Tree tenure consists of a buddle of rights over trees and their produce, which may be held by different people at different times. These rights include rights to own or inherit trees, the rights to plant trees, the right to use trees and their products, the rights to dispose off trees and the right to exclude others from the use of trees and tree products. The nature of the tree, the nature of the use and the nature of the person or group influences who and what rights. Land owners tend to be relatively advantaged in terms of their rights to trees [10]. However, rights to plant trees have been restricted in Africa. It has been reported that trees may be planted as visible evidence of a claim to land in Kenya. “Reference [11] has also found that if the user does not have security over the intended planting location, adoption of the tree planting innovation may be quite out of question.” “Reference [12] also noted that in vast agricultural lands of tropical Africa, agroforestry has yet to make a break through. The reason is largely due to the flexible system of land tenure as well as its attendant insecurity.”

Land tenure reforms in Ghana has been advocated by [13] on the grounds that the old system does not provide security of tenure; that it discourages the investment of natural resources and does not encourage investments, which bring about development in the land. Miniature farm sizes and the manner in which they are fragmented and scattered constitute an

obstacle to farm improvement for they do not enable farmers to take advantage of economies of scale in production. The old system, prevent the use of farmland as collateral for credit; also it discourages the adoption of innovations and individual initiative in farming.

Studies have shown that ownership of land title is found to increase total factor production (TFP) in all models. For instance, [14], [15], and [1] assert that having secure land title promotes a farmer's investment in land improvement. Land size has a negative effect, possibly because a small-scale operation is more efficient in subsistence production, which does not rely heavily on machinery. This results from the intensification of production with decreases in land size [15]. This paper is an output of one of the objectives of the study, which partly investigated the factors that influence the adoption of agroforestry. The paper gives an account on how land tenure system in Kenya is a critical determinant on adoption of agroforestry among rural households.

2 RESEARCH METHODOLOGY

The research on which this paper draws was conducted in Nambale District, Busia County. Nambale District, one of the Districts in Western Province of Kenya, is the indigenous home of the Bakhayo people. Busia County falls within Lake Victoria basin. The altitude varies from 1130m on the shores of Lake Victoria to 1375m. The County falls under latitude 0° and 0° 25° North and longitude 34° 54° East. It covers a total area of 1262 squire kilometers, with 137 squire kilometers under permanent water surface. The county has 924,200 hectares (924 sq. km) of agricultural land but only 40,000 hectares is under crop production. The high potential parts are found in Nambale, Matayos and Butula areas [16].

The study was conducted through a descriptive survey research. A survey research according to [17], is a self-report study, which requires the collection of quantifiable information from the sample. A survey is a method of collecting information by interviewing or administering a questionnaire to a sample of individuals to obtain data useful in evaluating present practices and improving basis for decisions. For the purpose of this study, survey design was suitable for data collection in order to gather qualitative and quantitative data from the target population. Simple random sampling technique was used to select a sample of 200 respondents' from Nambale District, Busia County and a structured questionnaire was administered to the sample. Key informant interviews, informal group discussions and participant observation were also employed. Data was analyzed both qualitatively and quantitatively. This paper is an outcome of one of the objectives of the study that examined famer-oriented factors that influence adoption of agroforestry.

3 RESULTS AND DISCUSSION

3.1 LAND OWNERSHIP AND ITS IMPACT ON ADOPTION OF AGROFORESTRY

3.1.1 LAND TENURE SYSTEM

Study results indicated that all the respondents owned the land in which they were farming but their sizes varied. During informal discussions, it was established that personal land ownership encouraged the adoption of Agroforestry systems in the study area given that majority of rural farmers have personal land which was either culturally acquired (inheritance) or bought by an individual. Other types of land ownership such as rented or borrowed lands hindered the adoption of agroforestry practices for the reason that farmers could not use the land for long term production. However, allocation of land by household head to older sons with no clear demarcation and no title deeds hindered tree planting. This is because tree planting is seen as a claim of that portion of land since trees are long lasting and therefore, the cause of witnessed tree tenure conflicts in the area. As such, under such circumstances, the household head who is the father of the sons has all the rights to land ownership and tree tenure.

From the literature review, it is evident that nearly all small-scale farmers in many African societies fall within the customary tenure system whereby families depend on acquiring land through ancestry accession. This implies that each family is restricted to sharing land that belongs to their forefathers. Therefore, as family size increases, their share of land gets smaller since they have to pass on portions to the younger generation and more so to their sons. This has also led to land fragmentation into small portions which are hardly enough for household food production. Land ownership is mostly vested in men and women and they can plant their desirable crops on a parcel of land only when it is given to them as a gift [18]. However, for all the respondents, the land sizes varied. 63 (31.5%) of the respondents had land size between 1-3 acres, 77 (38.5%) had between 4-7 acres, 31 (15.5%) had between 8-11acres, 19 (9.5) had over 11 acres, while 10 (5%) had land but

did not know how many acres it was (Table 1). The number of acres included all the land, which did not have formal ownership vested to the care taker of the split piece of land.

Table 1. Land ownership and its impact on adoption of agroforestry

Responses	Frequency	Percent
1-3	63	31.5
4-7	77	38.5
8-11	31	15.5
>11	19	9.5
Unspecified	10	5.0
Total	200	100

Results indicate that majority of the farmers (70%) have less than 7 acres, which is relatively small given their household size and the fact that most of the respondents are subsistence farmers. The land tenure in this community is in the form of individual land holding. Men being the household heads are the ones that have the title deeds to the household's land, which make them have both usufractory and disposal rights to it. The implication of individual land ownership and the specific control of land resources by men in this community meant that men make most of the important decisions when it comes to issues of how to use or dispose the household land.

Out of informal discussions, the study found out that some of the men could even sell land without the knowledge of the wives or children. When it comes to decision making on what to plant, the wives would have to consult the husbands before they can know which crop to grow that season. For instance, one of the women said that they did not have sugarcane on their farm because her husband was in town and yet he was the one to approve whether to plant sugarcane or not, a decision he could not have taken when in town without coming back to see the situation on the ground, and also could not be convinced by the wife's justification for the same. This means that women are generally reduced to making proposals whose decisions are ratified by men, and after such decisions, women again implement the decisions by working or managing the farms through provision of labour.

3.1.2 LAND SIZE AND TREE PLANTING

Study results indicated that land size influenced tree planting (Table 2). Size of land impact greatly on farmers' decision to plant trees. A study done in Nyeri showed that farm size was one of the variables that were found to be statistically significant in explaining the size allocated to planting trees. As the size of the land increases, the acreage allocation to tree planting increases. Farmers with large farm size will spare larger portions of land to plant trees compared to their counterparts with small parcels of land [19].

Table 2. Cross tabulation results between size of land and number of trees on the farm

Variables x		Approximated number of trees on land			Total
		<10	10-30	>30	
Size of land (Acres)	1-3 count	28	36	0	64
	% within size of land	43.8%	56.3%	.0%	100.0%
	4-7 count	4	71	2	77
	% within size of land	5.2%	92.2%	32.6%	100.0%
	8-11 count	1	29	0	30
	% within size of land	3.3%	96.7%	.0%	100.0%
	>11 count	4	9	6	19
	% within size of land	57.9%	15.8%	26.3%	100.0%
	Unspecified count	4	6	0	10
	% within size of land	40.0%	60.0%	.0%	100.0%
	Total count	41	151	8	200
	% within size of land	20.5%	75.5%	4.0%	100.0%

A cross tabulation between size of land and the number of trees planted showed that famers with 1-3 acres of land had the majority (43%) with <10 trees on their farm, while those with >11 acres had the majority (26.3%) with > 30 trees on their farm. A chi square value of p=0.001) significant at 0.05 level showed a significant relationship between size of land and number of trees planted on farm meaning that there was a positive influence on size of land and number of trees planted and therefore, adoption of agroforestry practices. As the land size increases, adoption of agroforestry technologies also increases. [20] revealed that land size has a positive correlation with farmer's decision to plant improved fallows in Zambia. This could be because farmers with extra land are likely to use it for experimenting new technologies.

Study results are in tandem with what [21] found that land size has a positive effect on adoption because farmers with more cultivatable land are more likely to set aside a piece of land for fodder trees without impacting much negatively on land available to grow food crops or disturbing household food security. This is in contrast with a study done in Muranga in 1995, which observed that despite the pressure of land, trees were grown in 5 to 10% of the agricultural land [22]. Another study done in Kakamega district in western Kenya showed that 80% of the rural households had planted trees on 25% of their farms despite the small household land sizes in the district [23].

Study results are also consistent with the findings of [24] who found out that as parcels of land increases, more land will be allocated to tree planting. Ref [25] noted that tree growing awareness through extension services related positively to tree growing in the fields. Study results indicated that there was high awareness on tree growing in Nambale Division, but tree growing was limited by sugarcane farming which does not allow intercropping with perennial crops and more so trees. However, the findings of the study agreed with what was reported in Zimbabwe, Philippines and Ethiopia where land size of household was positively correlated with the number of trees planted by individual households [26]. Therefore, size of land limits farmers to certain agroforestry practices, which depicts the number of trees planted. During focused group discussions, it was found that secure land tenure systems influenced to a larger extent the adoption of agroforestry practices. For instance, those who did not own land or rented land could rarely involve themselves in agroforestry practices. This concurs with [35] who found tree planting in the Brazilian Amazon to be 15.4 times more likely under secure land tenure, and [36] study of contour hedgerow adoption in east Indonesia found that the landless comprised 31% of the population but only 11% of participants participated in *leucuena* based farming systems.

Tree tenure and gender was also blamed 70 (35%) for limiting trees on crop land and adoption of certain agroforestry practices. Men being the land owners are more advantaged to tree planting and rights over trees, while women implement men decisions and only benefit from harvesting tree products, and some tree parts for the welfare of the family. The situation regarding tree tenure and gender varies in different parts of the country: In some areas tree planting is clearly dominated by men (justified by the fact that men are the owners of the land), and trees are markers of ownership [2]. In many African communities, land use is decided by men who are the household heads and owners of land. Therefore, tree planting being long-term and involving land use is controlled by the household head. Women and children can only plant trees on permission from the household head and can only own the trees by association but cannot decide on when to cut the trees and how to use the tree products.

3.1.3 GENDER CONSIDERATION

Gender considerations in the promotion of agroforestry have been highlighted partly because of the varying gender perceptions of tree resources, their different roles in production activities and land ownership rights. 70% of the respondents indicated that gender influenced tree planting in the study area. According to [27], gender is an important factor in influencing adoption of agroforestry practices and the probability of adoption was higher for men than women farmers in the highlands of south western Uganda. This is perhaps due to the gender-equity issues in the introduction of technology to farmers which include land tenure issues, where women in Uganda do not have secure land and tree tenure due to the largely patrilineal inheritance systems [27]. Only old women, widows and female-headed households are often able to have access to more secure land rights. This is because the right to ownership of land by women in patrilineal societies is fully transferred to the woman in case the husband dies and/or when she takes the official household headship roles for the absentee husbands. Similar results in Cameroon, found that the gender of farmer facilitate the adoption of agroforestry systems [28]. Conversely, results from Tanzania indicated that 30% of the males and 26% of the females in the selected villages drawn from farming communities in Kilimanjaro were testing improved fallows, and there was no significant difference between the two proportions. Moreover, single females are often disadvantaged relative to female heads of household whose husbands live away [29]. Results showed that the same proportions of these two groups were testing the technology [30]. This means that other factors, beyond gender, were responsible for the kind of findings observed.

3.1.4 DECISION MAKING ON LAND USE

In many African communities, land ownership and land rights dictate and limits land use. Land use is decided by men who are the household heads and owners of land. Therefore, tree planting being long-term and involving land use is controlled by the household head. Women and children can only plant trees on permission from the household head and can only own the trees by association but cannot decide on when to cut the trees and how to use the tree products. Respondents were also asked who makes decisions to undertake the various activities on their farms. This question was intended to find out how decision making in a household can influence land use and the adoption of agroforestry practices depending on who makes decisions. Ref [31] noted that gender related decision making, which is often related to intra-household resource allocation is an important determinant of the adoption of agroforestry practices.

Study results indicated that decision to hire labour, choice of tree species, cash crop growing, location of trees and use of trees was majorly done by men. Shared decisions are made on cropping pattern, types of livestock and change of land use and mainly because it involves food security of the household which needs the contribution of woman of the household. Similar results were recorded in Ukambani where 65.5% of the decisions were made by men, 21.1% were shared decisions and only 14.4% were done by women [31]. Ref [32] noted that women's decision making power in household is limited to by products of men's trees and subsistence crops that have low cash returns on labor and women have obligations to provide labor for male controlled fields. The study results are in line with [31] who indicated that in western Kenya, the general understanding among the Luhyia community, for instance, is that the husband as the head of household has the overall control of the household resources and in that capacity everything in the household is viewed as belonging to him. A study done among the Akamba indicated that men as the heads of households are the main decision makers on matters of tree planting. In Malawi, decisions on harvesting of tree products was dependent on the part of the tree: women's influence on harvesting decisions decreased with corresponding increases in men's influence in decisions moved from twigs to the trunk[31]. Decisions on labor was equal among men and women who made individual decisions and considering that hiring labour is cash based, a role associated with men, the study found that labor was divided depending on the work to be done. Men made a sole decision to hire labour towards cane farming and tree growing that required more cash, while women made a sole decision to hire labour for food crops. However, results indicated that many women belonged to farmer groups and therefore, had ready labour from the members of the groups who organize to provide labour to each group member at different days.

Study results also indicated that choice of tree species to be planted in the farm was a male issue and women would be required to provide labor. Similar results were given by [32]. A study done in Rwanda showed that men's knowledge related to big trees such as Eucalyptus, Grevillea and *Makhamia lutea*, the planting and management of trees, introduction of new species and or varieties of trees and decision making aspect related to species choice, placing, timing and harvesting trees for timber, fuel wood or stakes, while women knowledge focused on species identification and naming, utility of the species for seasoning, medicine, love portions and fuel wood qualities [33]. Therefore, changes in productive relationships and in the pattern of resource ownership which might be brought about by tree cultivation must fall within culturally accepted strategies for resource distribution. Further, appropriate and culturally sensitive technical expertise must be available.

4 CONCLUSION AND RECOMMENDATION

The decision to adopt agroforestry was influenced by land and tree tenure, size of land and gender equity (women's rights to property and recognition of co-ownership). Additionally, rural households' investments in agroforestry increase with increasing in land tenure. Land tenure system is a major factor that could hinder agroforestry adoption in cases where no formal responsibility is vested on the caretaker of the piece of land given to him by the household head. Therefore, tree tenure rights could encourage tree planting if incorporated to the current land tenure rights. Decision to hire labour, choice of tree species, cash crop growing, location of trees and use of trees is majorly done by men. Shared decisions are made on cropping pattern, types of livestock and change of land use and mainly because it involves food security of the household, which needs the contribution of woman of the household. Land size influences tree planting, and in an area where cane farming is a major cash crop, compatible tree species are inevitable in the study area. The question of land tenure, tree tenure, gender disparity and land use decisions, which greatly influence agroforestry adoption, should be resolved by updating and harmonizing laws affecting land rights.

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Analysis of Scheduling Algorithms in Grid Computing Environment

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ABSTRACT: Grid Computing is the technology of dividing computer networks with different and heterogeneous resources based on distribution computing. Grid computing has no limitation due to its geographical domain and the type of undercover resources. Generally, a grid network can be considered as a series of several big branches, different kinds of microprocessors, thousands of PC computers and workstations in all over the world. The goal of grid computing is to apply available computing resources easily for complicated calculations vie sites which are distributed geographically. In another words, the least cost for many users is to support parallelism, minimize the time of task operation and so on in scientific, trade and industrial contexts. To reach the goal, it is necessary to use an efficient scheduling system as a vital part for grid environment. Generally, scheduling plays very important role in grid networks. So, selecting the type of scheduling algorithm has an important role in optimizing the reply and waiting time which involve as two important factors. As providing scheduling algorithms which can minimize tasks runtime and increase operational power has remarkable importance in these categories. In this paper, we discuss about scheduling algorithms which involve independent algorithms such as Minimum Execution Time, Minimum Completion Time, Min-min, Max-min and XSuffrage.

KEYWORDS: Grid Computing, Scheduling, Scheduling Algorithms, Network, Resource.

1 INTRODUCTION

Grid computing technology provides an opportunity for users to access different types of remote resources using communicational substructures of computer networks and distributed systems [1]. Nowadays, heterogeneous computing networks can be connected to each other using grid technology as it seems as a fully integrated machine. Then, very complicated application programs can be implemented which require high processing power and large amount of data [2]. For example, by using grid technology, several super and PC computers can be connected to each other. Grid computing has no limitation due to its geographical domain and the type of undercover resources. In general, a grid network can be considered as a series of several big branches, different kinds of microprocessors, thousands of PC computers and workstations in all over the world. Grid network makes connection between those heterogeneous computers which have no consistency among them. It also recognizes different types of resources and manages to remote reach to them and finally makes possible big and complicated processing to be implemented with huge amount of resources as distributed in a powerful context [3], [4].

In fact, by linking to one of the gridding networks, we can obtain very high computing to implement very big projects. At the other hand, grid network provides different organizations' association about common project fields an all over the world. In distributed environments, a group of users send their programs to a series of resources to implements. Grid computing scheduling system is responsible for program and resources management. The scheduling system must be able to assign appropriate resource to programs and also meets the efficient goals. The scheduling system is capable of providing parallel computational environments link to perform easier due to the same features of programs and resources. Briefly, it can be

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said that grid computing is a software frame which collects resource status data, prepares appropriate resources, anticipates the efficiency of each resource and determines the best resource [5], [6] and [7]. In another word, grid resource management system is the responsible for controlling grid resources and its goal is to promote efficiency [8]. Grid data service is a part of grid resources management system which provides dynamic data of grid resources. Grid scheduling is another part of grid resources management system. It provides an assignment of tasks to resources using resource data which created by grid data service and their tasks data. It is called scheduling assignment. An efficient scheduling causes to decrease ending time and tasks implementation costs, more reliability and better error controlling. To reach these efficiencies, scheduling algorithms are created which are discussed in this paper.

We organized general structure of this paper as follows: in section 2, we discuss about the challenges of grid scheduling system; in section 3, grid computing is discussed; in section 4, it is presented various types of independent works of scheduling algorithms; in section 5, we will discuss about grid scheduling algorithms and finally in the section 6, conclusion and future works is presented.

2 GRID SYSTEM CHALLENGES

Although grid network is placed in distributed parallel computational systems, but its unique features which is scheduling makes the resources links difficult in grid environment. Grid scheduling system must overcome challenges which we note to be able to provide services with appropriate efficiency and perform grid potentials [9]. The main challenges of grid scheduling system are as follow:

2.1 HETEROGENIC OF RESOURCES

Grid computing consists of two resources: computational resources and communication (network) resources. There is heterogenic in these two resources. The networks are different in band width and communication protocols. The computational resources include different hardware (e.g. series of orders, architecture, number of processes, physical memory size, processing rate) and different software (e. g. operating system, file system, cluster management software). So, scheduling system must use these different computational powers as optimal [9], [10].

2.2 INDEPENDENT DOMAINS

It is possible that grid consists of several various management domain in which each one has its own particular security and management policies and usually allow the group of users to use resources. It means that it must be impossible to implement invalid users programs on that domain. Each site has an independent nature and its own particular scheduling policy. This makes the anticipation of task implementation impossible. At the other hand, the goal determination of unit general efficiency is also impossible because each site makes decision about scheduling due to its goals and independent from others [9, 11].

2.3 UNALLOCATED RESOURCES

Due to the available unallocated resources, there is a remarkable competition about using the resources. It means that a resource is connected to several grids and local users and other grids use that, simultaneously. One of the competition results is that resources don't allocate to all works. For example, in widespread networks which use internet protocol series, network features such as delay and band width are changed due to the simultaneous usage of users. In such an environment, designing a precise efficient model is a difficult task. By assessing the fraction of available resources dynamically, competition can be recognized. In grid network, resource management system facilitates resource efficiency anticipation by guaranteeing service quality and resource reservation [9], [12]. The simplest way is that the tasks are executed on several machines. The machine which is running normally may involve in computation abnormally due to facing with a lot of activities. So, the tasks must be executed on no-use machines.

2.4 VARIETY OF PROGRAMS

The increasing numbers of grid users have programs with their own particular needs. It is possible that the programs need sequential or concurrent implementation. The programs include dependent and/or independent tasks. It is also difficult to build an all-purpose scheduling system to be able to manage different programs [9], [13].

2.5 DYNAMIC BEHAVIOUR

In traditional parallel computational environments such as clusters, there are a mass of constant resources. But, there is also dynamic either in network or computational resources in grid network. Firstly, a network which is connected by many users couldn't be able to provide guaranteed band width. Secondly, resource accessibility and their capabilities are also dynamic. It means that new resources are added to the network or may be removed from accessibility due to network problems. Due to the available competition among machines to access the resource, the efficiency of them is also changed over time. Scheduling must be able to adapt such a dynamic behavior, recognize it automatically after connection to a new resource, consider it in the future decision making and finally guarantee its reliability (grid system) as a resource becomes out of reach due to ambiguous reasons by applying mechanisms such as checkout point and/or re-scheduling [9], [14].

Fig 1. shows a sample of grid scheduling for users.

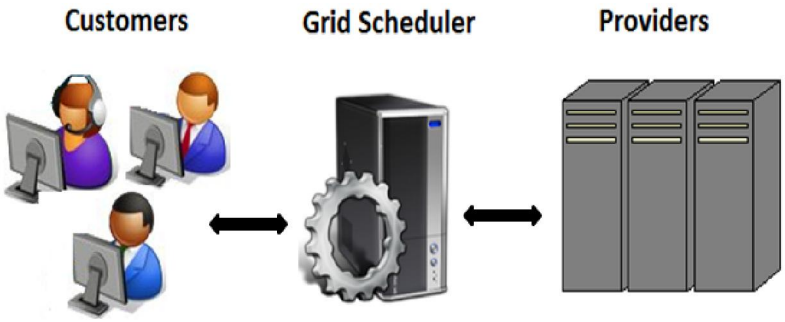

Fig. 1. A Sample of Grid Scheduling for Users

3 GRID SCHEDULING

In grid scheduling, there are several hierarchical scheduling which include algorithms. In this paper, we begin to discuss about hierarchical scheduling to get familiar with them. Independent tasks scheduling is considered as one of the hierarchical scheduling in which its algorithms are discussed in this paper.

3.1 LOCAL AND GLOBAL SCHEDULING

Local scheduling determines assignment and implementation methods in a processor. However, global scheduling policy uses system data to divide the tasks among several processors in such a way to optimize system efficiency [15]. In grid scheduling, it is used global scheduling to assign resources to the tasks.

3.2 STATIC AND DYNAMIC SCHEDULING

In static scheduling, it is assumed that data related to both all grid resources and tasks of an applied program while scheduling is available [16]. In dynamic scheduling, the main idea is that tasks assign is implemented while the applied program is running. This method is useful as it is impossible to determine running time, branching orientation and unknown number of loop repetition and real time of tasks. Grid computing can be performed in two types of static and dynamic [17].

In static scheduling, each task for implementation is assigned to a resource once. So, the location of applied program is constant and accurate estimation can be provided from computing costs during real implementation development. The main advantage of this method is the simplicity of programming from scheduling view. This model provides a global view about tasks and costs. However, cost estimation based on static data isn't in accordance with new positions (situations). For example, if a node which is assigned to perform a computing destroys or inaccessible due to network defaults and/or the response time becomes more than expected due to network traffic. Of course, to decrease such problems, it can be used special mechanisms such as re-scheduling to provide opportunities for tasks transmission which naturally impose additional extra load to system. Using these mechanisms makes the distance between static and dynamic scheduling less important. Dynamic scheduling is usually used when it is difficult to anticipate cost of applied program and/or tasks are dynamic and on the line [16]. Dynamic scheduling includes two parts: situation estimation (rather cost estimation in static scheduling) and decision making [17]. The system situation scheduling includes gathering the total data situation of grid network and building estimation. Based on noted estimations, it is decided tasks assign to which resource. As the cost of assignment isn't

estimated, the natural way to keep the system dynamic and secure is to balance the total load of system resource. The advantage of dynamic balancing to static scheduling is that system doesn't need to know about implementation time of applied programs before it [18]. This issue is particularly useful in the system that its goal is to maximize resource efficiency. If a lot of tasks are added to a resource, the balancing policy will determine whether it is necessary to send some tasks to the other resources and if it is needed which tasks must be sent.

3.3 Optimal Scheduling

If all data related to resources and tasks are known, optimal assigning will be performed based on criteria such as "minimizing spreading time" or "maximizing resources efficiency". However, due to NP-complete nature of scheduling algorithms, having logical assumptions and optimality proving of such algorithms would be difficult. For this reason, the solutions close to the optimal are investigated in current researches. Algorithms close to the optimal solutions are divided in to two groups: approximation and innovation [19]. In approximate algorithms, it is applied formal computing models but doesn't investigate the total reply space. However, when a good enough solution found, the search would be stopped. This method decreases the spent time to find scheduling. The other group of algorithm close to the optimal solution is innovative. These algorithms include assumptions based on facts about processing and system load characteristics. The solution it produces wouldn't be lead to the optimal reply but its resources and cost is logical. Assessing these kinds of solutions is performed in real and/or simulated environments. Innovative algorithms are considerably adjusted to grid environment [19], [20].

3.4 Distributed Scheduling and Central Scheduling

In dynamic scheduling, decision making is assigned to central scheduling about global scheduling or shared among several distributed scheduling [21]. Central scheduling implementation is a simple process but not expandable, can't bear error and it is possible to be just a data entry. In distributed scheduling, the resource assigning decision making process is performed in parallel with the real process of tasks to save processes expensive cycles. In distributed scheduling, the tasks are sent to task machines which involved resources in parallel. It acts well when all tasks have request of resource in a same site.

3.5 Cooperative Scheduling and Independent Scheduling

The other considerable point of distributed scheduling algorithms is that whether scheduling involved nodes do their tasks cooperatively or independently? In independent status, each scheduling decides as independent and based on its optimal goals without considering its decision effects on other systems. For example, this kind of scheduling is the scheduling of applied program level. In cooperative status, each scheduling is supposed to program and schedule the related tasks. However, all scheduling are going to achieve a systematic common goal and the common goal is to promote the efficiency of total system rather local and/or particular program efficiency [22].

3.6 Compile Time Scheduling and Runtime Scheduling

Scheduling which compute the time of applied series of tasks in compile time is so called compile time scheduling. It is supposed that data such as processing rate are known. It is favorite model because it is easy to program scheduling. In runtime scheduling, total time to perform tasks is determined by scheduling during runtime [23, 24].

4 Independent Tasks Scheduling Algorithms

Technology growth and various integrated tasks in a form of comprehensive and integrated system causes that time management process face with a lot of challenges in grid computing. As grid computing is a series of distributed heterogeneous computers and connects to each other through network and shares programs, data and heterogeneous computing resources. So, wide computing systems such as grid must involve algorithms which include high speed rate and efficiency. As a series of independent tasks enters a system, it will be used a common strategy to assign them to the resources based on resources load. The goal is to reach higher operational power [22]. The most important algorithms of independent tasks scheduling is as follow:

4.1 MINIMUM EXECUTION TIME ALGORITHM

Minimum execution time algorithm assigns the task to a resource which has the best anticipated executed time for it. It doesn't consider whether this resource is available or not. Its main goal is to assign each task to the best machine. It may cause extreme imbalance of load. So, it isn't appropriate for heterogeneous computing environments because it doesn't consider tasks and resource features [24], [25]. In this algorithm, it is assigned tasks to machine without considering workload of processing machine and causes it can't end up the task in the determined time [26]. Due to the time changeable nature of this algorithm, the resources aren't under the control of central management and can't be sure about tasks execution in the determined time [27].

4.2 MINIMUM COMPLETION TIME (MCT) ALGORITHM

MCT algorithm assigns tasks to the resource which has the smallest time of completion. It causes that some tasks are assigned to machines which don't contain the smallest running time. S, in this algorithm, the task is mapped to a resource which can end up the execution sooner than the other resources. Of course, if all possible resources have similar workload, the selected resource will certainly involve more capable resources and can end up execution sooner. The idea of this algorithm is to combine time and load balance advantages in MET and refuse imbalance circumstances in which MET acts weaker [17]. It tries to assign the task to the best machine as soon as possible and replies to requests as optimal in the least possible time [28]. In MCT algorithm, each task is assigned to the resource considering its time to be able to end up execution sooner [29].

4.3 MIN-MIN ALGORITHM

Min-min algorithm begins to execute using U series (the series of all un-mapped tasks). Then, it is created the minimum series of completion times for tasks according to Equation (1).

$$M = [\min_{0<j<\mu}(ct(t_i, m_i)), for \quad each \quad t_i \in U] \tag{1}$$

So, the task which has the shortest time of completion is selected from M series and then assigned to that resource. Then, another task is selected from U series and the noted stages are repeated. It continues as all members of the U series become mapped. Similar to MCT method, it acts according to completion time minimizing but in Min-min method, all un-mapped tasks are considered during decision making for mapping. While in MCT, only a task is considered each time [17], [24],[25]. This algorithm is use to manage single or several tasks. A central machine acts as the resource manager to schedule tasks in it and all processing machines in grid environment are under the control and management of this machine. The tasks are first assigned to central scheduling and then central scheduling transfer them to the other appropriate processing machines. The tasks which don't assign them resource will put in an array of central task to be placed in the processing later [27], [28].

4.4 MAX-MIN ALGORITHM

It is similar to Min-min algorithm except that after building M series, it is selected the task which has the longest completion time. Intuitively, Max-min algorithm tries to minimize the related problems of task execution with the longest execution time [18, 30]. For example, suppose that a program has a lot of tasks with short execution time as well as a task with long runtime. If long task is mapped to the best machine, it provides the opportunity to execute long task along with the short one concurrently. By using this method, Max-min algorithm will have better map, load balance and expanding time. In this way, Max-min map has better function than Min-min map. But, if it is executed all short tasks and then long ones, a lot of machines will remain useless in the site. So, in Max-min, all tasks are firstly arranged chronologically as descending (from highest to lowest. Then, the first task is selected among them and the required time assigned to execute it. The task is assigned to a resource which can end up the execution as soon as possible. This process is applicable for all tasks to finish all requests. Min and Max-min algorithms have good efficiency and can easily incorporate with other scheduling algorithms [30]. They also guarantee tasks service quality partly and also minimize the access time to resources [28].

4.5 XSUFFRAGE ALGORITHM

Suffrage is another algorithm to schedule independent tasks [7]. The logic of this algorithm is that each task is assigned to particular machine and can't be take resource from other machines. The efficiency and function of tasks scheduling in Suffrage algorithm is performed based on MCT. In Suffrage algorithm the tasks faces problems as there are input and output

data as well as clustering resources. In this way, logically, the task must be assigned to the free resources to prevent time waste. If the resources are clustered and have similar efficiency, Suffrage algorithm won't have good performance and the tasks may not be assigned to free resources with good efficiency. Consequently, the desired task is removed due to the lack of resources from requests array. To solve this problem, a group of researchers have been improved Suffrage algorithm and called it Xsuffrage. In this way, each task receives resources in cluster level chronologically.

5 DISCUSSION

Nowadays, an efficient and effective scheduling is required to increase efficiency in grid computing. In grid networks, the resources are heterogeneous and this causes the increasing complexity of applicable scheduling in these environments. Grid computing shares the distributed resources geographically to achieve common goals with each other and this performs using scheduling algorithm. So, one of the main parts of grid computing is scheduling. Scheduling is responsible to manage resources and divide the tasks among computing resources accurately. Error controlling is also considered as one of these responsibilities. Optimal scheduling leads to increasing service quality.

Scheduling algorithms in grid computing is divided to two groups of global and local. In local scheduling method, it is decided about processes assigning to a process and its execution. In global scheduling method, it is performed processes assigning to several processes to optimize the general efficiency of system using systems data. The next level in scheduling hierarchy is to select static and dynamic scheduling. In static scheduling, the required data is available about all grid resources during scheduling. So, accurate estimation can be performed from computing resources in real execution. In this method, assigning requests are confirmed and resource request estimation is simple. But resource estimation based on static data isn't compatible esp. in cases that one of the selected nodes are destroyed to do computing and/or amount of load is increased due to available requests which their reply time is longer than expected. But in dynamic algorithms, the main idea is to assign request in programs runtime. The increasing dynamism in grid computing causes that these algorithms have better function. So, dynamic scheduling acts well in most cases but the main problem occur as the scheduling task is delivered to the desired resource and placed in the expecting list. If it is executed small tasks by scheduling algorithms and the bigger tasks are distributed among the resources at the end, wasted time will be increased in the resources and consequently runtime difference will increase in the most applicable resource than the other resources. Because, it isn't easy to assign transporting conditions of a big task from most applicable resource to faster one due to time limit and this isn't appropriate for grid environment considering time. If bigger tasks are distributed at first and then the smaller ones, it can be provided an opportunity to minimize the difference between the most applicable resource and the other ones using the remaining time to distribute the small tasks among the resources. It is possible that the amount of tasks reach a point which causes increasing rate of resource requests in grid computing. If applied programs are applicable in grid network, it can be transported to useless machines to execute in these cases. In general, a grid can perform the computing load balance in widespread series of resources.

Grid computing provides a software and hardware infrastructure in which local resources of each machine for users can be used in a network environment of distributed and heterogeneous machines. In fact, grid network is associated with a series of resources in widespread scale which commonly used. There are a lot of obstacles to decrease efficiency and scalability of grid computing. The first obstacle is algorithms which are used to classify tasks among a lot of processes. If algorithm is divided to only a few numbers of time independent parts, it can be an obstacle against scalability. The second obstacle is that the executing parts don't be fully independent from each other which causes tasks interruption and limits scalability. For example, all tasks are commonly performed writing and reading a file or a database if necessary. In this case, access limitations to that file or database will be a limiting factor for tasks scalability. We, in this paper, propose to discuss about scheduling algorithms which involve independent algorithms such as MET, MCT, Min-min, Max-min and XSuffrage. Each algorithm tries to minimize runtime and resource heterogeneity and reaches to high operational power.

6 CONCLUSION AND FUTURE WORKS

Due to the developing rate of trade, industry and science world, scheduling is considered as one of the main discussions in grid environment. As providing scheduling algorithms which can minimize tasks runtime and increase operational power has remarkable importance in these categories. Along with, there are algorithms which meet the needs as far as possible which is noted to a few of them in this paper. Grid scheduling system and various types of challenging features in grid are discussed in this paper to get familiar with scheduling challenges and be selected an algorithm to remove these challenges. Then, grid computing hierarchy is discussed to get familiar with them. Independent tasks scheduling algorithms are also

explained. We hope to provide researches in future to solve some un-solved scheduling challenges using scheduling algorithms incorporating.

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Technical Analysis of Coal Utilization and Environmental Pollution

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ABSTRACT: Coal is known as black gold, the food of industry. It has been used as one of the main energies for human being since the 18th century. Although its important place has been taken by petroleum nowadays, due to the daily drying up of petroleum for quite a period of time in the future, the large quantity of coal reserves and with the rapid development of science and technology, especially maturity and wide use of integrated coal gasification technology, coal will become one of the energies that cannot be replaced in human life and production. Coal increased fastest for five successive years. Coal consumption increased by 4.5% in the world which is higher than the average level 3.2% of last ten years. However, the use of coal has brought up serious ecological environment problems. In the 20th century, serious air environmental pollution events, such as acid rain, damage to ozonosphere, global warming, photochemical smog and urban coal smog, are all related to coal burning. The principal source of main pollutants in air, for example, SO_2, NO_x, CO, fume dust, particles, organic pollutants and heavy metals, are caused by coal burning. These pollutants have caused irreversible damage to human health and ecological environment. Finally this paper describes coal consumption and environmental problems due to coal utilization.

KEYWORDS: Coal Consumption, Environmental Problems, Acid Rain Pollution, NO_X Pollution, Organic Pollutant, SO_2 Emission, CO_2 Emission.

1 INTRODUCTION

Global energy consumption in 2007 reached 16.73 billion tons of standard coal with increase rate of 2.5%, of which coal consumption is 4.849 billion tons of standard coal, natural gas consumption is 3.943 billion tons of standard coal, consumption of mineral oil is 5.923 billion tons of standard coal, consumption of nuclear energy is 960 million tons of standard coal, water energy consumption is 1.055 billion tons of standard coal. According to the forecast of International Energy administration (IEA), global energy consumption in the future will increase steadily at a rate 1.8% per year [1]-[2],[4].

Coal consumption can be divided into two parts, coal for industry and coal for living. In industries, coal consumption concentrates in power, building materials, steel & iron and chemical industries, where power industry is a big consumer. In 2004, the coal consumption was 1.8 billion tons in China in which 0.85billion tons are for thermal power plant (incl. heat supply), accounting for 47% against total coal consumption in China. In 2006, the proportion of coal consumption in power industry increased to 53% [3]-[4]. Therefore, it's imperative under the situation to control the environmental protection

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issues caused by coal combustion. Until now, many countries issued policies and regulations in respect of pollutants emission and control from coal-fired power plant, and as the development of economy and the increase of understanding level of human being, the requirements will be more stringent. So it's an important means for ensuring sustainable economic development based on coal-fired power and the health of human being to understand flue gas cleaning technologies for coal-fired power plant.

2 COAL RESOURCE AND UTILIZATION

2.1 COAL RESOURCE AND UTILIZATION IN THE WORLD

Global hard coal output in 2007: Germany, 22 million tons; UK, 17 million tons; Spain, 11 million tons; Poland, 87 million tons; Czech, 13 million tones; Romania, 3 million tons; Russia, 314 million tons; Kazakhstan, 96 million tons; Ukraine, 75 million tons; Canada, 37 million tons; U.S.A., 1.043 billion tons; Colombia, 69 million tons; Venezuela, 8 million tons; South Africa, 243 million tons; Australia, 322 million tons; India, 430 million tons; China, 2.523 billion tons; Indonesia, 230 million tons. World coke output is 580 million tons and 510 million tons in 2006 [6],[7].

Coal producing countries in Pacific Region has seen significant increase of coal output. China's coal output in 2007 reached 2.523 billion tons, an increase of 197 million tons as compared with 2006 (2.326 billion tons). China's coal output was increased by about 1.3 billion tons from 2000 to 2007. According to industry sources, China's coal output will be increased to 6 billion tons in the year 2013/2015. India is also one of the big coal producers in the world. The country is now building new coal mines to meet the coal demand of its electric power industry [5]-[6]. For details see Table.1

Table 1. Output of hard Coal of the Producing Countries in Pacific Region in 2007

Coal Producing Country	2004	2005	2006	2007
China	19.92	21.90	23.26	25.23
India	3.50	3.70	3.90	4.30
Australia	2.97	3.06	3.02	3.22
Indonesia	1.35	1.53	2.05	2.30
Vietnam	0.28	0.34	0.44	0.50
Total	28.02	30.53	32.67	35.55

Unit: Hundred Million Ton

In addition to the above countries, Korea, Mongolia and New Zealand in Asia have also seen significant increase of coal output.

Output of coal in North America decreased due to the lack of coal demand in power generation. Canada has increased the output of coke due to the large demand in the international market. In South America, Colombia has seen a continuous increase in output of coal. According to industry sources, coal export of Colombia will exceed that of South Africa in the coming few years. Output of coal in Venezuela will remain unchanged. Venezuela government has restricted its annual output of coal at 10 million tons.

In the Commonwealth of Independent States (CIS), Russia and Kazakhstan have seen increase of coal output. The coal output in Ukraine has seen a decrease due to the geological conditions and the operation problems of main coal enterprises. The output of hard coal in South Africa sees no increase. New coal mining projects are executed in Mozambique, Botswana and Zimbabwe. Recently, Madagascar is also in search for establishment of new coal mines.

According to forecast of International Energy Administration (IEC), output of hard coal will increase from 5.6 billion tons to 8.7 billion tons in 2030. Countries having seen increase of coal output mainly concentrate in Asia. Second to Asia is North America and CIS [7].

According to estimation, coal can still be mined for another 130~140 years when reckoned based on the world coal output of 5.6 billion tons in 2007 [8]. See Table.2 for details. For coal consuming status of countries, see fig.1 for reference.

Table 2. Coal Reserves and Mining in the World

Region	Coal Reserve in 2006	Coal Output in 2007
Europe	190	1.53
CIS	1110	4.85
Africa	530	2.43
North America (Canada)	2190	10.43
South America	200	0.77
China	1670	25.23
Rest of Asian countries	1060	7.4
Australia/New Zealand	410	3.27
Rest of the world	0	0.09
Total	7360	56.00

Unit: Hundred Million Ton

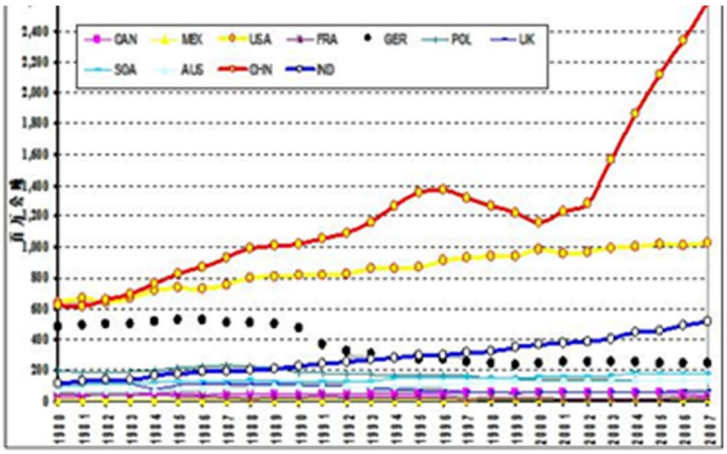

Fig. 1. Coal Consumption in main Coal Consuming Countries in the World (Million Tons)

2.2 COAL RESOURCE AND UTILIZATION IN CHINA

China is rich in coal resources. According to the third nationwide coalfield prediction data, total sum of coal resources above vertical depth of 2000m of China (Taiwan province) is 5,569,749 million tons, of which total sum of proven resource reserves is 1,017,645 million tons, predicted resource reserves is 4,552,104 million tons. In the proven resource reserves, resource reserve occupied by production and collieries under construction is 191,604 million tons. The resource reserve not utilized is 826,041 million tons [8]-[9]-[10].

2.2.1 GEOGRAPHICAL AREA DISTRIBUTION OF COAL RESOURCE IN CHINA

Coal resource in China is mainly distributed in the north from Kunlun-Qinling-Dabieshan Mountains. The sum of coal resource in the north provinces from Kunlun-Qinling-Dabieshan line is 5,184,282 million tons, accounting for 93.08% of the total coal resources of the whole country while the sum of the coal resources for the other provinces is 385,467 million tons, accounting only for 6.98% of the total coal resources of the whole country. The proven resource reserve in the northern regions from Kunlun-Qinling-Dabieshan mountains accounts for over 90% of the proven resource reserve of the whole country while the proven resource reserve in the southern part from this line accounts for less than 10% of the proven resource reserve of the whole country. Obviously, the coal resources of China characterize as more in the north and less in the south in geographical distribution [11].

If divided by Daxing'anling-Taihang Mountain-Xuefengshan Mountain, the coal resource in the 11 provinces and autonomous regions including Inner Mongolia, Sichuan, and Guizhou, in the west from the line is 5,114,571 million tons, accounting for 91.83% of the total coal resources of the whole country. In the western region from this line, the proven resource reserve accounts for 89% of the proven resource reserves while the proven resource reserves in the eastern part

from this line account for 11% of the proven resource reserves. Obviously, the coal resource distribution in China is characterized as more in the west and less in the east in geographical distribution [12][13].

The feature of the coal resource in China, "more in the north and less in the south and more in the west and less in the east" in geographical distribution determines the basic production pattern of "coal transportation from the west to the east and from the north to the south" in China.

2.2.2 COAL RESOURCE DISTRIBUTION IN THE MAIN PROVINCES AND REGIONS IN CHINA

China is rich in coal resource which distributes almost in all the provinces and regions excepting Shanghai. However, the distribution is very unbalanced. The coal resource of Xinjiang Uygur Autonomous Region which owns the largest quantity of coal resource is up to 1919353 million tons while that of Zhejiang Province which has the least coal resource is only 50 million tons. Provinces and regions having coal resource more than 1,000 billion tons include Xinjiang and Inner Mongolia autonomous regions, of which the sum of coal resource is 3,365,009 million tons, accounting for 60.42% of the total coal resource of the whole country. The sum of proven resource reserve of these two regions is 336,235 million tons, accounting for 33.04% of the proven resource reserves of the whole country [14].

Provinces and regions having coal resource over 100,000 million tons in China include Xinjiang, Inner Mongolia, Shanxi, Shaanxi, Henan, Ningxia, Gansu, Guizhou, of which the sum of coal resources is 5,075,083 million tons, accounting for 91.12% of the total coal resources in the whole country. The sum of proven resource reserves of these 8 provinces and regions is 856,624 million tons, accounting for 84.18% of the total sum of the proven resource reserves.

There are 12 provinces and regions having coal resources over 50 billion tons in China including the 8 provinces and regions having coal resources over 100 billion tons plus the 4 provinces of Anhui, Yunnan, Hebei and Shandong, the sum of coal resource of which is 5,377,378 million tons, accounting for 96.55% of the total sum of the coal resources of the whole country; the total sum of proven resources of the 12 provinces is 953,322 million tons, accounting for 93.68% of the total proven resources. The sum of the coal resources of the 17 provinces excluding Taiwan having coal resources less than 50,000 million tons is only 192,971 million tons, accounting only for 3.45% of the coal resources of the whole country. The proven resource reserve is only 64,323 million tons, accounting only for 6.32% of the proven resource reserves of the whole country [15]-[16].

2.2.3 MAIN COAL INDUSTRY BASES OF CHINA

In the regions between Daxing'anling-Taihangshan, Helanshan mountains in the north of China, the geographical range includes the whole or most part of the 6 provinces and regions of Inner Mongolia, Shanxi, Shaanxi, Ningxia, Gansu and Henan having coal resources more than 100 billion tons each and is the coal resource concentration area of China, the sum of coal resources of which accounts about 50% of the total coal resources of the whole country and over 55% of the coal resources of the northern part of China. The proven resource reserves in this area account for about 65% of the proven resource reserves of the northern part of China. Obviously, this region is not only rich in coal resources with good coal quality, but also the geographical position of this region is relatively close to the east and southeast parts China lacking of coal resources, hence is the most important coal producing base [17].

In the south of China, the coal resources mainly concentrate in the three provinces of Guizhou, Yunnan and Sichuan. The sum of coal resources of these three provinces is 352,574 million tons, accounting for 91.47% of coal resources in the south of China. The proven resource reserves of these three provinces also account for over 90% of the proven coal resources in the south regions. Especially, the west part of Guizhou, the south of Sichuan and the east of Yunnan are the richest regions in coal resources in the south of China. Obviously, this region is the most important coal producing base in the south area of China [18].

2.2.4 COAL UTILIZATION IN CHINA

In 2006, Chinese coal mining and washing and screening industries have realized RMB 698,829,619,000 Yuan of total accumulated production value, a 23.45% increase as compared with that of the same period of previous year; RMB 709,234,867,000 Yuan of accumulated sales income of product, an increase of 23.72% as compared with the same period of the previous year; and RMB 67,726,662,000 Yuan of accumulated total profit, an increase of 25.34% as compared with the same period of previous year [19]. In 2007, Chinese coal mining and washing and screening industries realized RMB 916,447,509,000 Yuan of accumulated total production value, an increase of 28.06% as compared with the same period of the previous year. In 2008, the whole country saw a continuous large increase in raw coal output, achieving 2,621,832,400

tons of raw coal production, a growth of 12.79% year-by-year, still saw an increase of 3.4% as compared with the same period of the previous year. In the two years from 2006 to 2008, the coal consumption in China increased by over 600 million tons [17],[20].

The "11_{th} Five-Year-Plan " period is the best period of structural adjustment and industry transformation of coal industry. Coal is the basic energy of China, accounting for about 70% in the constituent of primary energy (see Table.3). A basic principle of "Coal-Based Diverse Development has been established in the planning proposal of "11_{th} Five-Year-Plan " which has laid a base for the thriving development of Chinese coal industry. In the "11_{th} Five-Year-Plan" period, new coal mines sizing about 300 million tons will be constructed, of which 200 million tons will be produced, 100 million tons will be transitioned to the "12_{th} Five-Year-Pan" period. China's coal industry will continue to maintain a thriving development tendency and will see a very wide developing prospect for quite a long period of time in the future.

Table 3. Composition of Primary Energy in China

Year	Coal	Petroleum	NG	Hydro-Nuclear- Wind Electric Power
1980	72.2	20.7	3.1	4.0
1985	75.8	17.1	2.2	4.9
1990	76.2	16.6	2.1	5.1
1995	74.6	17.5	1.8	6.1
2000	67.8	23.2	2.4	6.7
2001	66.7	22.9	2.6	7.9
2002	66.3	23.4	2.6	7.7
2003	68.4	22.2	2.6	6.8
2004	68.0	22.3	2.6	7.1
2005	69.1	21.0	2.8	7.1
2006	69.4	20.4	3.0	7.2

Percentage of the Total Energy Consumption/%

3 ENVIRONMENTAL PROBLEM CAUSED BY COAL UTILIZATION

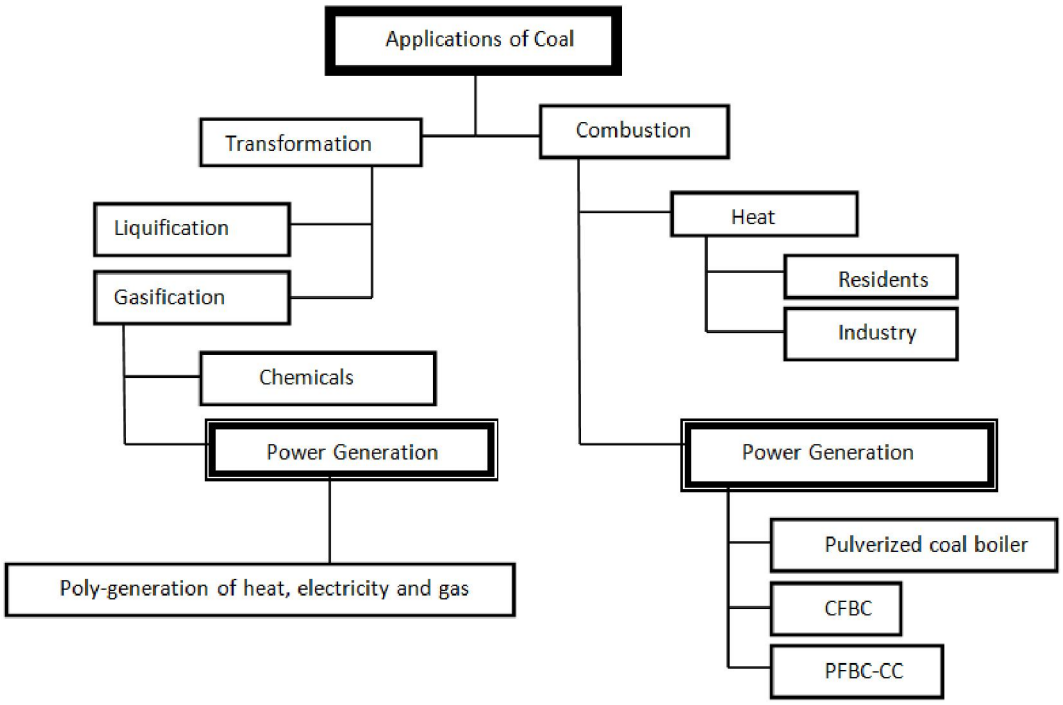

Fig. 2. IGCC- Integrated Coal-Gasification Combined Cycle; CFBC-Circulating Fluidized Bed Combustion; PFBC-CC-Pressurized Fluidized Bed Combustion Combined Cycle

Main applications of coal are as shown in Fig.2. Larger amount of soot, sulfur oxide, nitrogen oxide, heavy metal (like mercury) oxides and large quantity of carbon dioxide will be produced in the use of coal. In addition, environmental problems brought up by solid coal cinder and discharge of sewage which, if not properly controlled, will produce serious damage to human health and ecological environment. This problem is even more evident in China due to the use of coal on a large scale. According to statistics, 90% of CO_2 emission, 67% of NO_x, 70% of flue dust and 35% of inhalable particles come from coal combustion in China.

3.1 SO_2 Pollution and Acid Rain

3.1.1 Sulfur Dioxide Emission in China

In more than a decade, emission of sulfur dioxide in China has been exhibiting a gradual increasing trend. In 1995, emission of sulfur dioxide in China reached 23.7 million tons, exceeding that of Europe and U.S.A. for the first time and China has become the first big country in the world in the emission of sulfur dioxide. Thereafter, the emission of sulfur dioxide was under control for a time due to the execution of a series of control and emission reduction measures. However, with the rapid development of electric power industry in recent years, emission of sulfur dioxide starts to rise again. Since 2005, the total emission of sulfur dioxide in China has been ranking the first in the world continuously for several years and reached record-breaking value of 25.888 million tons in 2006. In 2007, emission of sulfur dioxide saw decreased as compared in the same period, however, still in the high rankings [21]-[22]-[23]. Fig.3 shows the emission conditions of sulfur dioxide in our country in more than 10 years in the past.

Energy consumption in China has been growing abnormally since the "10_{th} Five-Year-Plan" period. Consumption of coal rapidly increased from 1.32 billion tons in 2 to 2.167 billion tons in 2005. Emission of sulfur dioxide increased from 19.95 million tons in 2000 to 25.49 million tons in 2005. According to forecast of energy planning, total consumption of coal in China will maintain continuous increase. Till 2015, installed capacity of coal-fired power generation unit will increase to 1500 million kW. Coal used for power generation will reach to 2200 million tons [23]. Thus sulfur dioxide produced by burning of coal in the whole country will reach to about 45 million tons, of which thermal power generation industry will produce about 30 million tons [24]. From 2010 to 2020, the total consumption of coal in the whole country will be growing continuously. The generation capacity of sulfur dioxide by burning coal will also grow continuously. The increase in consumption of coal and the generation capacity of sulfur dioxide in thermal power industry will be higher than the mean increase of the whole country. According to the estimation by the World Bank, if sulfur dioxide remains uncontrolled, till 2020, loss of life caused by pollution due to burning of coal will amount to 600,000 cases; People suffering from chronic bronchitis and respiratory track or chest disorder will reach to 25,500,000 cases and economic costs thus paid will amount to 390 billion US dollars, accounting for 13% of GDP at that time [17],[24]. Therefore, the control of SO_2 emission in China will face a very serious situation.

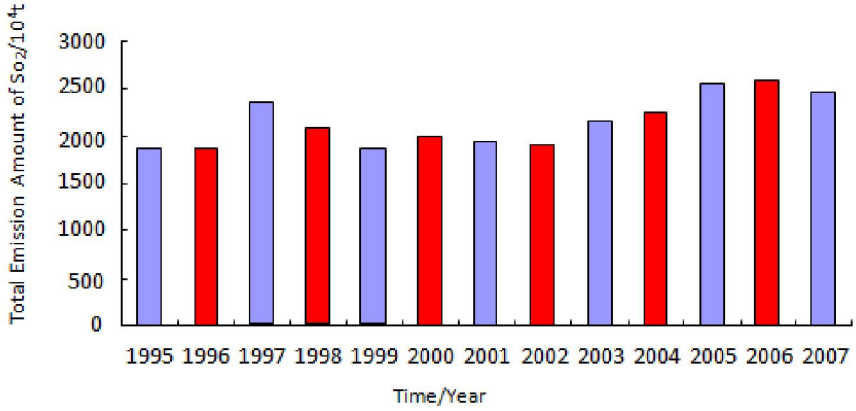

Fig. 3. SO_2 Emission Conditions of Our Country in Recent Years

(Sourced from Nation-Wide Environmental Conditions Bulletine)

3.2 POLLUTION OF SULFUR DIOXIDE

Abundant of environmental monitoring data shows that the clouds over most part of the earth are becoming acidified due to the increase of acidic substances in the atmosphere. If this situation remains uncontrolled, the area of acid rain will continue to expand and the harm thus brought up to human being will also increase daily. It has been recognized that sulfur dioxide and nitrogen dioxide in the air are the main substances forming acid rain. Sulfur dioxide and nitrogen dioxide in air mainly come from burning of coal and petroleum. According to statistics, sulfur dioxide emitted into air in the whole world each year is about 100 million tons and nitrogen dioxide emitted in to the air each year is about 50 million tons [25]. Therefore, acid rain is mainly caused by production activity and living of human being. In the constituents of acid rain measured by U.S.A., sulfuric acid accounts for 60%, nitric acid accounts for 32%, hydrochloric acid accounts for 6% and the rest percentage includes carbonic acid and small amount of organic acid. The acid rain in China belongs to sulfuric acid type and most of the acid rain is caused by emission of sulfur dioxide.

At the present time, three major acid rain regions have formed in the entire globe. In China, the acid rain deposition covers part of the provinces and cities of Sichuan, Guizhou, Guangdong, Guangxi, Hunan, Hubei, Jiangxi, Zhejiang, Jiangsu and Qingdao with an area over 2 million square kilometers which is one of the three largest regions with heavy acid rain deposition in the world. The other two major acid rain regions include North Europe centered by Germany, France and U.K. affecting better half of Europe and North America including U.S.A. and Canada. The speed the acid rain region expands and the acidification rate of rain water in China is very unusually seen in the world. In the "8_{th} Five-Year-Plan" period, acid rain polluted zone expanded from a few areas in the southwest to the south of Yangtze River, most of the areas in the east of Qinghai-Tibet Plateau and Sichuan basin. In 1995, areas with pH value of average rainfall less than 5.6 accounts for about 40% of the land, area with supercritical load of sulfur deposition is 2.1 million km^2 , cover 21.9% of the land. In 1998, the acid rain region in China expanded very quickly from the south to the north and exceeded 40% of the land [19],[26], sees in fig. 4.

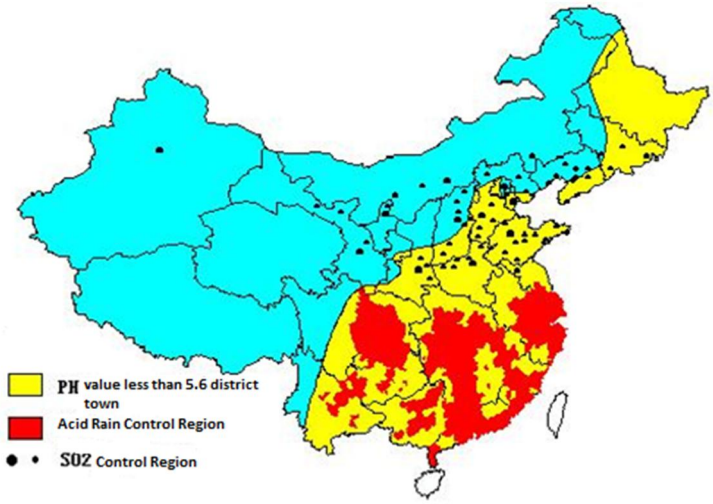

Fig. 4. Designation of Acid Rain and SO_2 Control Zones (1998)

At present, pollution caused by sulfur dioxide in China is characterized by the following main features:

3.2.1 ACID RAIN POLLUTION IS GETTING MORE AND MORE

Acid rain monitoring result shows that acidity of precipitation in the whole country in the 90s of 20^{th} century remained stable on the whole. The acidity of precipitation after 2000 exhibited an overall upward trend. Till 2005, the average concentration of sulfate radical and nitrate radical in the deposition were increased by 12% and 40% respectively.

The acid rain region in China is mainly distributed in the south of Yangtze River and the east of Qinghai-Tibet Plateau, including most part of the provinces and cities of Zhejiang, Jiangxi, Fujian, Hunan, Guizhou and Chongqing and part of the provinces and cities of Guangdong, Guangxi, Sichuan, Hubei, Anhui, Jiangsu and Shanghai. Acid rain deposition also began to appear in some regions in the north. The area of heavy acid rain is increased from 4.9% of the land in 2002 to 6.1% in 2005

[27].

In 2006, 524 cities (counties) participated in acid rain monitoring statistics, of which 283 cities (counties) experienced at least over one acid rain, accounting for 54.0%. The acid rain frequency of 6 cities (counties) (Jiande City, Xiangshan County, and Huzhou city, Anji County and Shengsi county of Zhejiang Province, Jiangjin of Chongqing City) was 100% [28]-[29]. The area distribution of nationwide acrid rain frequency in 2006 is shown in Fig.5.

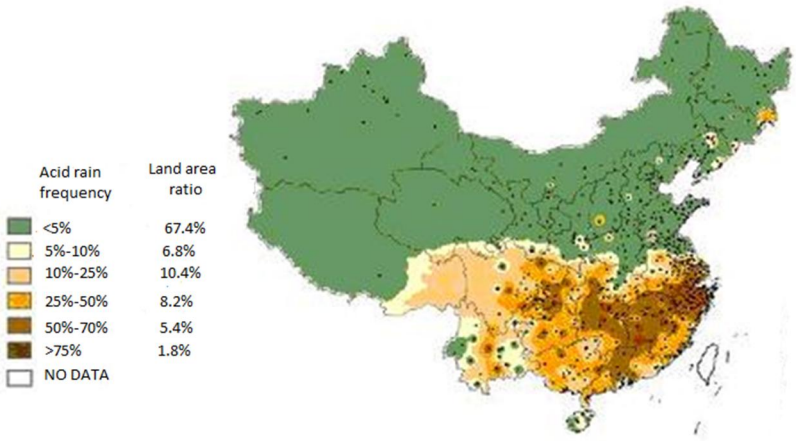

Fig. 5. Area Distribution of the National-Wide Acid Rain frequency in 2006

In 2006, the nation-wide acid rain distribution mainly concentrated in the south of Yangtze River and the east of Sichuan and Yunnan Provinces, including most part of Zhejiang, Jiangxi, Hunan, Fujian, Guizhou and Chongqing as well as the Yangtze River Delta and Zhujiang River Delta (see Fig.6).

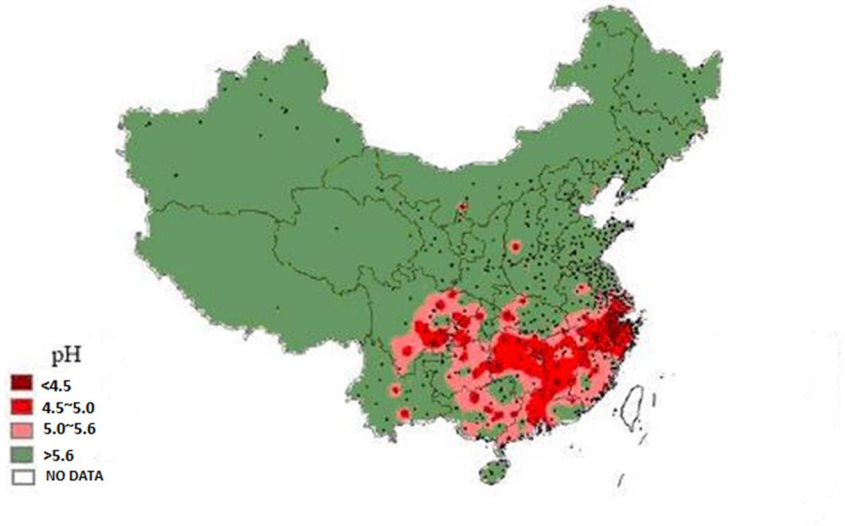

Fig. 6. Nation-Wide Area Distribution of Acid Rain

In 2006, 22 provinces of the whole country were affected by acid rain, of which, over 70% cities in the 5 provinces and cities of Zhejiang, Hunan, Jiangxi, Chongqing and Sichuan were suffered from acid rain (See Fig.7).

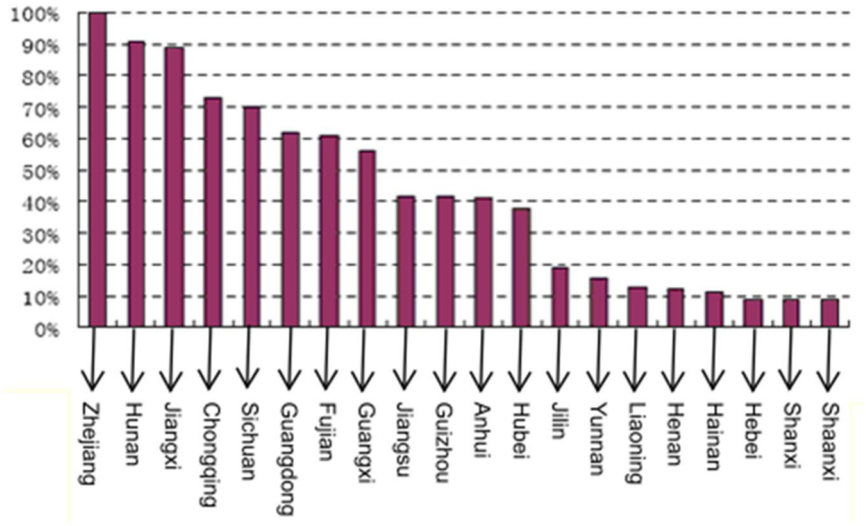

Fig. 7. The Percentage of Cities with Average pH value of Precipitation <5.6 in each Province or Municipality

3.2.2 THE AMOUNT OF SULFUR DEPOSITION IS INCREASING CONTINUOUSLY

Monitoring and research results show that 5 high intensity value sulfur deposition regions exist in China: southwest region with Guizhou as the center, east China region with Yangtze River delta as the center, south China region with Zhujiang River Delta as the center, Hebei-Shandong-Henan region and Beijing-Tianjin region. Regions with sulfur deposition intensity exceeding critical load cover an area accounting for over 20% of the land, where sulfur deposition intensity in Chongqing-Guizhou region, Yangtze River delta and Zhujiang River Delta has exceeded critical load by a large extent.

3.2.3 PRODUCTION OF FINE PARTICLES

Sulfur dioxide does not only cause acid rain, but also forms sulfate through chemical conversion in the long range transportation thus causing fine particle pollution in a regional scope. Research result shows that contribution of sulfate radicals and nitrate radicals to inhalable motes have reached to 15μg/m^3 in some regions of China. Fine particles or motes are harmful to human health and also lead to low visibility.

3.2.4 SO_2 POLLUTION IN CITIES SHOWS A SERIOUS SITUATION

In 2005, air quality monitoring result in 341 cities shows that annual average SO_2 concentration in the air of 22.6% of the cities exceeded Class 2 standard of the state and that of 6.5% of the cities exceeded Class 3 standard of the state, about 1/3 of the city population live in the environment with SO_2 concentration in the air out of standard [30].

4 NO_x POLLUTION AND PHOTOCHEMICAL SMOG

With the importance attached to acid rain pollution, SO_2 emission has obtained significant control in the world. In the first three years of the "11_{th} Five-Year-Plan" period, total SO_2 emission quantity has been reduced by 8.95% in China, nearly 90% of emission reduction task is fulfilled in the three years with notable achievements. However, NO_x emission is increasing continuously and rapidly. At the present time, NO_x emission in China is closing to 16 million tons, of which 67% originates from direct burning of coal. According to relevant research, NO_x emission, if remaining uncontrolled, will reach 30.94 million tons through 2015 [29][30]. It is estimated that the total NO_X emission will exceed that of SO_2 through 2015~2020 and become the first largest quantity of acid pollution gas in the emission in electric power industry.

The harm of NO_x had been reported at the beginning of the 40s of last century. NO_X was formally determined as one of the main air pollutants in the 60s of last century. The nitrogen oxide (NO_X) commonly referred to includes NO and NO_2, of which NO accounts for 95% of the NO_X in typical coal burning gas and NO_2 accounts for the rest percentage. NO can combine hemoglobin in blood causing degradation of oxygen carrying capability of the blood, hence oxygen deficit. In addition, NO has carcinogenic action and cause undesirable impact to cell division and genetic information. NO in air is slowly oxidized into

NO_2 under the action of O_2 which can enter man's respiratory system and contact the wet surface of lung causing lung illness and bronchial disease or leading death in serious case. NO_X can promote the formation of acid rain. NO_2 is the precursor of nitric acid and nitrous acid in acid rain. It will react with hydrocarbons in air under UV-irradiation to increase concentration of ozone in the near surface atmosphere causing poisonous light-blue photochemical smog affecting visibility in air. The acid rain and photochemical smog thus generated will cause large areas of crops and forests to be withered. Acid rain can also cause corrosion of buildings and equipment. Photochemical smog has strong irritation and harm action to human's eye, nose, heart, lung and hematopoietic tissues and obvious carcinogenicity. Ozone in the near surface atmosphere has extremely serious harm to nervus centralis. In addition, NO_x will cause ozone depletion in stratosphere by circulating reaction (1-5) and (1-6) with ozone in stratosphere causing ozone hole. NO_x has also some contribution to PM2.5. In a word, nitrogen oxide will bring serious harm to human health and destruction to ecological environment and national economy [31]-[32].

$$O_3+NO \longrightarrow O_2+NO_2$$

$$2NO_2+hv \longrightarrow 2NO+O_2$$

NO_2 concentration in air in big cities of Europe, North America and part regions of China is very high. In Los Angeles of U.S.A., photochemical smog pollution has appeared for several times. China has become the harder-hit area by NO_x emission. The data provided by the state environmental monitoring station also shows that NO_x pollution in China is very serious. The NO_x concentration in some cities and regions is out of standard and photochemical smog has appeared in several cities [12],[27]. Since the "10_{th} Five-Year-Plan ", the annual mean concentration of NO_2 in air of the 113 key cities for air pollution control has been exhibiting an upward trend on the whole. The concentration of NO_2 in air in the big cities of Beijing, Guangzhou, Shanghai, Hangzhou, Ningbo, Nanjing, Chengdu and Wuhan is relatively higher. Ozone concentration in air in the big cities of Beijing, Guangzhou and Shenzhen is sometimes out of standard. Viewing from the world map of NO_2 pollution in Fig.8, NO_X pollution in each country of the world is very serious.

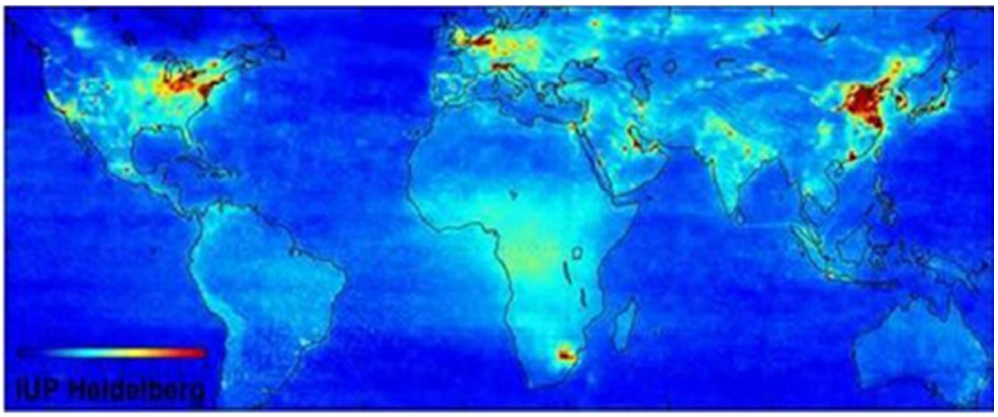

Fig. 8. World Map of NO_2 Concentration in Air

(Sourced from European Space Agency's Envisat Photo from Jan. 2003 to June, 2004)

5 PARTICLES POLLUTION AND HAZARD

About 1/3 of the particles in the environment of China comes from coal burning process. Solids suspended in air or fluids, no matter for long or short period, will cause harm to living creatures and human health, hence referred to as particulate pollution. Particles have many varieties, normally refer to dust particle, dust, fog dust, smoke, chemical smoke and soot with size between 0.1~75μm. Particles in size less than 1μm settle very slowly and spread far and widely.

Particles whether coming from nature or caused by human activities will bring up harm to animals and plants as well as human health. Particles dropped on plant leaves can cause mechanical burn and reduce photosynthetic intensity of leaves causing harm to plants.

Particles dissolved in water enter plant tissues with water causing damage. Heavy metal particles deposited on vegetables or forage plants enter the bodies of humans and animals through food chain. Particles in air have scattering and absorbing action to light, which will lead to appearance of obvious haze and reduction of visibility. What is more serious is that it will influence thermal balance of the earth. Increase of particles in air will cause more solar light to scatter and cause reduction of

solar radiation absorption on earth surface. The main heat in troposphere comes from radiation of earth surface. Contrary to greenhouse effect, the increase of particles in air will cause decrease of global air temperature. In addition, increase of particles in air will lead to increase of condensation nucleus near the earth surface providing favorable conditions for condensation of moisture forming foggy weather. Therefore, particles in air are also a factor causing major problems of low air visibility, acid rain, global climatic change, smog event, and damage to ozone layer.

According to statistics, the air volume inhaled by a person every day is far in excess of the water drunk and the food taken in. The air inhaled often carries large amount of particles, which becomes the main reason leading to rise of mortality of humans [28],[30]. The inhalable motes refer to the generic term of particles that can enter human's respiratory track through nose and mouth and is expressed as PM_{10} , the finer ones of which expressed as $PM_{2.5}$ are also referred as lung-entering particles that can enter alveolus or even the blood system, directly leading to cardiovascular disease. Although the fume dust control technology can reach very high level in the world, the capture rate of particles below PM_{10} (especially $PM_{2.5}$) is very low, thus causing huge quantity of inhalable motes entering ambient media. Inhalable motes are currently the principal pollutant of urban air environment. The pollution problem of $PM_{2.5}$ is especially serious. The harm of inhalable motes to human health exhibits mainly in the "three-causing" action aspect: causing cancer, causing malformation and causing mutation. The main reason is that the inhalable motes often are enriched by heavy metals (e.g. As, Se, Pb, Cr) and organic pollutant like PAHs (polycyclic aromatic hydrocarbon), PCDD/Fs (Dioxins). These are most of carcinogenic substance and poisonous gene mutagen having extreme hazards. If PM_{10} in air increases by 10μg /m^3 each time, the clinic patients of hospital will increase proportionally. PM_{10} exhibits expressive positive correlation with cough and bronchitis when people catch a cold. Pulmonary function of children degrades when air pollution becomes more serious. Occurrence of expectoration and cough symptoms of children exhibits a linear increase. The death rate of lung cancer in the urban areas of cities exhibits a positive correlation with the total suspended particles in air in recent years. The disease rate of congenital malformation of new born children in the residential district located in the downwind side of the stack of a certain electric power plant in China is obviously higher than that in the clean zone and the closer to the power plant, the higher the disease rate of congenital malformation is, on which the particles emitted play an important toxic role.

6 OTHER ENVIRONMENTAL PROBLEMS CAUSED BY COAL COMBUSTION

6.1 CO_2 AND GREENHOUSE EFFECT

Greenhouse effect caused by carbon dioxide has attracted wide attention of the international society. China is now the second largest country in emission of CO_2 and Control of CO_2 emission is imperative.

In the greenhouse gases, the gas having the most significant influence on the global climatic change is CO_2 emitted by burning fossil fuels rich in carbon content – coal, petroleum, natural gas. The contribution of concentration increase of CO_2 to greenhouse effect is about 55%. Calculation suggests that surface temperature will rise 1.5℃~4.5℃ with increase of CO_2 concentration in air by one time. Hazards brought by the rapid growth of CO_2 emission include: rigorous weather types, changing ecological system function, species extinction and loss of biodiversity, reduction of drinking water, reduction of land caused by sea level rise and rise of average air temperature. During the past 50 years, China's average air temperature has risen by 0.5℃~0.8℃, slightly higher than the average global temperature rise value in the same period. The annual average sea level rise rate along the coast is 2.5mm, again slightly higher than the average level of the world. Therefore, control of CO_2 emission is imperative [32].

In order to effectively control CO_2 emission, Kyoto Protocol came into force formally on February 16, 2005. According to the provisions of the protocol, the 39 industrially developed countries of U.S.A., U.K. and others must reduce the total greenhouse gas reduction by another 5.2% on the emission basis of 1990 within the 5 years from 2008 to 2013 [31]-[32]. The developing countries including China and India will set emission reduction target of greenhouse gases on a voluntary basis according to the principle of "Common but Different Responsibilities". China as a developing country will not undertake CO_2 emission reduction liability in the first stage. But this does not mean China has no pressure in the CO_2 emission reduction aspect.

According to relevant data, total global CO_2 emission in 2005 was 27,136 Mt while CO_2 emission produced through energy consumption in China reached 5,101 Mt, accounting for 18.8% of the total global emission. Thus China became the second largest country after U.S.A. in the world in CO_2 emission [33]. As a developing country, China must put great efforts in the preparatory work in technical, economic and policies, laws and regulations aspects according to the actual conditions of its own and take an active stance to utter in the "Post Kyoto Protocol Era".

6.2 POLLUTION OF HAZARDOUS TRACE ELEMENTS

Almost all the elements shown in the periodic table of elements are present in the coal. Quite a lot of elements though in existing in micro amount, have high toxicity and will cause a great impact to ecological environment and human health.

These toxic trace elements include mercury, scandium (Sc), antimony (Sb), Arsenic (As), cadmium, lead, terbium, barium, beryllium, chromium, nickel, manganese, silver, cobalt as well as radioactive elements like cesium (Cs), strontium, thorium (Th). Most of these elements are emitted in the air with soot dust in the burning process, causing serious pollution to the environment. Research has shown that individual elements like mercury and arsenic are the main man-made pollution causing ecological damage and coal burning takes up an important ratio.

The endemic fluorosis occurred in Guizhou Province of China has been proved through multi-years study to be caused by soot carrying fluorine pollution. This endemic fluorosis induced by coal burning pollution is a kind of chronic intoxication caused by fluorine pollution in indoor air and grain and other foods that is caused by long term burning of high fluorine-containing coal in coal piling or in open furnace manner for heating, food cooking or roasting by the residents. Another example also in Guizhou is the event that the use of high arsenic coal in some districts caused more than 3,000 cases of arsenic poisoning and the population affected reached over 10,000 people. The annual arsenic emission of China has exceeded 10000t and the impact is outlasting [31],[34].

6.3 ORGANIC POLLUTANTS

The hydrocarbons in coal, if not thoroughly broken down and burnt completely in the combustion process, will form organic pollutant with considerable concentration, for example, polycyclic aromatic hydrocarbons (PAHs), benzene, toluene, ethylbenzene, and xylene (BTEX), alicyclic hydrocarbon and straight chain hydrocarbon, dioxins, etc. Though the emission of organic pollutants is less than SO_2 and NO_x, due to its high toxicity and slow degradation in environment, especially the carcinogenic and malformation character of PAHs have been receiving more and more attention of the public.

Viewing from China, the annual concentration of SO_2, inhalable motes and NO_2 in the urban air of the whole country in 2008 has been reduced by 28.5%, 33.3% and 31.5% respectively as compared with 2000. Environmental protection has achieved big progress. However, 23.2% of the urban air quality of the whole country has still not reached Class 2 standard of the state. In the 113 key cities, the air quality of 48 cities has not reached Class 2 standard. The inhalable motes and SO_2 concentration in urban air still maintain on a relatively high level [17],[33]. Therefore, energy conservation and reduction of consumption and pollution are still an important issue for mankind.

CONCLUSION

Pollutions due to coal consumption become very serious problems in the world, and power plant is the biggest consumer of coal. The control of air pollutions from coal-fired power plant is the key to solve environment problems caused by coal burning. In 2007, energy consumption reached 16.73billion tons of standard coal all over the world, in which the consumption of coal accounts for 4.849 billion tons of standard coal, just lower than the consumption of petrol (5.923billion tons of standard coal) ranking the top second. Since the 18th century, coal is the main energy for the society, and it will be one of the non-replaceable energy in the production and life of mankind. However, utilization of coal brings us serious ecological environment problems, the main pollutants in atmosphere: SO_2, NO_x, CO, dust, particulates, organic pollutants, heavy metal are mainly coming from coal combustion which damaged irreversibly the health of human and the ecological environment.

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In *silico* modeling for Identification of promising antimicrobials of Herbal origin against highly virulent pathogenic strains of bacteria like New Delhi Metallo-beta-lactamase -1 *Escherichia coli*

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ABSTRACT: Drug resistance has mushroomed up after advent of every major class of antimicrobial drugs, varying in time from as short as 1 year (penicillin) to >10 years. Organisms associated with nosocomial and community acquired infections are also becoming drug resistant due to the over utilization of antibiotics, consequently leading to high morbidity, mortality and increased health costs. One such example of a beta lactamase producing bacteria is New Delhi Metallo beta lactamase (NDM-1) producing *Escherichia coli* and *Klebsiella pneumoniae*, and was reported for the first time in the year 2009 in a Swedish patient. NDM-1 bacterial strains possess more potent hydrolysis ability towards almost all antibiotics, including Carbapenems. NDM-1 bacterial strains are sensitive to Tigecycline and Colistin but there is problem of side effects associated with them. In such a situation where NDM-1 strains are displacing antibiotic sensitive strains and are resistant to most of the chemotherapeutic agents, there is a need for the search of novel alternative effective therapeutic agents. The present bioprospective study aims to analyze the potential of various natural plants or their products, based upon bioactivity parameters and presence of chemical constituents, using matrix based modeling, followed by optimization. The outcomes of the lead identification need verification with respect to antimicrobial potential against virulent NDM-1 *Escherichia coli*.

KEYWORDS: Antimicrobial agents, Herbal mitigation, Matrix modeling, Ethno pharmacology, Antibiotic resistance, Superbugs, NDM-1 *Escherichia coli*.

1 INTRODUCTION

Herbal medicine still holds mainstay in about 70% of the world population in primary health care attributed towards its better cultural acceptability, compatibility with the human physiology, possibly lesser side effects and ease of availability in a particular local region [1], [2]. An estimate revealed that about 25% of the drugs prescribed globally are either originated directly from plants or otherwise synthetic derivatives based on plant based precursors [3]. It has been reported that out of WHO recommended 252 basic and essential drugs, nearly 10% are of direct plant origin [4].

India holds 10% of the world's biodiversity, distributed in 16 agro-climatic zones in a peninsular geography, supporting 20,000 medicinal plants, therefore, ranked as one of the 12-megabiodiversity centers of the world [5]. It is revealed that the annual global turnover of herbal medicine industry, in the year 2008, was 90 billion dollars with a limited share of Rs. 2300 Crores to Indian subcontinent [6], [7]. It indicates a huge potential reserve that is yet to be explored for its judicious utilization especially against new world health challenges.

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The evolution of microbes towards antibiotic resistant patterns has been clearly indicated by 4,40,000 new cases of Multi-Drug resistant (MDR) Tuberculosis along with widespread of Extensively Drug Resistant (XDR) Tuberculosis in 64 countries ; 41% cases of Hospital- Acquired MRSA and increased upsurge of Vancomycin Resistant Enterococci (VRE) & Human Immunodeficiency Virus (HIV) infections and/or Gonorrhoea etc. [8], [9], [10]. This has forced the medical practitioners to recommend anti-retroviral and last line cephalosporin antibiotics [11], [12]. NDM-1, a new entrant of 2008, harbored Gram-negative bacilli, present in more than 15 countries has resulted in around 100 deaths till date.

The new officially accepted terminology for NDM-1 associated infections is CRE infections i.e. Carbapenem Resistant Enterobacteriaceae, indicative of a latent infection based alarming situation which might get worsened as it evolves to become resistant against new generation of antibiotics like Polymyxin, Colistin etc. Thus, this potentially dangerous Biothreat agent requires holistic mitigation approach for an effective medical management strategy [13].

It is therefore essential to develop a systematic and standardized approach to bioprospect, identify, test and validate the herbal candidates as potential therapeutic leads, using both in silico and in vitro approaches in conjunction.

The classical herbal bioprospection is identification of herbal medicinal plants based on its ethnopharmacological importance, as testified in ancient literature or otherwise in clinical literature of various countries. This process is time consuming, tedious, generally observation or experience based, and might lack scientifically evident and validated proofs [14]. Evolution of new techniques of deploying dynamic search protocols, priority indexing, systemic categorization and cross-verification could be referred to as an *in silico* bioprospection tool [15], [16], [17]. The parallel research efforts globally on both herbals and antimicrobials provides enormous web based data that requires to be filtered systematically towards a logical conclusion for further *in vitro* and *in vivo* validation.

The present study aims to simulate the above referred models utilizing *in silico* herbal bioprospection modeling, literature based parameter selection, priority indexing using random search model, scoring and decision matrix based analysis followed by optimization and validation. Such tool can be used to validate findings of the classical bioprospection. This study has provided an insight into a systematic collection and analysis of literary data to obtain a logical output for ascertaining a desired biological activity.

2 METHODOLOGY

2.1 SELECTION OF MICROORGANISM

Microorganisms to be targeted using alternative system requires to follow some of the important characteristics i.e., a) lethal, sub-lethal, incapacitating or potentially dangerous Biothreat agent; b) either no treatment regime/vaccine available or limited availability; c) evolving virulent forms from past; d) possibly could be used as bioweapon which are lethal and/or panic creating agent.

2.2 SELECTION OF BIOACTIVITY PARAMETERS USING CLASSICAL APPROACH

The holistic mitigation requires multi-targeted approach. Based on the understanding of the mechanistic aspects of antibiotic resistant patterns of micro-organisms, as in present study, NDM-1 harbored *Escherichia coli*, the various comparable targets attributing towards bactericidal activity of NDM-1 has been selected on the basis of extensive literature surge (Classical Bioprospection Approach). There are certain parameters which need to be assessed to analyze the bioactivity associated with a given herbal plant, with respect to its potential of treating dreadful infections allied with virulent multidrug resistant bacterial strains, like NDM-1 *Escherichia coli*. The seven testing parameters were selected for study based on mechanistic aspects of antibiotic resistance of NDM-1 harboring strains, including Beta lactamase inhibition, presence of phytocompounds, MDR Pump Inhibition, antibiotic action potentiation, quorum sensing inhibition, adhesion inhibition, antibiotic resistance modification and symptomatic relief provision [18]. The rationale supporting selection of these parameters using classical approach for bioprospection studies are given in Table 1.

Table 1. Rationale for Selection of the Bioactivity parameters for Bioprospection Study

S.No.	Parameter	Rationale for selection (Based on Classical Approach)
1	*β-lactamase inhibition* [19]-[20]	(a) Use of β-lactamase inhibitor with antibiotics as potentiator is an accepted tool to avert resistance, e.g., Augmentin. (b) Several plants have been reported to exhibit β-lactamase inhibition activity and are effective antimicrobial agents, e.g., *Camellia sinensis*, *Papaya carica* etc. (c) β-lactamase, produced by NDM-1 harboring strains, could be targeted to act as an effective bactericidal agent.
2	*MDR Pump Inhibition* [21]-[25]	(a) Multi-Drug Resistant Efflux pumps are bacterial membrane associated active transporters, sustaining the release of drug outside the bacterial cell thereby bestowing antibiotic resistance and restoring the concentration of active drug, e.g., Flavonolignans, Phenothiazines etc. (b) One of the associated phenomenon of resistance offered by NDM-1 *Escherichia coli* is due to the presence of MDR pump namely AcrAB-TolC and AcrEF-TolC classified under RND (Resistance/Nodulation/Division superfamily) which are secondary active transporters driven by ion gradients. (c) Several herbals namely *Aegle marmelos*, *Camellia sinensis*, *Plumbago zeylanica*, *Punica granatum*, *Acorus calamus*, *Hemidesmus indicus*, *Holarrhena antidysentrica*, *Syzygium cuminii* etc., have been shown to contain various molecules like 5'-methoxyhydnocarpin-D, Pheophytin etc., which are reported as MDR pump inhibitors.
3	*Quorum sensing inhibition* [33]-[38]	(a) Quorum sensing is a cell-to-cell signalling mechanism in which bacteria secrete autoinducers, which act as self limiting at a certain threshold concentration by acting at the transcription level and regulating bacterial gene expression. The inhibition of such phenomenon can avert resistance. (b) NDM-1 *Escherichia coli* produce the autoinducer-2 (AI-2), which is synthesized by the product of the luxS gene. Inhibiting the production of AI-2 is a way to control the spread of NDM-1 bacterial infection. (c) *Camellia sinensis*, *Plumbago zeylanica*, *Berberis aristata*, *Hemidesmus indicus*, *Punica granatum*, *Holarrhena antidysenterica*, Horseradish (*Armoracia rusticana)*, Garlic (*Allium sativum*), *Tetrazygia bicolor* (Melastomataceae), *Quercus virginiana* (Fagaceae) etc. are reported to inhibit intracellular communication amongst bacterial populations leading to Quorum sensing inhibition.
4	*Adhesion inhibition* [32]	(a) Major type of adhesion molecules reported include integrins, cadherins, IgCAMS, selectins etc. for which several synthetic agents such as Levocitrizine, Clarithromycin while herbal plants such as *Plumbago zeylanica* and *Aegle marmelos*, possessing Proanthocyanidins, acidic polysaccharide etc. have been reported to be effective in inhibiting the host pathogen interactions. (b) NDM-1 E. coli constitutively release nano-sized outer membrane vesicles (OMVs), Intimin and Adhesin, which could act as the potential targets for therapeutic strategies thereby preventing the adhesion of microorganisms to host cell surfaces.
5	*Antibiotic resistance modification* [29]	(a) Selective pressure induces multi-drug resistant strains, extensive drug resistant strains or pandrug resistant strains, depending on the degree of resistance developed, required to be downgraded. (b) Certain herbal plants have been found to exhibit antibiotic resistance modification activities, e.g., *Rosmarinus officinalis, Caesalpinia spinosa, Camellia sinensis* etc. by the virtue of phytocompounds like Epicatechin gallate, Ethyl gallate, Carnosic acid, Ferruginol, 5-Epipisiferol etc. (c) NDM-1 evolving continuosally, progressing towards a pandemia due to the vulnerability of human physiology and growing selective pressure of antibiotics. This needs to be mitigated at an early stage by the virtue of antibiotic resistance modification phenomenon so as to overcome the probable severe socio-economic impact.
6	*Symptomatic relief provision* [30]-[31]	(a) Palliative care using herbs is an accepted phenomenon that focuses on relieving and preventing the suffering of patients, e.g., *Allium sativum, Allium cepa* and *Ocimum sanctum* for bloating, cold and bronchial congestion respectively. (b) This broadens the scope of study to target less virulent strains of NDM i.e. NDM 2 to 7, with least virulence, however producing similar symptoms. (c) NDM-1 harbored *Escherichia coli* produces symptoms like Urinary Tract infections, Gastroenteritis, Nosocomial Pneumonia, Bacteremia, Wound infection and Fever. Herbal agents are required to prevent the aggravation of infection associated with predefined vulnerability profile of individual.
7	*Presence of phytocompounds* [21], [26]-[29]	(a) Phytocompounds such as flavonoids, tannins, lutein, limonene, theobromine, phytosterols etc. are known to have antibiotic resistance modifying activity, immunostimulation activity and/or bactericidal activity. (b) Holistic approach requires multi-component, multi-targeted, non-specific, immunostimulator and antibiotic resistance modifier herbal plant to be selected as alternative therapeutic modality so as to mitigate lethal impact of NDM-1 associated infections. (c) Selective pressure of Polymyxin and Colistin might lead to new antibiotic resistance pattern in NDM-1, thus holistic mitigation should include diverse phytochemicals enriched herbals as alternative therapeutic substitutes.

2.3 EVALUATION OF RELEVANCE FACTOR USING KEYWORDS HITS SCORING MATRIX APPROACH

The analysis was conducted using PubMed as selected search engine. The random search model using combination keyword as Bioactivity Parameter + Antimicrobial activity while advanced search model using the same combination keywords but in quotes, yielded 'N' hits. The first n=20 hits provided by the search engine, working on the principle of priority indexing, were based on the number of times a website is read/clicked. The first 20 hits are subjected to observational interpretation for assessing relevance using human interface. This sample set based analysis was used to evaluate the net weightage linked to each bioactivity parameter, using the following formula:

$$\textit{Average Percentage Relevance} = \frac{(No.of\ Relevant\ hits\ based\ on\ observational\ analysis * N)}{(n=20)}\ X\ 100$$

Relative weightage for each parameter assigned on the basis of percentage relevance is given in Table 2.

Table 2. Weightage assigned to the parameters based on Average Percentage Relevance

S.No.	Parameter Chosen	Average Percentage relevance (Advanced Search)	Average Percentage relevance (Random Search)	Mean Value	Relative Weightage assigned
1	β lactamase inhibitor	59.4% ± 0.198	19.8% ± 0.140007	39.60% ± 0.171499	5.910
2	Presence of Phytocompounds	44.2% ± 0.138125	16.575% ± 0.097669	30.39% ± 0.119638	4.535
3	MDR pump inhibition	39.25% ± 0.164	6.45% ± 0.115966	22.85% ± 0.14205	3.410
4	Antibiotic action potentiator / enhancer	38.775% ± 0.17625	3.525% ± 0.124628	21.15% ± 0.15266	3.157
5	Quorum sensing inhibition	33.075% ± 0.11025	11.025% ± 0.077959	22.05% ± 0.095494	3.291
6	Adhesion inhibition	20.55% ± 0.0685	6.85% ± 0.048437	13.70% ± 0.059332	2.040
7	Antibiotic resistance modification activity	11.925% ± 0.03975	3.975% ± 0.028107	7.95% ± 0.03443	1.186
8	Symptomatic relief provider	10.05% ± 0.0335	3.35% ± 0.023688	6.70% ± 0.029016	1

2.4 SELECTION OF HERBAL PLANTS USING CLASSICAL BIOPROSPECTION APPROACH

The classical bioprospection approach accounts for investigation of the following variables based on literature review to devise a logical conclusion, resultant in selection of plants. It includes a) Ethnopharmacological importance of plant; b) Relevance of Herb in traditional medicine; c) Availability factor or cultural acceptability in localized regions; d) Any vedic literature supporting its use; e) Investigations/ prior experience on potential of the herb; f) Indirect indications, if any etc. The final conclusion to select a plant for *in silico* bioprospection is based on learning of the subject area conjugating with prior experiences/ investigations. The rationale for selected plants is given in Table 3.

Table 3. Selected Herbal plants showing probable utility against NDM-1 Infection [21], [26]

S.No.	Herbal Plant	Ethnopharmacological Importance	Relevance of Herb in Traditional Medicine	Availability	Vedic Literature supporting its use	Prior investigation	Indirect Indications (if any)
1							Symptomatic relief in case of *E. coli* associated infections
2							Antibiotic action enhancement with Tetracycline and ciprofloxacin
3	*Allium sativum*	-	Used in bronchitis, constipation, joint pain and fever	Central to southern Asia	Recorded from Vedic times, from ancient Chinese to Egyptian culture	Alliin, the active compound, is antimicrobial, lipid-reducing, antioxidative and fibrinolytic	Antibacterial, antimycotic and Lipid-reducing effects also reported
4							Produce MDR inhibitors i.e. pheophorbide and methoxyhydranocarpin, hence may act as antibiotic resistance modifier
5							-
6	*Hemidesmus indicus*	Aphrodisiac, antipyretic, alexiteric, antidiarrhoeal, astringent to bowels and useful in treatment of fevers, foul body odour, asthma, bronchitis, blood disorders, leucorrhoea, dysentery, diarrhoea, thirst, burning sensation, piles, eye troubles, epileptic fits, poisoning, rat bites etc	Diaphoretic, diuretic and blood purifier	Found from the upper Gangetic plain eastwards to Assam in India	Reported in Ayurveda and Unani Medicine System	Employed in nutritional disorders, syphilis, chronic rheumatism, gravel and other urinary diseases	-

7							-
8	*Papaya carica*	Medicine for dyspepsia, hyperacidity, dysentery and constipation	Antihelminthic and amoebicidal activity, blood pressure reducing agent	Suitable for tropical climate of India	Reported in Ayurveda	Seeds - antibacterial properties	Effective against *E.coli, Salmonella* and *Staphylococcus* infections
9							-
10	*Punica granatum*	Used to treat diarrhea, dysentery, vomiting and eye pain. Also in hemorrhoids and as a gargle in cases of sore throat	Tapeworm infestation, diarrhea and dysentery, as an abortifacient and astringent	Probably originated in Asia	Reported in Ayurveda and Chinese literatures	Used for gastrointestinal disturbances and bacterial infections	Antibiotic action enhancement with Chloramphenicol, Gentamicin, ampicillin, Tetracycline and oxacillin
11	*Syzygium cuminii*	Seed – Antidiabetic, atonic and spastic constipation, Pancreatic complaints, nervous disorders and as a diuretic	Bronchitis, asthma, and dysentery, Also used for ulcers, leucorrhea, Stomachache, fever, dysuria, and inflammation	Indigenous to the east Indian Malaysian Region	Reported in Ayurveda and Unani Medicine System	Proved to be effective against Diarrhea Inflammation of the mouth, skin and pharynx	-

2.5 BINARY COEFFICIENTS MATRIX TO EVALUATE THE PRESENCE/ABSENCE OF A PARAMETER IN SELECTED PLANTS

This methodology works on the principle of 0-1 binary code of absence/presence of a particular parameter in selected plants from previous step. The range of outcome of matrix lies between 1 to 8 for any plant. The cut off value selected for this matrix based analysis is closest value to the median of 1-8 range. Based on this, all the plants having more than 03 parameters, reported in PubMed search engine (n= first 20 hits) against 'Bioactivity Parameter + Selected Plant' random search model, were selected. It relates to the fact that only these plants which can support holistic approach should be screened for the next level analysis, in line with the rationale of present study.

2.6 WEIGHTAGE MATRIX BASED ANALYSIS

This step includes evaluation of overall weightage of plants (Scores > 3 in previous step) by multiplying their binary score with weightage obtained in Step No. 2.5 [39]. This is a primary step to screen the plants utilizable to subsequent analysis and removes fake positive results attributed towards investigator's biasness due to 'experience factor'. This step enhances the 'uncertainty factor' required for statistically valuable outcome [40]. This step identifies potential plant leads based on *in silico* bioprospection approach subjected to fuzzy set membership analysis and optimization to validate the findings. Weightage matrix score for the selected herbal plants is exemplified in Table 4.

Table 4. Weightage Matrix Scores for herbal plants screened on the basis of binary matrix scores (Scores > 3)

Character weightage	Weightage: 5.910	Weightage: 4.535	Weightage: 3.410	Weightage: 3.157	Weightage: 3.291	Weightage: 2.040	Weightage: 1.186	Weightage: 1	
Herbal Plant	**β-lactamase inhibitor**	**Presence of phyto-compounds against NDM-1**	**MDR Pump inhibition**	**Antibiotic action potentiator / enhancer**	**Quorum sensing inhibition**	**Adhesion inhibition**	**Antibiotic resistance modification activity**	**Symptomatic relief provider**	**Total**
Aegle marmelos	-	-	+	+	-	+	+	-	**9.793**
Camellia sinensis	+	-	+	+	+	-	-	-	**15.768**
Plumbago zeylanica	-	+	+	-	+	+	-	-	**13.276**
Berberis aristata	-	+	-	+	+	-	-	-	**10.983**
Punica granatum	-	-	+	-	+	+	-	-	**8.741**
Rosmarinus officinalis	-	+	-	-	+	-	+	-	**9.012**
Acorus calamus	-	-	+	+	+	-	-	-	**9.858**
Hemidesmus indicus	-	-	+	+	+	-	-	-	**9.858**
Holarrhena antidysentrica	-	-	+	+	+	-	-	-	**9.858**

2.7 FUZZY SET MEMBERSHIP ANALYSIS FOR DECISION MATRIX

In this approach, the given mathematical relationship was used to calculate the relevance of the variety/product;

$$\mu S = S\text{-}min(S)/[max(S)\text{-}min(S)]$$

where: μS represents the desirability values of members of the fuzzy set S. Min(S) and max(S) are minimum and maximum values, respectively, in the fuzzy set S [41]-[42]. Scores after fuzzy set membership analysis of selected herbal plants are represented in Table 5.

Table 5. Fuzzy Set Membership Analysis for herbal plants screened on the basis of Weightage Matrix scores

S.No.	*Herbal Plant*	*μS**	*Optimized Score*
1	*Camellia sinensis*	1	+++++++ (7)
2	*Aegle marmelos*	0.5625	+++++ (5)
3	*Plumbago zeylanica*	0.8125	+++++ (5)
4	*Berberis aristata*	0.5625	++++ (4)
5	*Punica granatum*	0.375	+++ (3)
6	*Rosmarinus officinalis*	0.375	+++ (3)
7	*Acorus calamus*	0.1875	+++ (3)
8	*Hemidesmus indicus*	0.1875	+++ (3)
9	*Holarrhena antidysentrica*	0.0625	+++ (3)

** μS = [(S) – min(S)] / max(S) – min(S)], where [S] is the Weightage matrix score*

2.8 OPTIMIZATION OF DECISION MATRIX SCORE

In this approach the numerical value of scores obtained were converted into a leveled score by using a scaled magnitude represented by a symbol.

3 RESULTS

3.1 KEYWORDS HITS SCORING MATRIX

On the basis of the keyword hits scoring results weightage was given to various parameters selected for screening of herbal plants with respect to antimicrobial activity. Weightage was decided according to the percentage relevance obtained

for each parameter, as elucidated in table 2. Highest percentage relevance was obtained for β-lactamase inhibitor, followed by other parameters like Presence of phyto-compounds against NDM-1, MDR Pump inhibition, Antibiotic action potentiator / enhancer, Quorum sensing inhibition, Adhesion inhibition, Antibiotic resistance modification activity and Symptomatic relief provider. Consequently weightage factors were given to selected parameters in the range of 1-6, based on statistical unitary approach, with highest weightage i.e. 5.910, given to β-lactamase inhibitor, followed by other parameters in decreasing order, as explicated in Table 4.

3.2 BINARY (PRESENCE-ABSENCE) COEFFICIENTS MATRIX

Out of 50 herbal plants, 9 herbal plants were shown to contain either 3 or more than 3 characteristic and hence illustrated a better score as compared to other herbs, e.g. *Aegle marmelos, Acorus calamus, Berberis aristata, Camellia sinensis, Hemidesmus indicus, Holarrhena antidysentrica, Punica granatum, Plumbago zeylanica* and *Rosmarinus officinalis*, as shown in figure 1. Also 11 herbal plants although had low scores but exhibited specific bioactivity related features fulfilling the criteria to be chosen as a therapeutic aid against multidrug resistant bacteria such as the presence of MDR efflux pumps and β lactamase inhibition potential, e.g. *Allium neapolitanum* (Spring Garlic), *Borago officinalis* (Gaojaban), *Papaya carica* (Papita), *Piper longum* (Long pepper), *Pinus nigra* (Pine), *Rheum officinalis* (Rhubharb), *Ranunculus repens* (Crowfoot), *Sinapis alba* (White Mustard), *Spartium junceum* (Spanish broom), *Senebierra didyma* (Senebierra) and *Spondias mombin* (Taperiba).

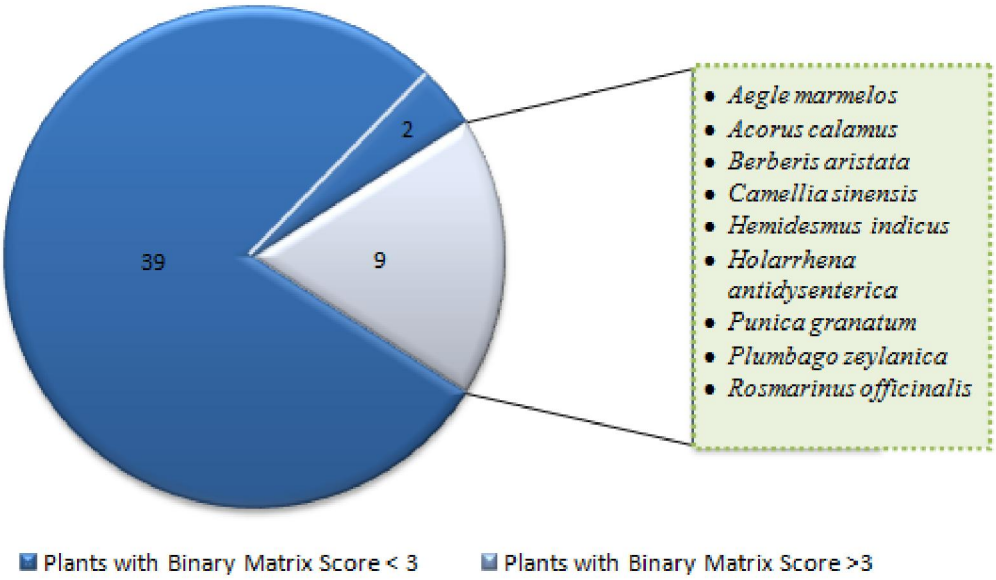

Fig. 1. Binary Matrix Scores for Herbal Plants

Out of the 50 Plants studied, 39 Plants had a Binary matrix score of 1 (Abrus precatorius, Allium neapolitanum, Andrographis paniculata, Azadirachta indica, Adhatoda vasica, Beta vulgaris, Borago officinalis, Capsicum, Camomile, Casuarina equistifolia, Caesalpinia spinosa, Coffea, Caesalpinia bonducella, Cyperus rotundus, Daucus carota, Euphorbia hirta, Ficus religiosa, Jatropha elliptica, Lawsonia inermis, Nelumbo nucifera, Ocimum sanctum, Papaya carica, Plantago ovata, Piper longum, Pinus nigra, Polyathia memorials, Rheum officinalis, Ranunculus repens, Sinapis alba, Spartium junceum, Senebierra didyma, Spondias mombin, St. John's wort, Tagetes, Terminalia arjuna, Terminalia belerica, Thymus vulgaris, Vitis vinifera and Ziziphus jujube) ; 2 plants had a Binary Matrix Score of 2 (Allium sativum and Syzygium cuminii) and rest 9 plants had a binary matrix score of ≥ 3 (Aegle marmelos, Acorus calamus, Berberis aristata, Camellia sinensis, Hemidesmus indicus, Holarrhena antidysentrica, Punica granatum, Plumbago zeylanica and Rosmarinus officinalis).

3.3 SIMPLE ADDITIVE WEIGHING MATRIX

Out of 9 plants selected on the basis of binary coefficient matrix (Binary Matrix score ≥ 3), it was revealed that 3 herbal plants showed immense potential of acting as a therapeutic agent against drug resistant microorganisms, as their combined weightage scores were even higher than the median value score i.e. 9.858, e.g. *Camellia sinensis, Plumbago zeylanica* and *Berberis aristata* as shown in Table 4.

3.4 DECISION MATRIX

On the basis of Decision matrix, 3 plants were found to show high percentage relevance to be chosen as potent therapeutic herbal plants against drug resistant bacteria, as shown in Table 5. Amongst these, *Camellia sinensis* (Green Tea) held the topmost position with 100% relevance, followed by *Plumbago zeylanica* (Chitraka), *Aegle marmelos* (Bel), *Berberis aristata* (Daruhaldi), *Punica granatum* (Anar), *Rosmarinus officinalis* (Rosemary) and others.

3.5 OPTIMIZED SCORING

Optimized values were given to the selected herbal plants, on the basis of which top 3 relevant herbal plants were revealed, e.g. *Camellia sinensis, Plumbago zeylanica* and *Berberis aristata*, as shown in Table 5.

4 DISCUSSION

Antibiotics have become mainstay of our lifestyle disease control strategy as these chemotherapeutic agents are often used to treat many infectious diseases. An overuse and abuse of such agents has led to the transformation of the antibiotic sensitive bacterial strains into resistant ones through natural selection and defined mutations. An alternative pipeline of herbal/natural therapeutic agents have to be searched for the adequate control of the emergence, re-emergence and spread of antibiotic resistant microorganisms like NDM-1 *Escherichia coli*, Methicillin Resistant *Staphylococcus aureus*, Multi-Drug Resistant Tuberculosis.

The present study is an attempt to combine classical literature based analysis with statistical interpretation of data output obtained by both random and advanced search model using the PubMed web tool. The seven parameters are selected on the basis of their direct significance in a) symptomatic relief provision, b) antibiotic resistance modification, c) antibiotic action potentiation, d) drug efflux inhibition (Table-1). Similar study using web tools for bioprospection has been done by Elizabeth S. Jenuwine *et al* for the evaluation of sleep wake cycle in healthy individuals (selected parameter) [43]. This similar model using multi-parametric approach has been used in conjunction with evaluation of their relative relevance based on priority indexing (Table-2)

The classical bioprospection of natural plant products has provided drugs of immense importance e.g., Taxol (anticancerous, *Taxus baccata*), Quinine (Antimalarial, antipyretic, *Cinchona officinalis spp.*) Vincristine (anticancerous, *Rosmarinus officinalis)*, Vinblastin (anticancerous, *Rosmarinus officinalis)*. In this study, selection of plants has been done on the basis of parameters like ethnopharmacological importance, use in traditional medicine, ease of availability, any indication in Vedic literature or available scientific evidence for complimentary use. Such investigatory analysis has provided 50 plants showing variable significance with respect to different descriptors chosen.

The plants were subjected o both random and advanced search model, (Using PubMed as search engine) followed by Binary Coefficient matrix analysis ($p < 0.05$), revealing 11 out of 50 plants to be used for *in silico* cross matrix bioprospection analysis. Binary coefficient matrix analysis is used to extract items of choice with probable higher significance based on all or none principle. This practice removes bulk outliers, thereby reduces database size to measurable proportion. This is achieved by selecting plants with binary score > 3, so as to scale down the number of plants from 11 to 9 and thereby reducing the timeframe of screening significantly (Figure 1).

The selected 9 plants are subjected to *in silico* bioprospection model where additive weightage matrix based analysis is performed to analyze the weighted scores for each selected herbal plant on the basis of presence of each weighted parameter. This matrix works on two principles a) binary (0/1) presence or absence law and b) weightage scoring analysis in conjunction. The net scoring was analysed in priority ranking providing relevance of natural plants with respect to their possible role in overall antimicrobial activity against NDM-1 *Escherichia coli* (Table 4). The optimization of obtained data was a fuzzy set membership analysis for decision matrix, revealing 04 plants with optimization score > 3.

5 CONCLUSION

As resistance to old antibiotics spreads, the development of new antimicrobial agents has to be advanced if the problem is to be contained. Bio-assay would reveal the presence of multiple antimicrobial compounds or synergic effects of these compounds. Therefore, standardization of active fractions and study for toxicity and in vivo efficacy may result in development of better antimicrobial drugs. It may provide nature friendly and cheap drugs accessible to all the people of world.

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Condition-Based Maintenance Decision-making Support System (DSS) of Hydropower Plant

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ABSTRACT: Condition-based maintenance is a kind of maintenance which conducted before fault by judging device exception and predicting device fault based on device condition information provided through monitoring device condition. The analysis result of fault diagnosis technology and production management information system which has namely arranged the maintenance plan. The implement device maintenance in light of device health condition due to prevents excessive maintenance or disrepair of device to the utmost extent. During operation, primary device of hydropower plant constantly suffers from sand abrasion, cavitation damage, mechanical wear and other mechanical or electrical damage, which reduces the efficiency of generating equipment and shortens the service life. If timely monitoring and diagnosis and appropriate maintenance are not provided, accident may be induced and cause great economic losses; to make primary devices for production and transmission of electric energy of hydropower plant have high reliability and be in good operating conditions, such primary devices must be maintained. The aim of this paper is to define the gradually improving sensor and monitoring technology which offer the possibility of condition-based maintenance of hydroelectric generating unit and the extraction and analysis methods of fault characteristics. Therefore discussion is summarized briefly on composition, configuration and functions of Condition-based Maintenance System (DSS). And also describes the short introduction of Condition-based Maintenance (DSS) system in typically project of Songjianghe Hydropower Plant as used for primary devices.

KEYWORDS: Condition-based maintenance, DSS, Monitoring device, fault diagnosis, Primer device, Hydropower Plant.

1 INTRODUCTION

The Condition-based maintenance is a maintenance technique that involves monitoring machine condition and predicting machine failure [1]. Generally these systems are controlled by computers. Device maintenance mode has two modes, Break-down maintenance mode and planning maintenance mode. Break-down maintenance which refers to the maintenance conducted after device fault. And at that time, the fault has occurred and loss has been induced. In planning maintenance mode, it refers to the maintenance conducted based on the artificially prescribed maintenance cycle.

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It is obvious that “excessive maintenance” and “insufficient maintenance” will necessarily happen in case devices under different conditions are maintained based on the unified cycle. So the planning maintenance cannot give full play to the potency of the devices and shall waste a large number of financial and human resources, and the fault cannot be found in time, which shall not only cause economic losses and waste of human resources but also may induce disastrous accident. The condition-based maintenance is conducted before fault by judging device exception and predicting device fault based on device condition information provided through condition monitoring device, analysis result of fault diagnosis technology and production management information system, namely, arrange the maintenance plan and implement device maintenance in light of device health condition and prevent excessive maintenance or disrepair of device to the utmost extent.

Evaluate the device condition in real time to grasp current operating condition of the device, timely eliminate the hidden risk of device with defect, improve device serviceability rate and health level, ensure safe operation of the device; for devices in favorable operation, properly extend maintenance cycle, reduce waste of human resources and material and avoid excessive maintenance of device. Carrying out the reasonable device maintenance strategy and reasonably applying condition-based maintenance management mode are of great significance in improving device reliability, reducing device maintenance cost and extending asset life cycle [2]. Reduce planning maintenance, avoid break-down maintenance, develop condition-based maintenance and promote optimal maintenance are device maintenance guidelines. The fig.1 shows composition of Proportions of the Optimal Maintenance Model as per maintenance guidelines.

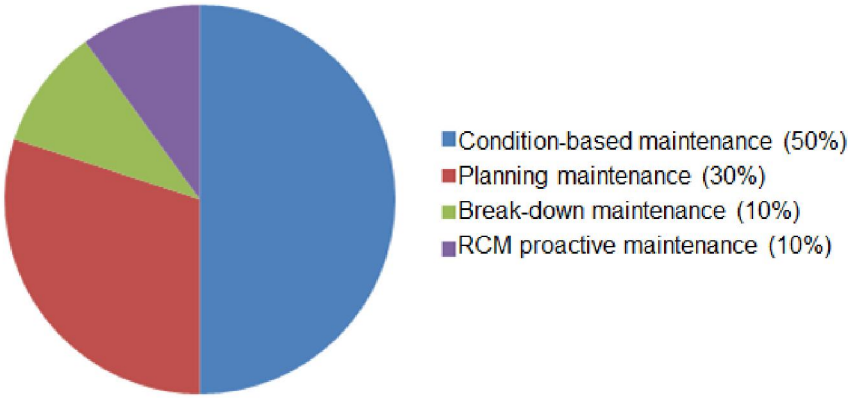

Fig. 1. Composition of Proportions of the Optimal Maintenance Model

Development course of condition-based maintenance: The evolution of device maintenance system reflects productivity development level and technology management level and the appropriate maintenance mode should be adopted along with advancement of theoretical and technological levels. The evolution of device maintenance system reflects productivity development level and technology management level and the appropriate maintenance mode should be adopted along with advancement of theoretical and technological levels. Currently the gradually improved sensor and monitoring technology offer the possibility of condition-based maintenance of hydroelectric generating unit and the extraction and analysis methods of fault characteristics are also improved, but objectively speaking, there is no hydropower station where condition-based maintenance is realized in its true sense in China.

Technological orientation of condition-based maintenance: To establish a unified maintenance information platform for condition monitoring of hydropower plant to realize acquisition of condition data, feature calculation, real-time monitoring, fault record, performance test record and technical diagnosis of hydropower generating primary devices like generator, hydraulic turbine and transformer, offer unified data access model and analysis and diagnosis model for different devices and provide technical assurance for transition from planning maintenance to condition-based maintenance of hydropower plant, thus promoting the realization of condition-based maintenance. Based on device reliability maintenance technology, borrow ideas from asset management thought of device whole lifecycle and adopt the method that conforms to the international network communication standard IEC61850-MMS to carry out data transmission and sharing and establish a unified maintenance information platform for device condition monitoring of hydropower plant.

Implement method that adopts condition-based maintenance assistant decision-making mode, construct subject data center of device condition, apply diagnosis and analysis system, reliability maintenance strategy and other advanced application algorithm and model to realize condition evaluation, fault diagnosis and condition forecast of the devices.

2 CONSTRUCTION COMPOSITION OF CONDITION-BASED MAINTENANCE SYSTEM

Composition of condition-based maintenance technical system has Unit vibration/swing protection system, Monitoring system of circuit breaker and transformer, Condition monitoring and tendency analysis system of hydropower plant, Computer supervisory monitor system, Production management system and Condition-based maintenance decision-making support system (DSS).

Establish a unified maintenance information platform for device condition monitoring of hydropower plant, acquire relevant basic data of the generator, hydraulic turbine, transformer, circuit breaker and other primary devices of hydropower plant, real-time/historical data of the devices and other characteristic parameters that reflect device health condition and evaluate current health condition of the devices, carry out effective risk evaluation, finally implement comprehensive analysis, reasoning and diagnosis through the optimal maintenance strategy model, give maintenance suggestions, and transmit the analysis conclusions and maintenance suggestions to production information management system through service bus to facilitate the inquiry and reference, thus providing technical assurance for the transition from planning maintenance to condition-based maintenance of hydropower plant to effectively support the specific implementation of condition-based maintenance work [3].

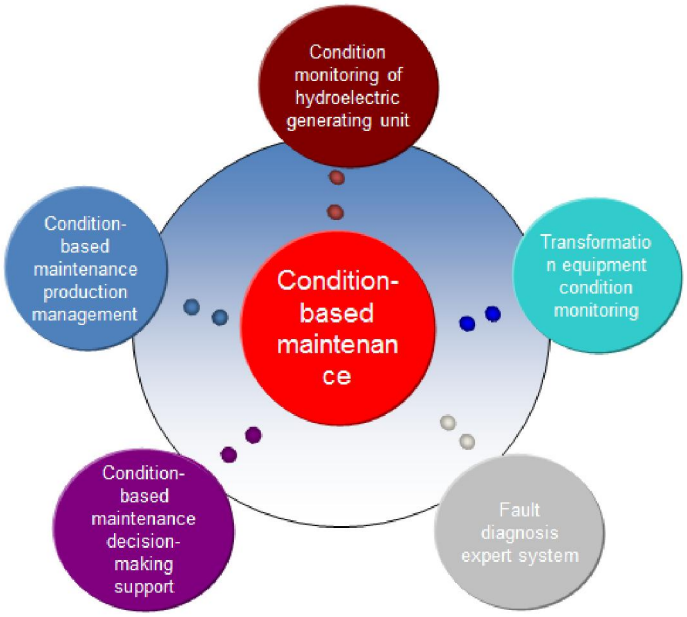

Fig. 2. Maintenance information platform for device condition monitoring of hydropower plant

3 CONFIGURATION OF CONDITION-BASED MAINTENANCE DSS

3.1 HARDWARE COMPOSITION

Plant station access server: service for access to data acquired and analyzed by condition monitoring equipment of each station, Real-time plant station database server: service for storage and inquiry of the original 72h "black box" data of condition monitoring equipment of each station, Centralized control monitoring data server: service for storage and inquiry of condition monitoring access data of equipment of the whole plant, Centralized control maintenance application server: service for operation access application of condition-based maintenance assistance decision-making of equipment of the whole plant, Mobile engineer work station (EWS): system equipment model definition, user permission management and database maintenance service, Network auxiliary equipment: safe networking service, System software function framework: Data acquisition, Data processing , Monitoring & early warning , State analysis, State diagnosis, State evaluation, Forecast evaluation, Risk assessment, Making suggestions for decision.

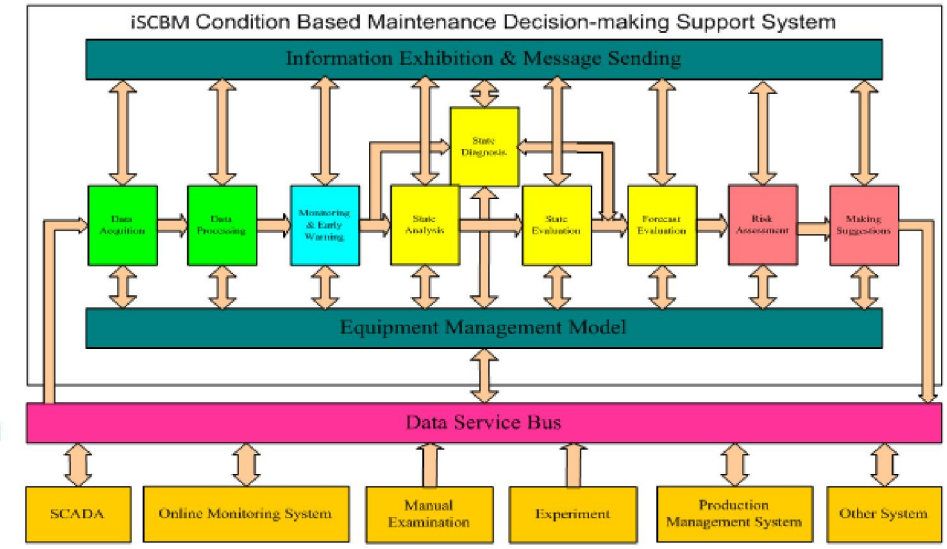

Fig. 3. Diagram of Software Functions of Condition-based Maintenance Decision-making Support System

4 FUNCTIONS OF CONDITION-BASED MAINTENANCE DSS

Data acquisition module: Analyze object model of hydropower generating primary device, and effectively acquire from external system or device various basic equipment data, real-time data, inspection and test data and other data that reflect equipment health condition to provide data resources for further judgment and evaluation.

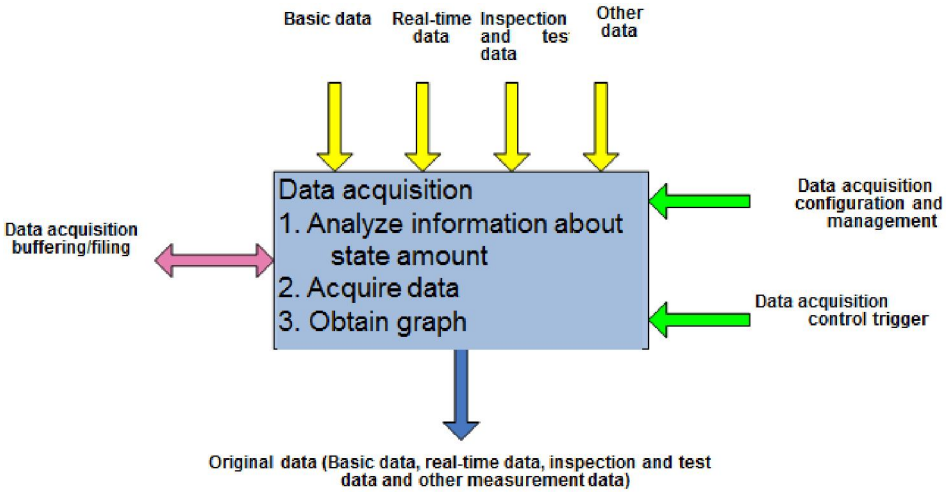

Fig. 4. Data acquisition module

Data processing module: Process the data based on the acquired data resources in light of business demand and extract the data concerning amount of state the reflect current operation performance of the equipment for monitoring & early warning and state evaluation.

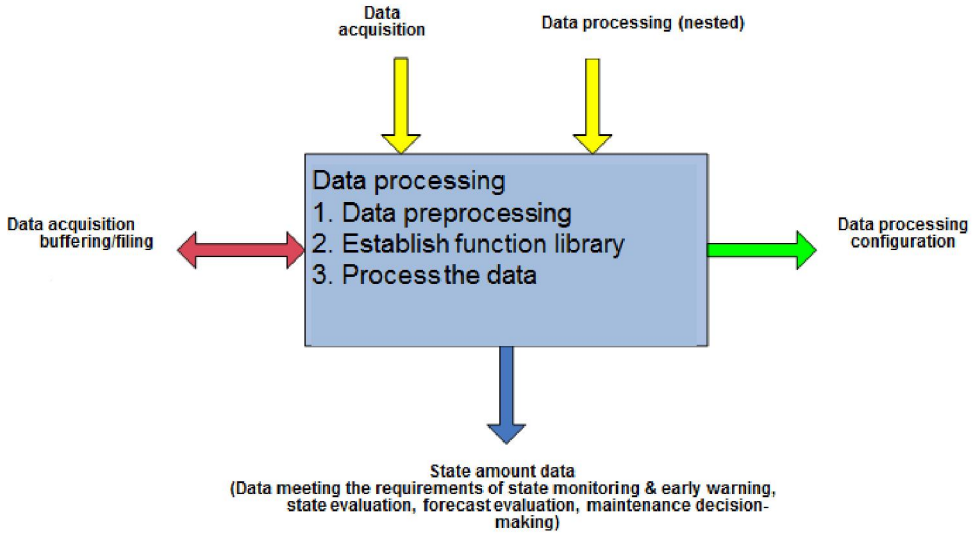

Fig. 5. Data processing module

Monitoring & early warning module: Monitor the change of state amount index, give early warning for equipment state amount going beyond the scope specified by state evaluation guidelines and regulations and timely release early warning information to equipment management personnel at all levels based on the various categories and levels.

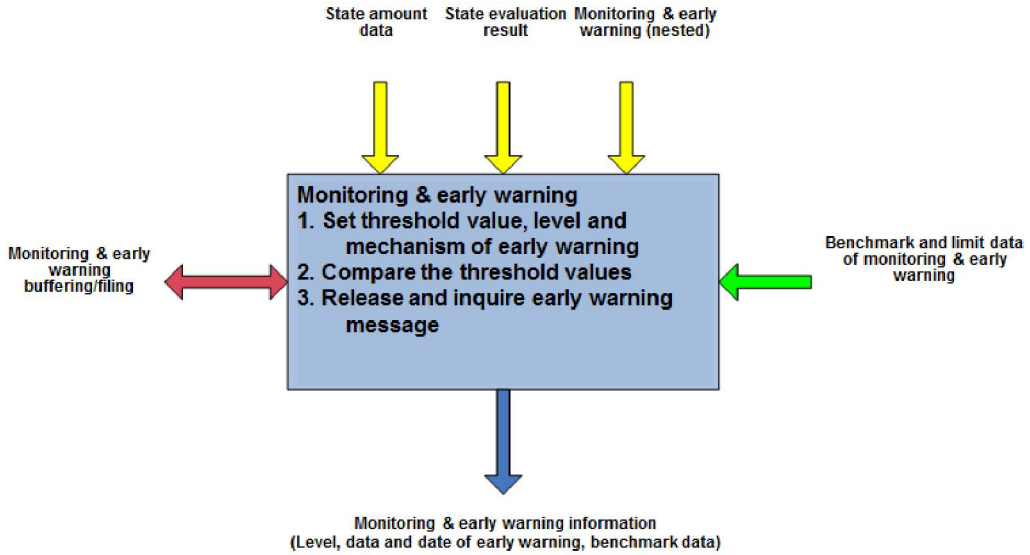

Fig. 6. Monitoring & early warning module

State Analysis module: Adopt various state analysis methods (time-domain analysis, frequency-domain analysis, correlation analysis, wavelet analysis, tendency analysis, transient analysis, characteristic spectrogram analysis, etc.) to analyze current operating condition and health level of the equipment/component. And you may integrate state analysis function of condition monitoring system and historical tendency analysis function of tendency analysis system.

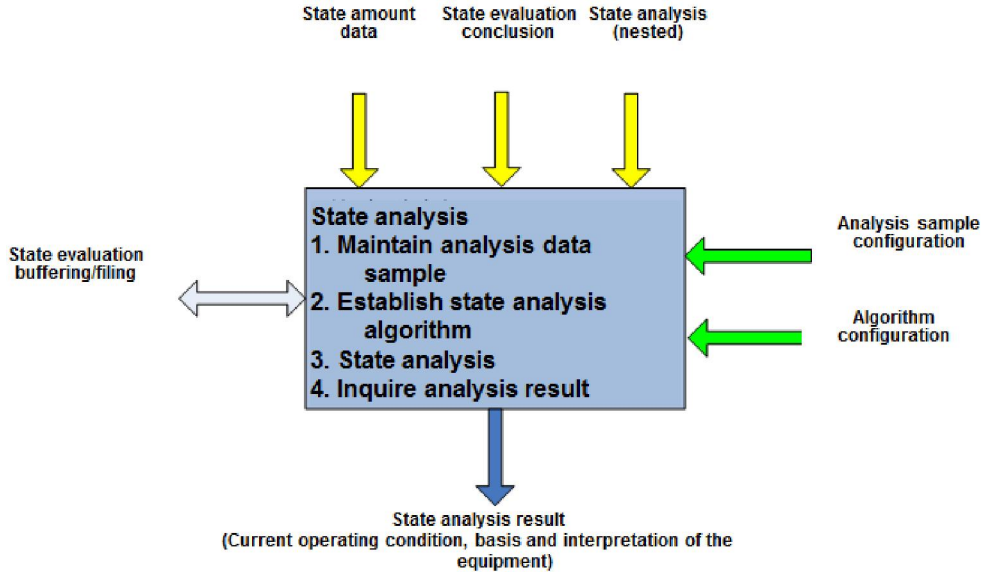

Fig. 7. State Analysis module

State diagnosis module: For equipment with state amount index going beyond the early warning or that with descending health level, adopt state diagnosis method to diagnose the cause and position of possible fault of the equipment and guide fault handling and state recovery.

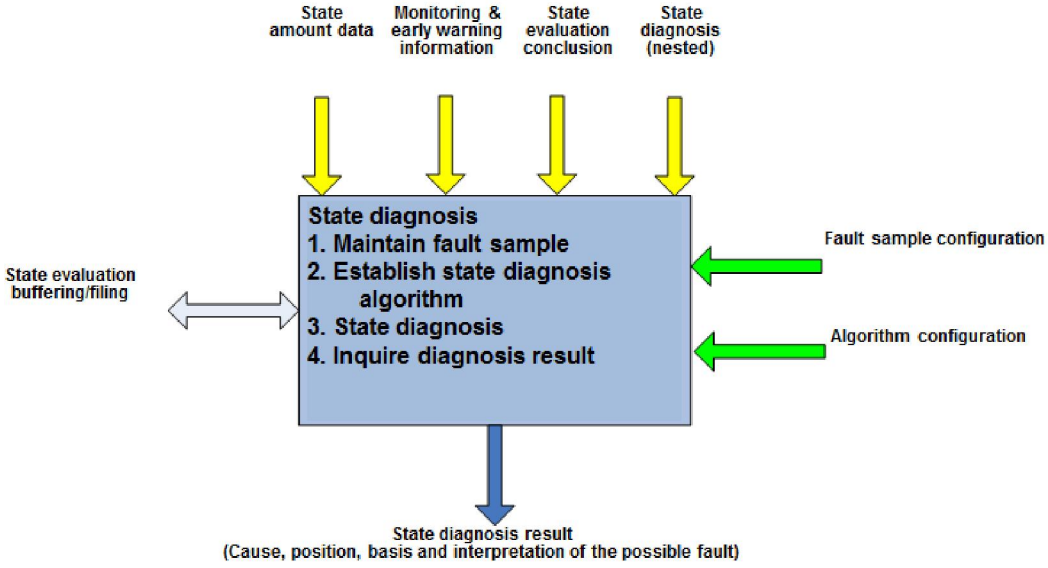

Fig. 8. State diagnosis module

State evaluation module: Analyze and evaluate date concerning all state amount indexes that reflect equipment health condition in accordance with state characteristic quantity and state evaluation guidelines and standards for primary devices of hydropower plant.

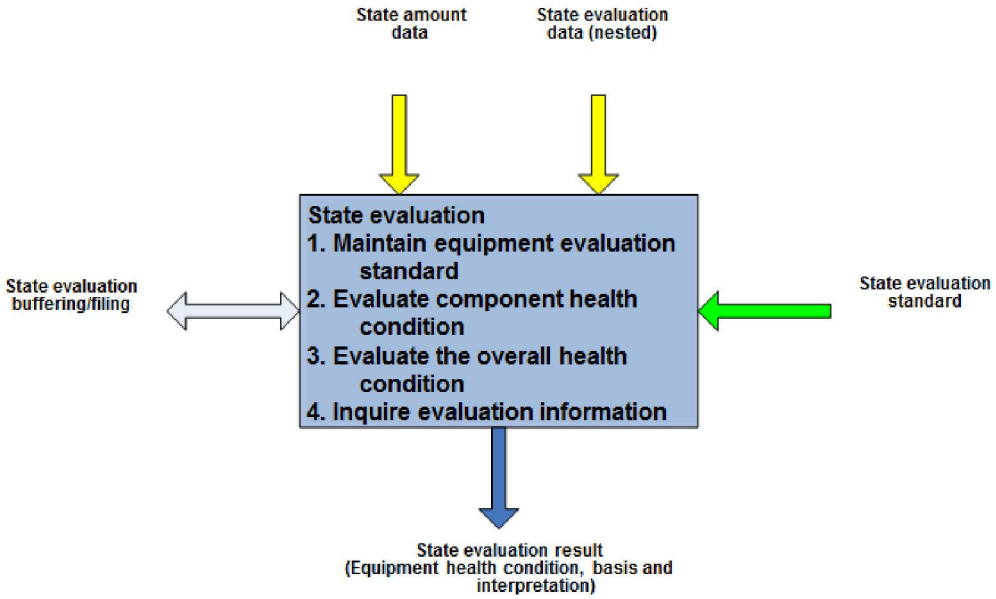

Fig. 9. State evaluation module

State forecast module: Use current and historical state data of the equipment and adopt appropriate forecast algorithm to diagnose and evaluate the state development tendency of the equipment in a future period

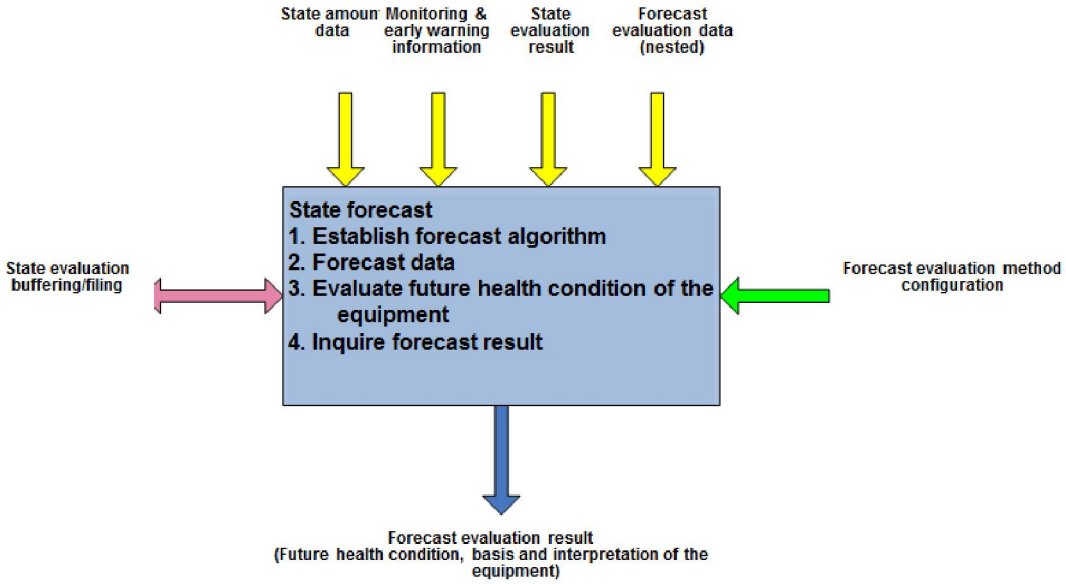

Fig. 10. State forecast module

Risk assessment module: Analyze asset loss degree in case of equipment failure threat and the probability of such threat by identifying the potential internal defect and external threat of the equipment, and obtain equipment risk level through risk assessment algorithm.

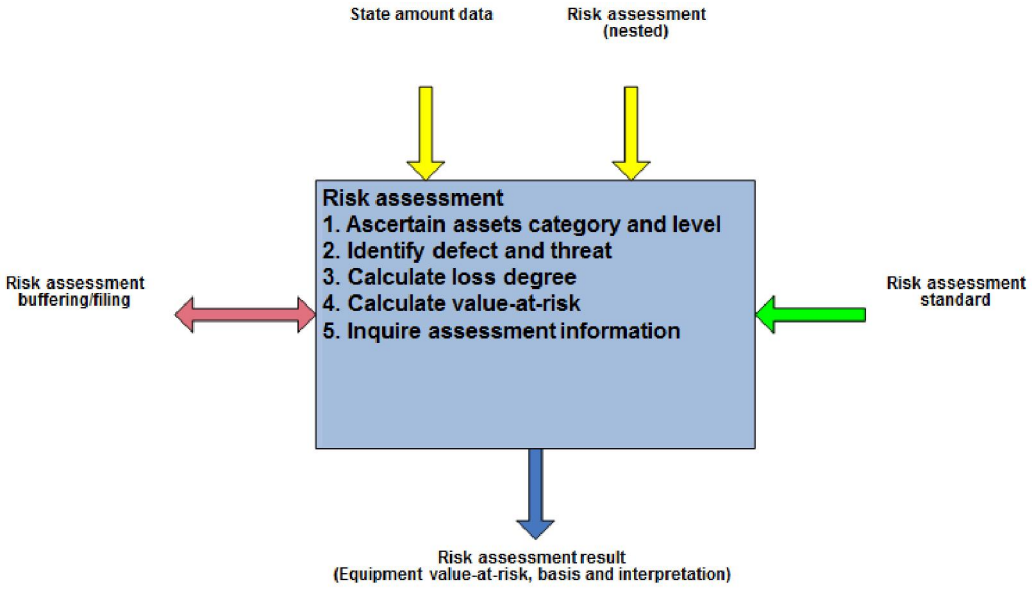

Fig. 11. Risk assessment module

Decision suggestion module: Take equipment state evaluation result as the basis, take account of risk assessment conclusion, optimize maintenance sequence, maintenance time and maintenance grade arrangement of primary devices for hydropower generation, and submit the suggested results to equipment management personnel or deliver them to related external production management system.

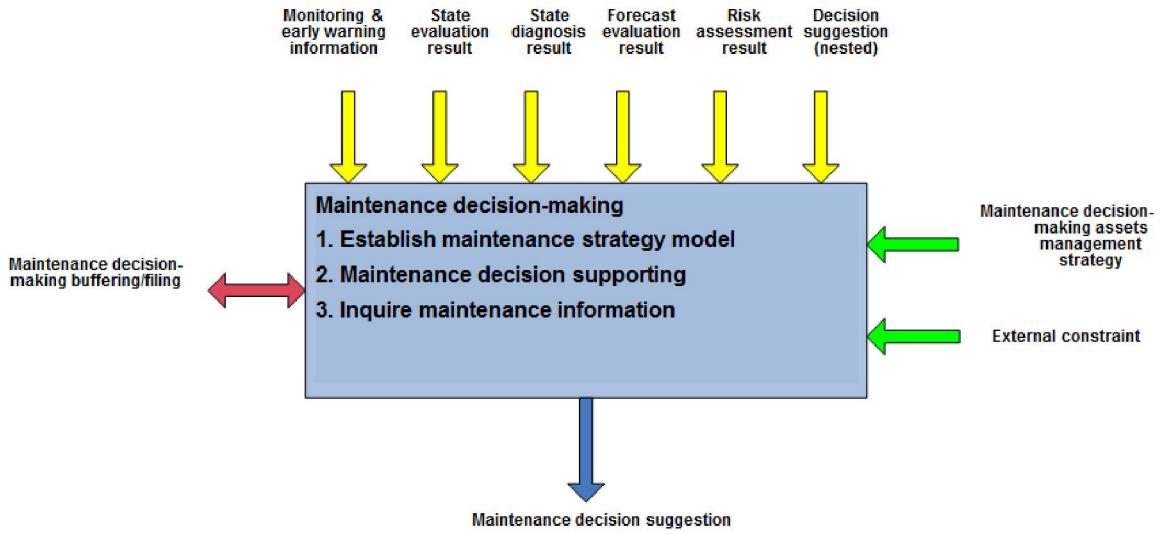

Fig. 12. Decision suggestion module

4.1 KEY TECHNOLOGIES TO THE SYSTEM

In fault diagnosis system, There are three intelligent diagnosis methods, namely, expert system approach, fault tree analysis (FTA) and case-based diagnosis method, shall be adopted for system fault diagnosis at the same time, and multi-information fusion technology based on D-S evidence theory (Dumpster/Shafer evidence theory) shall be used to integrate the three kinds of diagnosis results and obtain a final diagnosis result.

4.2 SYSTEM TECHNOLOGICAL CHARACTERISTICS

Introducing hydraulic turbine, generator equipment type, equipment component and equipment parameter modeling system into online monitoring and condition-based maintenance assistant decision-making support conforms to

development idea of equipment condition-based maintenance. Based on B/S mode and service-oriented architecture (SOA) distributed "online monitoring and condition-based maintenance assistant decision-making system of primary devices for hydropower generation", set up a unified platform for condition monitoring, fault diagnosis and maintenance decision-making of primary devices of hydropower plant; Introduce the technology for monitoring, analysis and diagnosis of conditions like vibration, swing, pressure fluctuation, air gap, magnetic flux, partial discharge, energy efficiency, operating condition, transformer oil chromatography, the technology for information interconnection and sharing of the unified platform and production management system and the standard data communication technology of IEC61850 intelligent substation, to provide the complete signal sample acquisition, multi-dimensional tendency analysis, in-depth data mining, comprehensive decision-making supporting and other technical means for setting up online monitoring and condition-based maintenance decision-making support platform.

Provide the data concerning the actual vibration region of the unit to the monitoring system, guide the automatic generation control (AGC) to keep away from the actual vibration region of the unit for operating so as to truly improve unit operating efficiency and extend unit service life; Based on the application of real-time database, provide the favorable solutions for organization, compression, transmission, storage, management and retrieval of mass data of equipment condition monitoring and maintenance system of hydropower plant; Applying three-dimensional digital modeling technology in model view building and dynamic demonstration of hydraulic turbine, generator and other primary devices and components of hydropower plant conforms to friendly and interactive development direction of current condition-based maintenance system

5 TYPICAL APPLICATIONS OF CONDITION-BASED MAINTENANCE DSS

PROJECT PROFILE

Songjianghe Hydropower Plant was established in August 1997 and lies in Fusong County of Jilin Province, China. The entire project is composed of three power stations (Xiaoshan Power Station, Shuanggou Power Station and Shilong Power Station) and two diversion projects (respectively in Songshan and Sandao Songjianghe), with the design total installed capacity of 510MW and average annual energy output of 836,900,000KWH. Decision support system (DSS) introduces technology, and presents a function & composition of multiage based maintenance decision support system used for Songjianghe Hydropower Plant equipment today [5].

Fig. 13. online monitoring and condition-based DSS information platform of Songjianghe Hydropower Plant

We studied previously some decision support systems (DSS) to maintain the equipment in hydropower plant [5]. In Songjianghe Hydropower Plant monitoring parameters are set up online monitoring and condition-based DSS information platform to realize state monitoring, state evaluation, fault diagnosis, state forecast and maintenance decision-making for 6 hydraulic turbines, generators, transformers, circuit breakers and other primary devices of the whole plant, thus making equipment health records.

6 CONCLUSION

This paper actually provides an introduction to the maintenance profession and studies various approaches to the practice of Condition-Based Maintenance Decision-making Support System (DSS). Condition-based maintenance Decision-making Support System (DSS) is a primary device of hydropower plant which requires maintaining in monitoring machine

condition and predicting machine failure. With the maintenance systematic plan strategy and reasonably applying condition-based maintenance management mode are of great significance in improving device reliability, reducing device maintenance cost and extending asset life cycle in hydropower plant.

ACKNOWLEDGMENT

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Control and Configuration of Generator Excitation System as Current Mainstream Technology of Power System

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ABSTRACT: An Integral part of generator is Excitation System and new technology of Excitation System has been developed utilizing a power sources. The most important a portion of electric power system is synchronous generator due to it is the source of electrical energy and energy transformation is possible only when generator excitation exists. The generator excitation systems work when generator excitation system operates a dc charge to the generator heads to energize the field of magnetic around them to enable the electricity that should be generated. There are brushless and brush-type exciters and generators are built in exciters or charge can be established from any external source. This paper presents the control and configuration of synchronous generator excitation system as current mainstream technology, which is widely designed for feeding of turbo generator excitation winding with auto- regulated DC in generator operation, control normal and emergency modes. In this paper discuss appended on excitation system models of synchronous generator and emphasis on drawbacks, different possibilities to regulate generator excitation, de-excitation systems and overvoltage Protection with special newly developed nonlinear system regulation. And also append short descriptions of functions, compositions, Structure and Working Principle of Generator Excitation System.

KEYWORDS: Generator, Excitation System, De-excitation System, Overvoltage Protection, Function, Working principle.

1 INTRODUCTION

Synchronous generator excitation system is key part of the power system [1]. The excitation system of a synchronous generator makes it possible to supply the energy generated by an engine (turbine) to the power grid. As a result, high priority is assigned to the reliability and availability of excitation equipment when choosing systems [7]. This paper looks at the issue of current mainstream technology of generator excitation system and brief introduce is done of technical levels of generator excitation and de-excitation system for the industrial technical communication.

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2 FUNCTIONS OF GENERATOR EXCITATION SYSTEM

The function of generator excitation system contributes stable operation of power system which is included in three mainstream steps [2]. First is maintaining the voltage of generator or other control points at reference value. Second is Control the reasonable distribution of reactive power of parallel operation unit and third is improve the stability of power system. 1st step is ensure the safety of operating equipment of power system, Ensure the economical operation of generator and the requirement for improvement of capability of maintenance generator voltage is consistent with that for improvement of power system stability in many respects. 2nd step is droop/ voltage-droop compensation, droop expressed as percentage of rated generator voltage when the reactive current of generator changes to rated value from zero under such conditions that voltage-drop compensation unit is switched on, reference value of voltage is fixed and power factor is zero and drop of generator is calculated according to the following formula:

D(%)=[(Ug0-Ug)/Ug]×100%

In which, Ug0 --- voltage value when the reactive current of generator is zero

Ug --- voltage value when the reactive current of generator equals to rated reactive current

3rd step cases the Parallel connection at high voltage side of generator-transformer unit: droop of transformer (positive droop) + droop of generator (negative droop), droop of long power transmission line (positive droop) + drop of generator (negative droop), expanded unit connection of 2 generators with 1 transformer: Positive droop

3 STRUCTURE AND WORKING PRINCIPLE OF GENERATOR EXCITATION SYSTEM

Composition of Generator Excitation System: Composition of generator concluded in the following technical levels

- Excitation transformer
- Thyristor rectifier bridge
- Automatic excitation regulator
- Field flashing device
- Rotor overvoltage protection and de-excitation device

3.1 CONTROL ALGORITHM OF GENERATOR EXCITATION SYSTEM

PID regulator for control as per proportion, integral and differential is one of the most widely used regulators with mature technology in continuous system control. Proportional regulation can reduce the inertia time constant of control system, but will lower its stability and cannot eliminate the steady-state error; Integral regulation can eliminate the steady-state error; Differential regulation can improve the stability of control system and accordingly increase the amplification factor of proportional regulation.

$$Gc(s)=\frac{Y(s)}{E(s)}=Kp\bullet\frac{1+Tc1\bullet s}{1+Tb1\bullet s}\bullet\frac{1+Tc2\bullet s}{1+Tb2\bullet s} \quad (1)$$

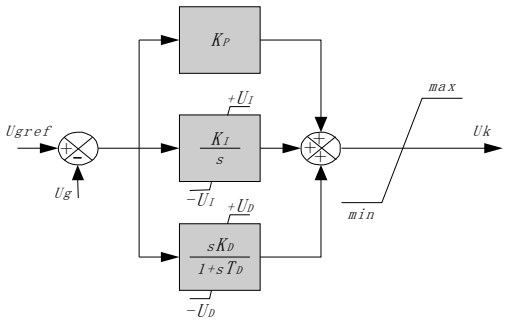

Fig. 1. Model of Parallel PID Regulation

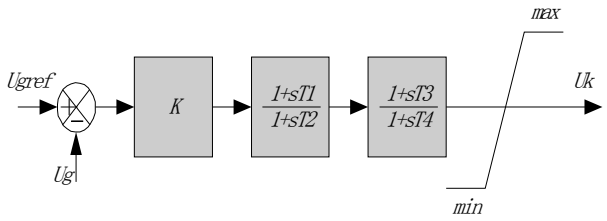

Fig. 2. Model of Series PID Regulation

3.2 POWER SYSTEM STABILIZER (PSS)

To solving the dynamic instability problem in power systems is widely installed Power system stabilizer (PSS) [9]. With the development of power system, occurrence and expansion of interconnected power system and application of fast automatic excitation regulator and fast excitation system, the low-frequency power oscillation occurs in power system, seriously affecting the safe and stable operation of power system, which has been one of the most important restriction factors for improvement of transmission power limit of tie line. The power system stabilizer, PSS for short, designed according to F.D. Demello and C. Concordia principle, is just set to suppress the low-frequency oscillation and improve the dynamic stability of power system.

At present, the control mode PID+PSS has been widely applied in excitation system [3]. The electromagnetic torque of generator can be classified into synchronous torque and damping torque. Synchronous torque (PE) has same phase with Δδ and damping torque with Δω. Insufficient synchronous torque will lead to sliding step-out and insufficient damping torque to oscillation step-out. An additional control input has to be introduced to counterbalance the negative damping torque caused by fast excitation regulation and increase the positive damping of unit. Make the additional torque produced by the additional input have the same phase with Δω through design and calculation. ΔMex=DAΔω+KAΔδ, producing negative damping DAΔW.

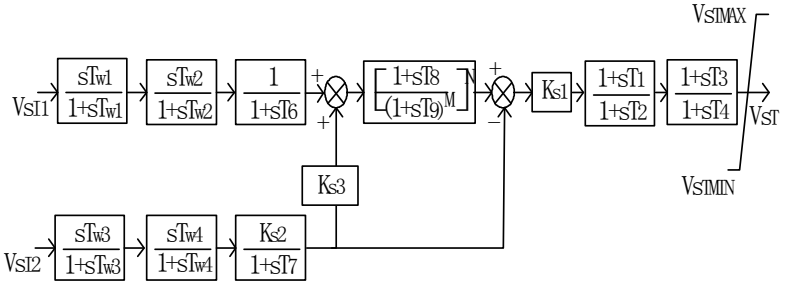

Fig. 3. Model-Block diagram PSS2A Model

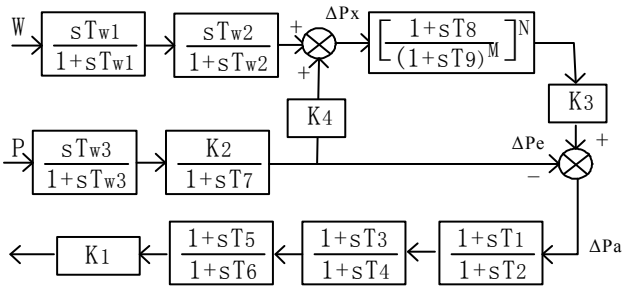

Fig. 4. Model-Block diagram PSS2B Model

4 THYRISTOR RECTIFIER OF GENERATOR EXCITATION SYSTEM

Firstly, discuss the case when controlling angle α=0. Within ωt0-ωt1, the potential of phase A is the highest and that of phase B is the lowest, which may form access. If the trigger pulse Ug6 of SCR6 of common anode group still exists before ωt0, trigger the pulse ug1 of SCR1 of common cathode at the time of ωt0 (α=0). In this way, SCR1 and SCR6 can form access: phase A of AC power →SCR1→R→SCR6→return to phase B of power supply. Obtain line voltage (Uab) from load resistance (R). Then, trigger pulse of each bridge arm in order to convert current successively. The waveform of 3-phase fully-controlled bridge rectifier circuit output voltage (Ud) is of 6 equal segments in one period, i.e. the period of output voltage (Ud) is one sixth of AC voltage period. Therefore, for calculation of its average voltage Ud, we only have to determine the average value of AC voltage U1cosωt within (-π/6+α)- (π/6+α). When α＜90°, the output average voltage Ud is positive value and 3-phase fully-controlled bridge is in state of rectifier, which converters AC to DC.

$$U_d = \frac{1}{\frac{2\pi}{6}} \int_{\frac{2\pi}{6}+\alpha}^{\frac{2\pi}{6}+\alpha} \sqrt{2U_1} \cos \omega t d\omega t \quad (1)$$

$$U_d = \frac{3}{\pi} \sqrt{2U_1} \times 2 \sin \frac{\pi}{6} \cos \alpha \quad (2)$$

$$U_d = 1.35 U_1 \cos \alpha \quad (3)$$

4.1 INVERSION WORKING CONDITION

When α＞ 90°, the output average voltage Ud is negative value and 3-phase fully-controlled bridge is in state of inverter, which converts DC to AC. With 3-phase full-wave fully-controlled rectifier circuit, inverted de-excitation can be carried out when there is fault inside generator, which quickly feeds the energy originally stored by generator rotor field to AC power, so as to lower the damage extent of generator. The inversion of separate-excitation wiring can be finished quickly with good performance; while the inversion of self-excitation wiring is of poor performance. Besides, during excitation regulation, when α＞90°, the excitation voltage of generator rotor becomes too negative value and reducing excitation quickly.β=180°-α is often called as inversion angle in fully-controlled bridge. Since inversion occurs only when α＞90°, the inversion angle β is always less than 90°. The reverse DC average voltage of 3-phase fully-controlled bridge in state of inversion working can be expressed with following formula, Uβ=-1.35U1 COS (180°-β) =1.35U1COSβ. For 3-phase fully-controlled bridge rectifier circuit, the conduction angle of thyristor is fixed. The inversion angle is usually expressed with β, which varies within 0°-90°with the controlling angle α.

4.2 PROTECTION OF THYRISTOR

The performance of silicon element to withstand overvoltage and overcurrent is poor. The thyristor has limited capacity to bear forward voltage and current rate of rise. And the insulation of excitation winding of rotor has limited voltage-withstand capability. If no proper protection and suppression measures are taken, the tolerance range may be exceeded in operation, resulting to damage of related components in semiconductor excitation system. The overvoltage protection and overcurrent protection are two important basic part of protection of thyristor.

5 DE-EXCITATION AND OVERVOLTAGE PROTECTION OF GENERATOR EXCITATION SYSTEM

The safe and reliable de-excitation of synchronous generator not only concerns to self-safety of excitation system, but also has a direct bearing on the safe operation of whole power system. When generator stops normally: invert de-excitation.

When generator stops due to accident: de-excitation due to accident stop when there are faults inside generator, the relay protection activates to cut off main circuit breaker. In this case, quick de-excitation is required to be carried out; when electrical accident happens in generator, the de-excitation system quickly cuts off excitation circuit of generator and consumes the energy of magnetic field stored in excitation winding rapidly in de-excitation circuit.

5.1 REQUIREMENTS OF DE-EXCITATION

The requirements of de-excitation are involved in Time for De-excitation shall be as short as possible, The inverse voltage of De-excitation cannot exceed the specified multiple, The circuit and structure of de-excitation device shall be simple and reliable, The field circuit breaker shall have sufficient capacity to break the current of generator rotor and The de-excitation system shall have enough capacity.

Fig. 5. De-excitation of synchronous generator

5.2 CLASSIFICATION OF DE-EXCITATION SYSTEM

- Classification as per breaker function:
- Energy-consumed de-excitation: the field circuit breaker consumes energy of magnetic field.
- Energy-transferred de-excitation: the field circuit breaker doesn't consume energy of magnetic field.
- Classification as per breaker position:
- De-excitation of DC field circuit breaker: the field circuit breaker is installed at DC side.
- De-excitation of AC field circuit breaker: the field circuit breaker is installed at AC side.
- De-excitation of crowbar: use crowbar rather than field circuit breaker
- Classification as per type of de-excitation resistance:
- De-excitation of zinc oxide nonlinear resistance
- De-excitation of silicon carbide nonlinear resistance
- De-excitation of linear resistance

5.3 PRINCIPLE OF DC DE-EXCITATION

Principle for de-excitation of DC breaker: trip DC breaker MK at the time of de-excitation. Electric arc is produced at the break of DC breaker. The arc voltage plus SCR output voltage of rectifier equals to rotor induction against potential. The induction against potential is added to both ends of de-excitation resistance at the same time. When UR is more than the break-over voltage of de-excitation resistance, the de-excitation resistance circuit is conductive, which consumes energy of magnetic field for the purpose of de-excitation [6].

$$U_R = U_K - U_{SCR} \tag{4}$$

In De-excitation conditions of DC breaker: It is necessary to ensure that the sum of arc voltage at switch break and voltage output by rectifier exceeds the break-over voltage of de-excitation resistance when carrying out de-excitation in all operating conditions of generator. De-excitation features of DC breaker: Advantage: external logic cooperation is not required for de-excitation, ensuring simple operation. Disadvantage: high requirement for arc voltage at break of DC breaker, resulting to difficult breaker manufacturing.

5.4 DE-EXCITATION OF CROWBAR

The crowbar refers to rotor overvoltage protection device. Its basic circuit and principle are as follows: a group of thyristors forward and reverse paralleled connects with one discharge resistance firstly and then connects to two ends of

excitation winding in parallel. When the trigger circuit of thyiristor detects rotor over-voltage, it sends out trigger pulse immediately to make thyristor be conductive and absorbs overvoltage energy through making use of discharge resistance. Advantage of crowbar: No breaker in main circuit, simple structure and high reliability; Disadvantage of crowbar: The maximum break-over voltage of crowbar circuit cannot be more than the peak voltage of AC line and the time for de-excitation is longer accordingly.

5.5 DE-EXCITATION RESISTANCE

The resistance for de-excitation can be linear resistance, nonlinear zinc oxide resistance or nonlinear silicon carbide resistance. For de-excitation of turbo generator, the solid generator rotor has strong damping effect. Although the current in excitation winding is rapidly reduced to zero, fast voltage attenuation of generator cannot be realized as the current in damping winding cannot be reduced quickly. And the current in damping winding is uncontrollable. Therefore, most generator units with strong damping effect use linear resistance for de-excitation and ones with weak damping effect use nonlinear resistance for de-excitation. For de-excitation of hydro generator, the generator rotor is not solid and its damping effect is also not strong. Besides, the generator voltage will raise a lot in failure conditions. Therefore, it is recommended to use nonlinear resistance for de-excitation, so as to effectively prevent accident expansion. The nonlinear resistance is classified into zinc oxide and silicon carbide.

5.6 SELECTION OF DE-EXCITATION CIRCUIT BREAKER

Rated voltage of de-excitation circuit breaker: shall be more than the maximum operational voltage of rotor; Rated operational current of de-excitation circuit breaker: shall be more than maximum long-term continuous operational current of rotor; Current breaking capacity of de-excitation circuit breaker: shall be more than ceiling current of rotor; Voltage breaking capacity of de-excitation circuit breaker: shall be more than the sum of voltage on field suppressing resistance and voltage output by thyristor rectifier.

5.7 DESIGN OF DE-EXCITATION

According to the stipulation of excitation national standard, the design multiple of de-excitation voltage shall not exceed 5 times of rated excitation voltage and is usually 3-5 times .According to the stipulation of excitation national standard, the design multiple of overvoltage shall not exceed 7 times of rated excitation voltage and is usually 5-7 times.

Problems taken into considerations for design of excitation system

1. Calculation of de-excitation capacity
2. Selection of de-excitation valve plate
3. Residual voltage and chargeability of de-excitation resistance
4. Average energy and current of nonlinear resistance

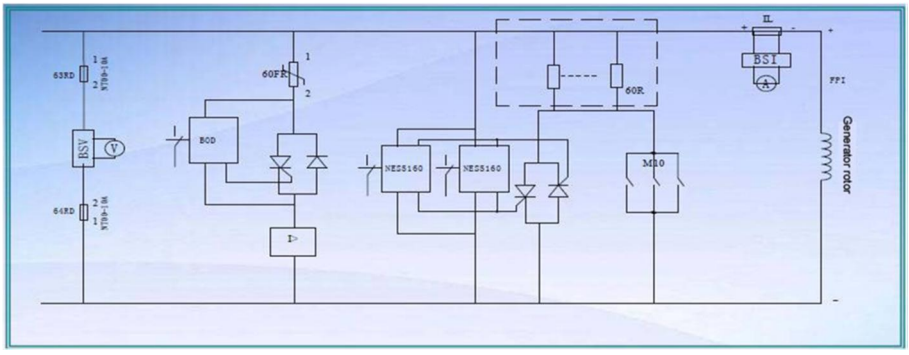

Fig. 6. Schematic Circuit Diagram of De-excitation

Main Circuit Design of De-excitation concluded in Crowbar is composed of mechanical corwbar M10, electronic corwbar and thyristor trigger module; Adopt linear or nonlinear resistance forde-excitation; the main element inside overvoltage trigger module is BOD; the overvoltage nonlinear resistance adopts ZnO resistance.

5.8 OVERVOLTAGE SOURCE

In addition to atmospheric overvoltage, the overvoltage is mainly caused by the mutual conversion and transfer of electromagnetic energy excited in circuit during circuit breaker operation in system and commutation and switch-on/off of thyristor element. The latter two kinds of overvoltage are respectively called as commutation overvoltage and operation overvoltage. The suppressing overvoltage protection is classified into AC side protection, DC side protection and element protection. The commonly used overvoltage protections are as shown in the figure (1—4RC is resistance-capacitance protection.

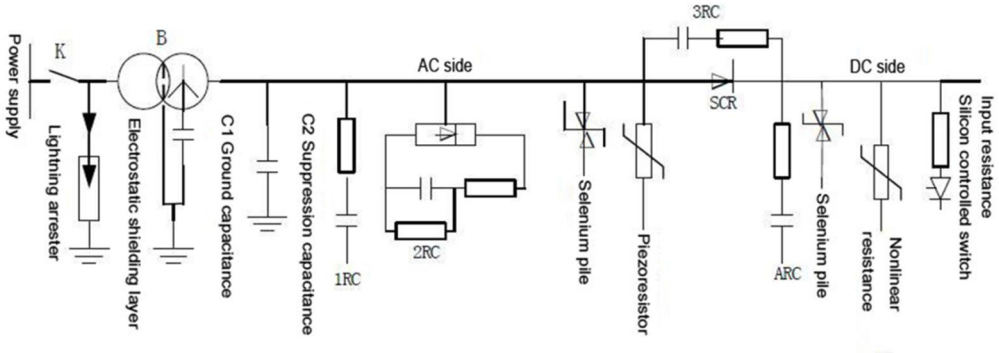

Fig. 7. Measures for Suppression of Overvoltage

In overvoltage protection, In order to limit the discharging current of capacitor, reduce the forward current increase rate di/dt caused by capacitor discharging current at the moment of thyristor switch-on and avoid oscillation produced by capacitance and circuit inductance, we usually connect proper resistance in capacitance circuit in series to form resistance-capacitance absorption protection. Usually, the transient voltage can be suppressed to such effect that not exceeding some permissible value, so as to realize the overvoltage protection of AC side, DC side and silicon element. Since the voltage at two ends of capacitor cannot sharply change, but can store electric energy, the transient surge energy can be absorbed to limit overvoltage.

6 CURRENT MAINSTREAM TECHNOLOGY AND CONFIGURATION OF GENERATOR EXCITATION SYSTEM

6.1 EXCITATION TRANSFORMER

The excitation transformer provides excitation source for excitation system. In early days, the excitation transformer usually adopts oil immersed transformer. Recently, with the development of dry-type transformer manufacturing technology and considerations for influence of fire protection, maintenance and other factors, the epoxy dry-type transformer is often used for excitation. The exciting transformer of large capacity is usually composed of 3 single phase dry-type transformers. The connection group of exciting transformer is usually of Y/△-11. Like common distribution transformer, the short-circuit voltage drop of exciting transformer is also 4%～8%.

6.2 THYRISTOR RECTIFIER

The thyristor bridge rectifier is a reliable productive topology and relative to the cost usually employed in medium voltage applications [8]. All large power rectifiers in self-excitation system are wired in 3-phase bridge mode, which ensures low voltage on semiconductor element and high use ratio of exciting transformer. Most self-excitation systems adopt fully-controlled bridge. The generator rotor is inductive load. When the controlling angle within 0°-90°, the 3-phase fully-controlled bridge is in rectifier state (produce forward voltage and forward current); when the controlling angle is within 90°-165°, the 3-phase fully-controlled bridge is in inversion state (produce reverse voltage and forward current). Therefore, when generator loads changes, we can regulate the field current through changing the controlling angle of thyristor, so as to ensure the constant generator voltage. Multiple rectifier bridges in parallel are usually adopted for excitation system of large unit, so as to ensure sufficient field current. The number of parallel branches of Rectifier Bridge is determined by the principle "(N+1) bridges". N stands for number of rectifier bridges required for normal excitation of generator. One rectification bridge faulted has no influence on normal excitation of excitation system.

6.3 EXCITATION CONTROL DEVICE

The excitation control device includes automatic voltage regulator and field flashing control circuit. For the automatic voltage regulator in self-excitation system of large unit, the regulation of PID (proportion, integral and differential) is carried out as per deviation. Voltage closed-loop regulation: measure generator voltage and compare it with given value. When the generator voltage is more than reference value, increase the controlling angle of thyristor and reduce field current, making the generator voltage return to setting value; when the generator voltage is less than reference value, reduce the controlling angle of thyristor and increase field current, maintaining generator voltage at setting value. At present, the regulator of NARI Electrical Control Company which has been put into operation mainly includes: SJ800 (no longer produced); SAVR2000 (no longer produced); NES5100.

6.4 DE-EXCITATION AND ROTOR OVERVOLTAGE PROTECTION DEVICE

De-excitation and rotor overvoltage protection device can be configured with field circuit breaker (must meet the breaking requirement under all extreme working conditions), linear de-excitation resistance and nonlinear resistance (flexibly select de-excitation resistance according to unit characteristics, unit capacity and difference of concrete requirement). When linear de-excitation resistance is configured, it has to be used together with the normally closed contact of field circuit breaker and be configured with independent rotor overvoltage protection device. When nonlinear resistance is used Forde-excitation, it can also ensure the rotor overvoltage protection. Therefore, the nonlinear resistance for de-excitation is widely applied in large generator unit, especially in hydro generator. Domestic companies mostly use high-energy zinc oxide valve plate and foreign companies mainly adopt silicon carbide resistance. At present, some domestic large units also adopt mechanical switch + silicon carbide Forde-excitation.

6.5 INTRODUCTION TO NES-HMI EXCITATION INTELLIGENT MONITORING INTERFACE

NES-HMI excitation intelligent monitoring interfaces Software is widely using in the industrial projects at China. NES5100 field regulator is equipped with 1 set of liquid crystal industrial control computer, 1 set of D-LINK exchange, and 3 pieces of network lines. The operating system is Windows XP. Here, the 3 pieces of network lines are connected with the industrial control computer, regulator A, and regulator B respectively. Well connect the network line of the regulator and D-LINK exchange, and of D-LINK exchange and industrial control computer. Input all power supply on the field regulator cabinet in the following sequence: D-LINK exchange, industrial control computer, regulator A and regulator B, and input and output power supply. In system topology, there are the schematic diagram of system connection, and visual graphic marks. If a graphic clicked is highlighted or brightened, it shows that the internal related data of this graphic may be observed. The interface is divided into upper part and lower part. Where, the upper part is the analogy pointer meter for generator unit stator sampling analog and the lower part is the real-time digital quantity of analogy sampling.

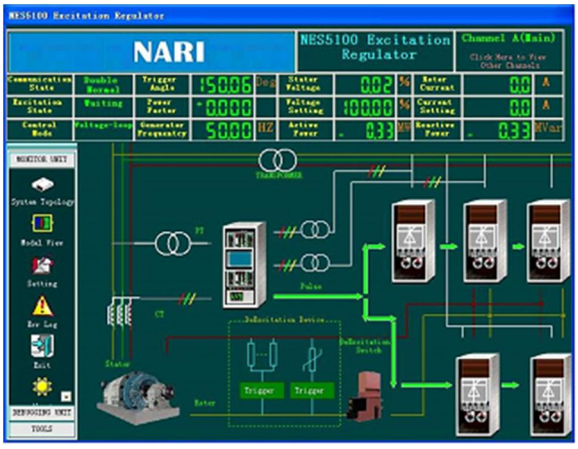

Fig. 8. Topology of NES-HMI excitation intelligent monitoring interface Software made by NARI Group of Corporation, China

The curve includes over-excitation and under-excitation curve; and the main interface includes graphic simulation zone and numerical value setting zone. The graphic simulation zone includes 5 buttons as shown in fig. 9. The vernier determines the “Starting Point Determination” and “End Point Determination” through moving vertical rectangular coordinate, and “Automatic Analysis” to automatically calculate the maximum value and the minimum value.

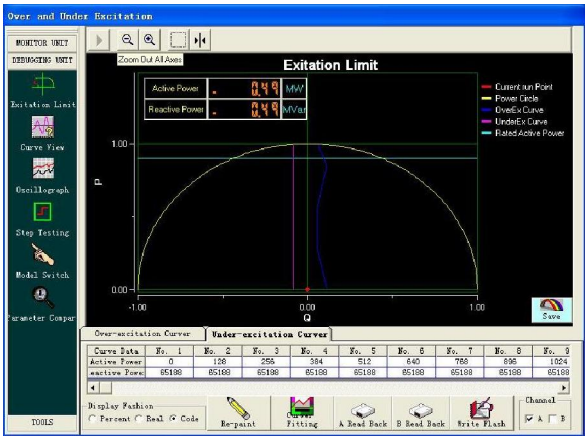

Fig. 9. Over/under-excitation parameter interface

7 CONCLUSION

The generator excitation system is most maintenance intensive subsystems in various kinds of power plants and improves the dynamic stability of power systems [4], [5]. The conclusion comes up with the discussion of the aspects current mainstream technology of generator excitation system and the short review of their function operation and control, principle and structuring of excitation system. And topology of NES-HMI excitation intelligent monitoring interfaces software is introduced which keeps operation and control of generator excitation system.

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