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VERTICAL DUCTING AND VERTICAL-HORIZONTAL COAXIAL BLADE COMBINATION EFFECTS ON THE PERFORMANCE OF VERTICAL AXIS WIND TURBINE (VAWT)

Abdul Latif Manganhar*, Saleem Raza Samo**, Mohammad Ramzan Luhur***, Altaf Hussain Rajpar****

ABSTRACT

Horizontal wind flow ducting of wind turbines is not new in the turbine history. It is conventionally applied with horizontal axis wind turbines to accelerate wind at turbine section to generate more power from low-speed wind. In few cases vertical axis wind turbines are integrated with wind accelerating duct structures to improve their power generation performance. This technique has been proved effective in low-speed wind zones and reviewed mostly to improve efficiency and environmental characteristics of VAWT. The present study experiences vertical ducting of VAWT with horizontal inflow and vertical outflow. A Vertical Cylindrical House was fabricated with horizontal inlet door and vertical opening. Auxiliary wind source (low-speed open type wind tunnel) was used to inlet wind in the house changing the direction and velocity. Three rotor systems a/ Savonius Four Bladed VAWT, b/ Horizontal Blade-Vertical Axis Rotor(HB-VAR) and c/Vertical-Horizontal Coaxial Blade Combination, were developed and tested in the fabricated rotor house. Results of three setups were compared and concluded that vertical ducting of VAWT is more beneficial with vertical–horizontal coaxial blade combinations and can be preferred for low wind conditions.

Keywords:- *Blade combination, Horizontal inflow, Low-speed wind ,Savonius rotor, VAWT, Vertical Duct, Vertical outflow*

1. INTRODUCTION

The performance improvement of wind generators is the first priority of wind energy experts. There are two option in this regard, either more efforts be on turbine design or the power of incoming wind be enhanced. For later option, ducting or funneling concepts are introduced mostly in HAWTs and in few cases of VAWTs, to accelerate and guide wind before it strikes on the rotor. Literature shows that sites for wind flow intensities, worldwide, required for power production are very less. Major portion of the world has wind less than 5m/s, which is in sufficient for power generation [1]. The suggestions are that the wind power generators should be located near the more populated zones, unfortunately more populated zones increase turbulence intensity in wind flow [2]. In urban area wind is always changing its speed, and direction is rarely uniform. VAWTs are reliable since they are omni-directional and can be more effective in the complex urban terrains to harness the wind energy [18]. More effective systems are required to generate power, in such sites. Recommendations from researchers are that the systems to be located near or in the urban zones may be integrated with such techniques that may improve the quality of wind flow and increase striking power of incoming wind. Converging diverging ducts were introduced as integral part of wind rotors to obtain a higher energy density [3-6]. Ducting and shrouding the rotor highlighted the importance of such wind accelerating techniques. Comparative studies were conducted with and without ducts [7,8] and it was claimed that integration of ducting techniques multiplied the power performance of the bare rotor. The positive results from low speed and turbulent wind improving techniques provided new direction to the researchers in the field of wind power generation. Flow converging ducts and

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diffuser geometries were studied [9,10] to optimize their effects on the rotor performance. Surprising results were came forward with increasing power factor more than double as compared to the bare cases of wind turbines [11]. Wang, et al [12] used scoop to utilize lower winds and claimed that such techniques increase the catchment of wind and improve performance of wind turbine at lower wind speeds.

The performance improvement of straight bladed vertical axis wind turbine was claimed, with the use of guide vane row, 1.5 times higher than the same rotor without the attachment of any guide vane [13].

H40 turbine was assembled on vertical shaft [14] with vertical duct to study ducting effect on its performance. In this setup wind enters horizontally and leaves vertically. Upper end of the duct was designed to perform as diffuser and the blades were fixed at the throat. 80% improvement in its performance was claimed.

A building integrated vertical axis wind turbine was developed and tested by [15]. In this system wind enters horizontally and leaves the duct vertically after shifting its energy to the vertical rotor. Carcangiu and Montisci [16] developed an innovative system suitable for wind power generation in urban areas. The wind energy conversion system was installed on the roof of the building. They claimed through analysis that the developed system can satisfy the energy demands of a common building. Omni-directional-guide-vane (ODGV) was designed and analyzed to in house Vertical Axis Wind Turbine [17, 19]. According to the claim, the ODGV accelerated and concentrated the low speed incoming wind resulting two times increase in the rotational speed of the rotor.

The objective of above researchers was, mostly, to search ultimate wind accelerating geometry of duct and its beneficial integration with the rotor. These efforts were intended to bring low-speed wind zones in the working range of VAWT. In the present work vertical ducting of VAWT and vertical-horizontal coaxial blade combination effects on its performance are taken into consideration.

2. MATERIAL AND METHODS

The test setup shown in Fig.1, comprises,

- A four blade savonius rotor
- A vertical rotor in housing cylinder
- Fan type horizontal blade set with concentrator cap
- Instrumentation(hotwire anemometer and tachometer)
- Low-speed subsonic open-type wind tunnel

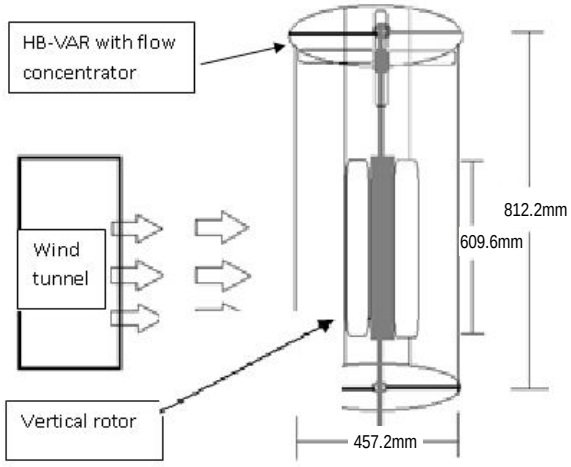

Fig 1: Test Setup Drawings

2.1 Rotor Dimensions

- Diameter = 440mm = 0.44m
- Height = 609.6mm = 0.609m
- Swept area = 0.268m^2
- Blade size = 0.2032m x 0.6096 = 0.124m^2
- Aspect ratio = h/d =0.6092/0.2032=3

2.2 Cylinder dimensions

- D_c(diameter of cylinder) = 0.4572m
- H_c(height of cylinder) = 0.8122m
- h_i(horizontal inlet) = 0.124m^2
- v_o(vertical opening) = 0.164m^2

2.3 Horizontal Blade-Vertical Axis Rotor(HB-VAR) with Flow Concentrator Cap

- H_{rd}(horizontal blade rotor diameter) = 0.443m
- H_{ra}(horizontal blade rotor area = 0.164m^2
- Concentrator blockage area = 0.041m^2
- Net Swept area of HB-VAR = 0.123m^2

3. TESTING METHODOLOGY

The performance of a four blade savonius rotor (savonius VAWT) was tested in following ways,

1. VAWT without vertical duct
2. VAWT with vertical duct.
3. Horizontal Blade-Vertical Axis Rotor(HB-VAR) with vertical duct
4. Combined VAWT and HB-VAR with vertical duct

The VAWT performance without duct was studied at the initial stages by changing the direction of wind beam from origin of rotor to the tip of blade.

Effects of ducting the rotor were analyzed by in-housing the rotor in a vertical cylinder with horizontal opening for inward wind flow and vertical opening for outward flow, as shown in fig.2.

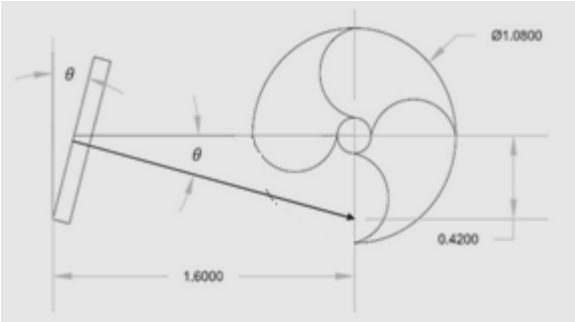

Fig.2: Positions, dimensions and orientation of the rotor, duct, slot and wind source

Two rotor setups, Savonius VAWT and HB-VAR, were fixed on same vertical shaft.

The performance of HB-VAR with vertical duct was studied separately and then combined with VAWT, where vertical cylinder was acting as an agent to modify wind direction and the power. This typical rotor setup and in-housing geometry as shown in fig.3 was used to study the performance of the proposed system. Out flow of subsonic wind tunnel provides the microclimate to the project. Outflow velocity variations up to 0.1 was observed through anemometry techniques which indicates free stream turbulence in the wind source. Mean values of inlet velocity and corresponding rotor rpm were rounded off and used for further analysis to minimize error occurrence.

Fig 3: Test setup

4. PERFORMANCE CALCULATIONS

The mathematical model to determine the power available in the wind beam of swept area A is;

$$P_w = \tfrac{1}{2}\rho A V^3 \quad (1)$$

Where,

P_w = the power available in the wind beam of cross-sectional area A(Watts),

ρ = the density of wind (kg/m^3)

A = the swept area of Savonius rotor (m^2)

V = the speed of wind(m/s)

The limiting power co-efficient of any design of rotor, determined by Betz [18], is Cp (max) = 0.59.

According to this limit, no turbine can extract power from wind more than this value. The value of Cp varies from design to design. The real achieved value of Cp, even in the best designed wind turbines is well below the Betz limit. It is not more than 0.45 [18]

Hence, the power co-efficient needs to be incorporated in wind power equation (1) to determine extractable power from the wind beam that hits the rotor, and is given by;

$$P_m = \tfrac{1}{2}\rho A V^3 Cp \quad (2)$$

Where,

P_m = the extractable mechanical power,

Cp = co-efficient of performance of the rotor and

$\frac{1}{2}\rho A V^3$ = the power of upstream wind (P_w) that hits the rotor.

Turbines are usually characterized by performance curves, which give Cp as a function of Tip Speed Ratio (λ).

$$\lambda = (\omega \times R)/V \quad (3)$$

Where,

ω = the angular velocity of Savonius rotor and

R = the radius of the Savonius rotor.

Cp as a function of λ curves for many turbines are shown in Fig.4.

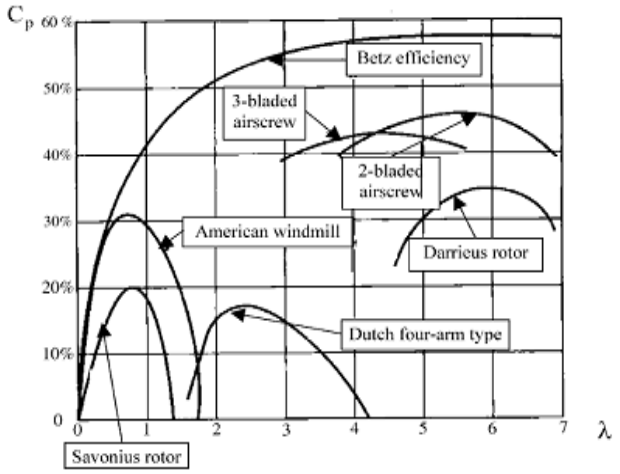

Fig. 4: Characteristic curves of many conventional wind machines

5. RESULTS & DISCUSSIONS

5.1. VAWT Without Vertical Duct

Performance of Simple VAWT was analyzed in terms of rpm with respect to angle made by wind beam, (i) by changing its direction from origin of rotor to the tip of blade at constant wind velocity V=5m/s to search the best flow direction and then (ii) by varying wind velocity from 1 to 10m/s with the searched best wind direction.

From fig.5, we can estimate that the most effective wind beam angle is 30° with which it hits the blade near its tip, at which maximum rpm 172 are recorded. Further increase in the angle causes reduction in rpm. Fig.6 shows the values of tip speed ratio(λ) with respect to wind direction for this rotor at 5m/s constant wind velocity. The value of λ=0.79, recorded at Θ =30°, coincides with Cp = 0.19 in figure 4, which indicates the performance co-efficient of this VAWT, whereas, fig.7 shows the performance of VAWT without duct at Θ =30° with respect to wind velocity.

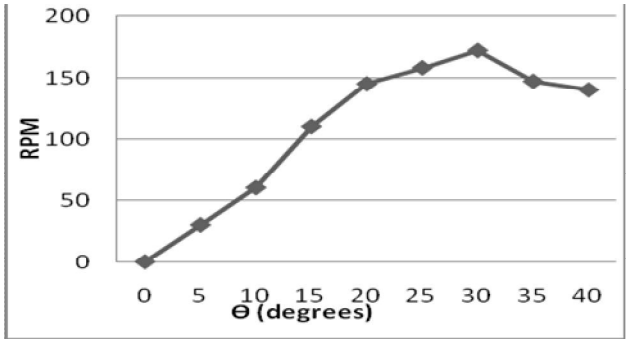

Fig. 5: Performance VAWT without duct with respect to wind direction at V= 5m/s.

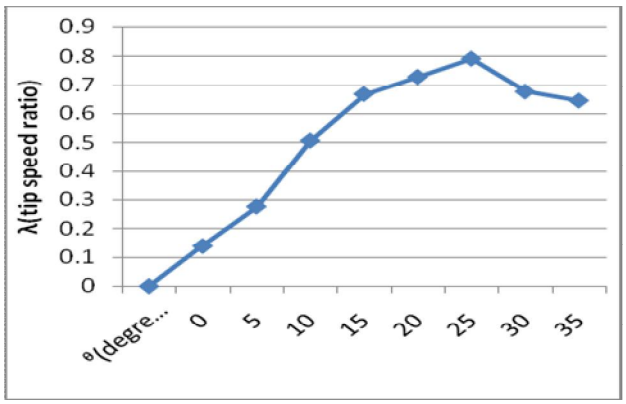

Fig. 6: Performance of VAWT without duct in terms of tip speed ratio with respect to wind direction at V= 5m/s.

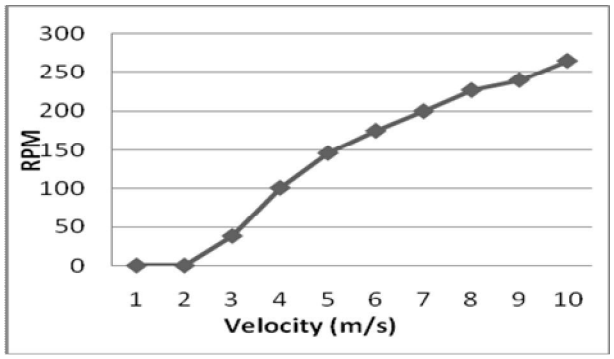

Fig. 7: Performance of VAWT without duct at Θ=30° with respect to wind velocity

5.2 VAWT with Vertical Duct.

In this test performance of VAWT was studied at a constant wind beam angle Θ=30° with respect to wind velocity.

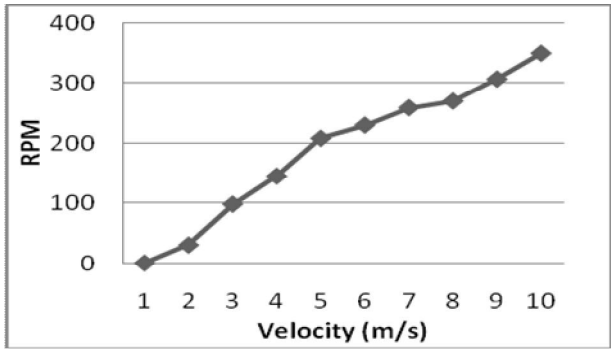

Fig. 8: Performance of VAWT with vertical duct with respect to wind velocity.

fig. 8 indicates improvement in the performance of VAWT with integration of vertical duct. This performance improvements can be indicated through fig.9, where RPM-1 indicates the case without duct and

RPM-2, with duct showing 42% improvement at 5m/s and 32% at 10m/s.

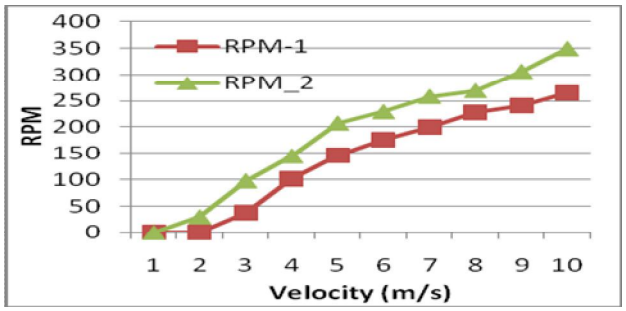

Fig. 9: Performance comparison of VAWT with and without vertical duct

5.3 Horizontal Blade-Vertical Axis Rotor(HB-VAR) with Vertical Duct

In this case, performance of HB-VAR was checked with vertical duct at wind direction (Θ=0) with respect to velocity.

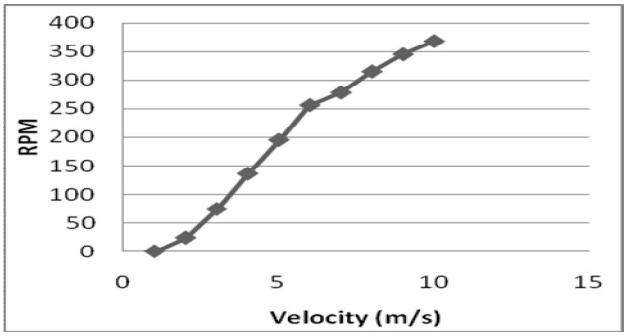

Fig.10: Performance of HB-VAR with vertical duct at Θ=0 with respect to velocity

According to fig.10 the HB-VAR with vertical duct performs very well. Comparative performance is shown in fig.11 which indicates more better performance of HB-VAR in higher winds i.e, 38%, 5% greater than first and second case respectively.

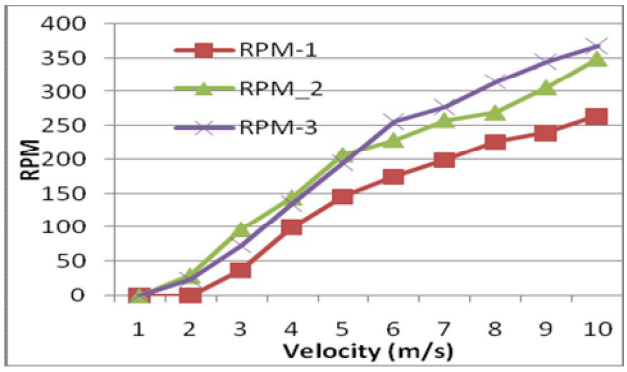

Fig. 11: Comparative performances of VAWT without duct (RPM-1), with duct(RPM-2) and HB-VAR(RPM-3)

5.4 COMBINED VAWT AND HB-VAR WITH VERTICAL DUCT

Effect of HB-VAR on the performance of VAWT inside the vertical duct was studied with respect to wind direction and velocity. It should be noted that the cap below the HB-VAR reduces vertical wind flow path and develops neck to concentrate the rising wind near the tip of blade resulting improvement in the performance of system.

Fig.12 indicates the performance of combined rotor system with respect to wind velocity. 409rpm at 10m/s were recorded which shows 54% greater performance as compared to bare VAWT. The performance comparison is shown in fig.13.

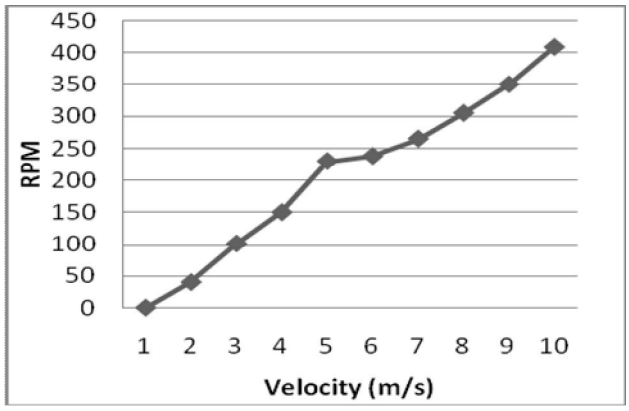

Fig. 12: Performance of the combined system with respect to wind velocity.

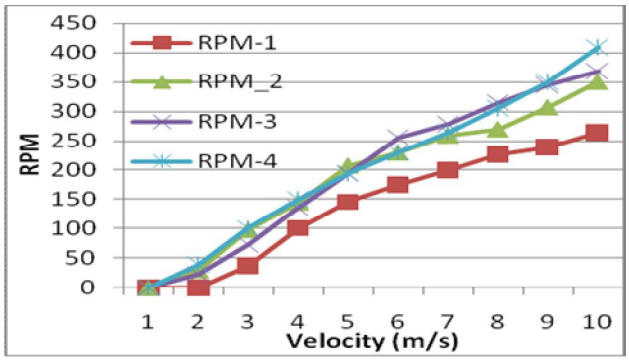

Fig. 13: Performance comparison of above four cases

6. CONCLUSIONS

The present study concludes following important observations.

- Co-efficient of performance estimated for the developed VAWT was Cp=0.19.

- The performance of VAWT with integration of vertical duct increases 42% and 32% at 5m/s and 10m/s respectively.
- Performance of HB-VAR is more better in higher winds i.e, at 10m/s, was 38% and 5% greater than VAWT without duct and VAWT with duct respectively.
- The performance of combined rotor system with respect to wind velocity was appreciable. 409rpm at 10m/s were recorded which shows 54% greater performance as compared to bare VAWT

6.1 RECOMMENDATIONS

Vertical ducting of VAWT is preferable for low wind conditions and will be more beneficial with vertical–horizontal coaxial blade combinations if proper wind direction be maintained with the help of any wind guiding and concentrating mechanism. This technique is better to improve efficiency and environmental characteristics of Vertical Axis Wind Turbine.

ACKNOWLEDGEMENT

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APPRAISAL OF AIR AND WATER POLLUTION IN HYDERABAD AND KARACHI, PAKISTAN

Asadullah Kazi*

ABSTRACT

Environmental pollution refers to mixing or contamination of undesirable substances in the environment, affecting the living organisms of the biosphere. This obviously includes human beings, who themselves may be responsible for introducing pollutants in the biosphere. Worldwide, more than 10 million people, die every year from the ingestion or inhalation of these pollutants.

This paper, mainly deals with pollution of air and water, which are the main sources of damage to the life of human beings. In this framework, the two largest cities of Sindh, namely Karachi and Hyderabad, and the areas around them, are selected for the analysis of contaminated air and water in these areas. Guidelines formulated by the US Environmental Agency, World Health Organization, as well as the Environmental Protection Agency of Pakistan are consulted. Clean air is essential for human health and environmental. Consequently, the presence of excessive amounts of pollutants, such as particulate matter, together with oxides of Carbon, Sulphur and Nitrogen, as well as Ozone is the main ingredients of concern in the studied areas. In a similar context, *water* is also an important ingredient of the environment. It is used for drinking, municipal, irrigation and *industrial* purposes. The discharge of untreated industrial and municipal waste, as well as the presence of contaminated drinking water, poses serious environmental concerns in Karachi and Hyderabad. Noise pollution is also a matter of apprehension, particularly in the thickly populated settlements, around the two cities surveyed in this study. Suggested are given to circumvent some of the environmental concerns through legislation and implementation by relevant authorities

***Keywords**: Pollution, environment, greenhouse gases, air, drinking water, wastewater*

1. INTRODUCTION

Pollution is defined as the introduction of contaminants into the environment that may cause undesirable changes in air, water and land, affecting living organisms in the ecosystem. As shown in Figure 1, there are four basic components of global environment. These include Atmosphere (Air), Lithosphere (Land), Hydrosphere (Water) and Biosphere. The latter is the living component of the environment including human beings, as well as parts of other components of the global environment.

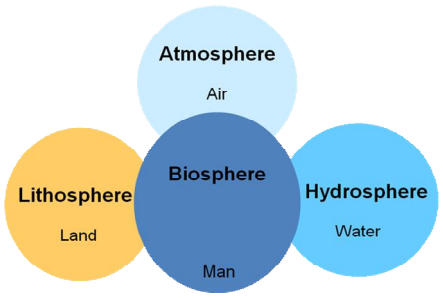

Fig. 1: Global Environment

It may be emphasized that the biosphere is a composite of living as well as nonliving parts (Figure 2). The living part constitutes ecosystem, which varies with type of species. Furthermore, each ecosystem requires a kind of habitat that may include living and nonliving counter parts, for its survival. A habitat is, therefore, a place where a living organism finds its shelter, obtains food and where it can reproduce.

The science of ecology, on the other hand, deals with the study of living organisms in their natural environment. However, the impact of anthropogenic activities, in particular, on the pollution of environment is a matter of concern for all involved in the study of environmental health hazards. A wide variety of environmental issues, generally resulting from the rapid urbanization together with industrialization, have led to contamination of air, water, land and the ecosystem of living organisms.

The influx of such contaminants, particularly the toxic materials and other pollutants, threatening survival of

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living organisms, predominantly human beings, is a pollutants, including the ones', introduced by the intensive use of materials, employed for the generation of energy needed for socioeconomic development of countries, has seriously affected the quality of life in the biosphere.

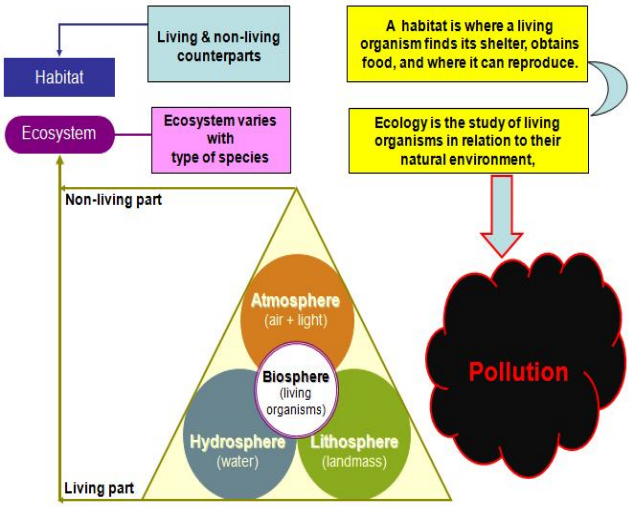

Fig. 2: Global Ecosystem

This paper will essentially address issues caused by the pollution of air and water in broad-spectrum and shed some light on guidelines for drinking water and disposal of industrial effluents. Finally, the situation of pollution related matters in the most populated two district of Sindh, namely Hyderabad and Karachi, as shown in Figure 3, will be addressed and remedial measures to circumvent the adverse situation affirmed.

Hyderabad and Karachi, and are the two most important cities of the province of Sindh (Figure 3). The urban and rural constituencies of these two cities constitute less than 5% of the total area of the Province. The two cities are inhabited by approximately 27 million people.

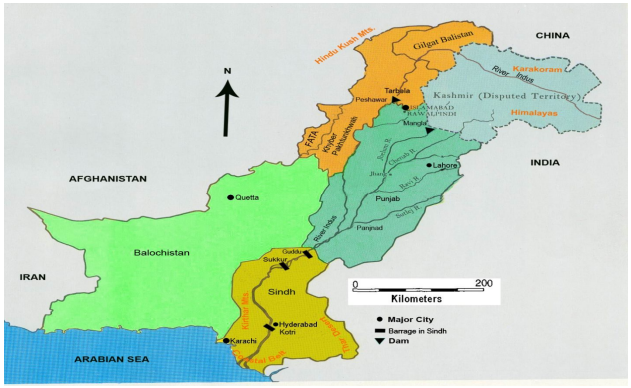

Fig. 3: Map of Pakistan, showing the route of River Indus and its main tributaries, contributing water to the Province of Sindh

matter of great concern. The cumulative effect of all these The main occupation of the rural population is generally agriculture, while the urban population is mainly involved in office work, service and industrial sectors.

The rural areas have generally clean air, mostly free of air pollutants, as well as the nuisance of noise. However, the lack of clean and hygienic water together with absence of hygienic conditions and poor sanitation, are a major problem in the rural surroundings. The urban areas, on the other hand are inflicted mostly with problems of air pollution, and generally untreated wastewater, as well as disposal of the untreated industrial effluents in the channels, carrying river water, or dispose it off directly in the Arabian Sea.

2. POLLUTION OF ENVIRONMENT

Air and water, besides others, are among the most significant pollutants affecting human beings. Environmental imbalance in these and noise, as well as other components often gives rise to a wide variety of health problems to human beings and other living organisms.

The earth's atmosphere consists of a mixture of various gases. By volume, it contains approximately 78% nitrogen, 21% oxygen, as well as argon and other inert gases to the extent of about 1.0%. Furthermore, carbon dioxide is another important constituent of the atmosphere, which varies in amount from 0.1% to 0.3%. The gaseous composition of clean dry air is given in Table 1.

TABLE 1: MAJOR CONSTITUENTS OF DRY AIR [17]

Gas	Volume Percentage
Nitrogen (N_2)	78.084%
Oxygen (O_2)	20.946%
Argon (Ar)	0.9340%
Carbon Dioxide (CO_2)	0.0397%
Neon (Ne)	0.001818%
Helium (He)	0.000524%
Methane (CH_4)	0.000179%
Not included in Major Constituents of dry air*	
* Water Vapor (H_2O)	Locally varies from 0.001% to 5.0%

Air pollution is a major environmental risk to health. It can be defined broadly as the introduction of chemicals, particulate matter, or biological materials into the atmosphere that cause harm or discomfort to humans or other living organisms, or cause damage to the natural environment or built environment. By reducing air pollution levels, countries can reduce the burden of disease from cardiovascular and respiratory diseases.

Air pollution can be classified into anthropogenic and non-anthropogenic origin. The latter includes natural events such as wildfires, volcanic activity and dust/sand storms [4]. These, as well as the anthropegenic pollutants including Carbon, Nitrogen, Sulphur, Lead and Ozone, as well as other containments, which may pose environmental hazards. The effect of Greenhouse gases, such as water vapor, carbon dioxide, methane, nitrous oxide. Ozone and Chloroflorocarbons, which greatly affect the temperature of the earth, are beyond the scope of this article.

Water pollution is the second most crucial environmental concern to human beings after air. It is estimated that over 96% of the water is saline. Of the total fresh water, fit for human consumption, more than 68% is locked up in glaciers and ice caps. Another 30% of freshwater is under the ground. Rivers are the source of surface water that people mostly use; but this constitutes only 0.0002% of the total water available in the hydrosphere. Table 2 and Figure 4 present, an estimate of global water distribution [10] [11].

TABLE 2: ESTIMATED GLOBAL WATER DISTRIBUTION [10]

Water source	Water volume in cubic miles	Water volume in cubic kilometers	Percent of freshwater	Percent of total water
Oceans, Seas & Bays	321,000,000	1,338,000,000	--	96.54
Ice caps, Glaciers, & Permanent Snow	5,773,000	24,064,000	68.7	1.74
Groundwater	5,614,000	23,400,000	--	1.69
Fresh	2,526,000	10,530,000	30.1	0.76
Saline	3,088,000	12,870,000	--	0.93
Soil Moisture	3,959	16,500	0.05	0.001
Ground Ice & Permafrost	71,970	300,000	0.86	0.022
Lakes	42,320	176,400	--	0.013
Fresh	21,830	91,000	0.26	0.007
Saline	20,490	85,400	--	0.006
Atmosphere	3,095	12,900	0.04	0.001
Swamp water	2,752	11,470	0.03	0.0008
Rivers	509	2,120	0.006	0.0002
Biological Water	269	1,120	0.003	0.0001

Water pollution is a grave problem in Sindh. Water is polluted from a wide variety of sources. It gets contaminated, when pollutants from different sources either come in contact with sources of water or are discharged into bodies of water. However, the effects of water contamination depend on the composition of effluent pollutants that get mixed up with water. This is particularly true for untreated industrial waste. The same is true for habitation situated close to urban centers.

The assimilation of garbage and other untreated hazardous chemicals, with sources of surface and groundwater, are a major health hazard in this regard. This reflects lack of hygienic control, which promotes the local inhabitants, as well as municipal authorities and manufacturing chemical industries to make use of the uncontrolled situation.

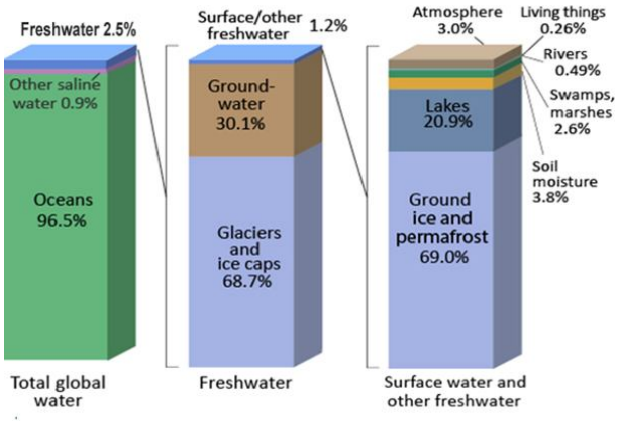

Fig. 4: Distribution of Earth's Water

There is a long list of hazardous chemicals, which generally pollute water, and are the main cause of environmental degradation. These, among others, include inorganic and organic, as well as microbial contaminants

and radio nuclides. The guidelines and specification together with environments guidelines including permissible limits, of these and other chemicals, will be outlined later on.

3. GUIDELINES FOR AIR POLLUTANTS

Air pollution often causes stroke, heart disease, lung cancer, and both chronic as well as acute respiratory diseases, including asthma. Guidelines for clean air are set by several international and domestic organizations for the benefits of public health and environment. The modified Clean Air Act requires [13] to set National Ambient Air Quality Standards for pollutants considered harmful to public health and the environment. For a lay person, one may refer to Air Quality Index [12] to make an assessment of the quality of air. This practice is nonexistent in Pakistan. Table 3, summarizes the type of air pollutants and the standards used in Pakistan [8].

TABLE 3: NATIONAL ENVIRONMENTAL QUALITY STANDARDS FOR AMBIENT AIR

Pollutants	Time-weighted average	Concentration in Ambient Air	
		Effective from 1st January 2009	Effective from 1st January 2012
Sulphur Dioxide (SO_2)	Annual Average*	80 µg/m³	80 µg/m³
	24 hours**	120 µg/m³	120 µg/m³
Oxides of Nitrogen as (NO)	Annual Average*	40 µg/m³	40 µg/m³
	24 hours **	40 µg/m³	40 µg/m³
Oxides of Nitrogen as (NO_2)	Annual Average*	40 µg/m³	40 µg/m³
	24 hours **	80 µg/m³	80 µg/m³
Ozone O_3	1 hour	180 µg/m³	130µg/m³
Suspended Particulate Matter (SPM)	Annual Average*	400 µg/m³	360 µg/m³
	24 hours**	550µg/m³	500µg/m³
Respirable Particulate Matter. PM_{10}	Annual Average*	200 µg/m³	120 µg/m³
	24 hours**	250 µg/m³	150 µg/m³
Respirable Particulate Matter. $PM_{2.5}$	Annual Average*	25 µg/m³	15 µg/m³
	24 hours**	40 µg/m³	35 µg/m³
	1 hour	25 µg/m³	15 µg/m³
Lead (Pb)	Annual Average*	1.5 µg/m³	1 µg/m³
	24 hours**	2 µg/m³	1.5 µg/m³
Carbon Monoxide (CO)	8 hours**	5 mg/m³	5 mg/m³
	1 hour	10 mg/m³	10 mg/m³
* Annual Arithmetic mean of minimum 104 measurements in a year taken twice a week 24 hourly at uniform interval.			
** 24 hourly /8 hourly values should be met 98% of the in a year. 2% of the time, it may exceed but not on two consecutive days.			

The "WHO Air Quality Guidelines" [15], also provide an assessment of health effects of air pollution and thresholds for health-harmful pollution levels. These Guidelines apply worldwide in all WHO regions; and are based on expert evaluation of current scientific evidence for the presence of Particulate matter (PM), Ozone (O_3), Sulfur Dioxide (SO_2), Nitrogen Dioxide (NO_2) as the indicator of larger group of nitrogen oxides. These guidelines include most of the pollutants listed by US EPA (2012) [13], but further troughs light on Nitrogen Oxide (NO_2), Chloroflorocarbons (CFCs), which affects the lower atmospheric zone leading to climate change, which among other things causes global warming. Furthermore, the presence of Ozone, in particular, at the upper atmospheric zone, is a blessing. It prevents the penetration of this zone by Ultraviolet radiation; and thus protects human beings from the incidence of cardiovascular and respiratory diseases. However, at the lower ground level, these constituents cause decrease in visibility, and difficulty in driving.

Commenting on climate change, Mu and Mu [16] reflect on the influence of mining of fossil fuels and other substances, which destroy the 'thermal insulating' layers inside the Earth's Crust. Any decrease in the thickness of these layers, eventually cause, the trapped heat inside the Earth, to escape at the earth's surface, leading to climate change, particularly in the regions, where such activities are intensely practiced. The climate change is, therefore, manifested by global warming gases, as well as the heat emanating from the surface of the earth.

Besides, quality of ambient air, the response of human ear to sound is also important. The noise has direct and specific effects on human health as described by Abbasi

et al [1]. WHO (1980) [14], recommendations of noise exposure, and guidelines for environmental quality standards are reproduced in Table 4. These guidelines are more specific about the environment, such as living areas, hospitals, industrial and commercial, as well as traffic congested areas, public address and music related activities.

The time of exposure and the duration of the specified level of sound, as well as the environment of work, are also significant in critical health effects Khan, et al [6].

The WHO Guidelines are more specific than Pakistan National Environmental Quality Standards, for Noise. The latter classifies the areas into residential, commercial, industrial and silent zones; but does not consider the time duration, as well as the critical health effects thereof. However in both the cases, the noise levels at day time does not exceed 65 accept in industrial and commercial areas where the maximum allowable limit varies between 65 and 75 dB. However, the acceptable limit for residential areas is 50 dB; but the allowable level for schools is 35 dB.

TABLE 4: WHO GUIDELINES FOR NOISE QUALITY STANDARDS

Specific Environment	Critical Health Effects		Allowable Noise Level (dB)	Time Duration (Hrs)
Outdoor living area	Serious Annoyance Day time		50	16
Indoor, Inside bed room	Moderate Annoyance	Day Time	35	16
		Night Time	30	08
Outside bed room	Sleep disturbance, windows open		45	08
Class room	Disturbance of information, message communication		35	During class
Hospital ward room	Sleep disturbance	Day Time	30	08
		Night Time	30	16
Industrial, commercial, shopping and traffic area	Hearing impairment		70	24
Public address	Hearing impairment		85	01
Music through head phone	Hearing impairment		85	01

4. GUIDELINES FOR DRINKING WATER & WASTEWATER POLLUTANTS

Water is important for the survival of all living organisms. There is a considerable variation in the amount of water in healthy human body; and it is generally agreed that 75% of the human body weight is composed of water. Besides being essential for survival, water is used for a variety of other purposes. This among others includes industrial, agricultural, municipal, as well as household purposes. Water quality standards for each purpose vary according to the purpose for which the water is put into use. The availability of drinking water cannot be over emphasized. But in many instances, the drinking water may contain a number of undesirable constituents. Therefore, most people in the developed countries of the world consume hygienically certified bottled water.

The presence of pollutants in drinking water is classified as Physical, Chemical, Organic and Bacterial, as well as Radio Nuclides (Table 5). The Physical Pollutants include color, odor, taste and turbidity in the form of suspended particles. There is a long list of Chemical Pollutants. It consists of pH, Alkalinity, Total Dissolved Salts, Ammonia, Arsenic, Barium, Boron, Cadmium, Chloride, Chromium, Copper, Iron, Lead, Manganese, Phosphorous, Selenium, Zinc, Nitrate & Nitrites, and Sulfate & Sulfide. The Organics include Pesticides and Phenolic compounds. Bacterial contaminants contain all forms of Coilform bacteria. The Radioactive materials essentially include Alpha Emitters.

The wastewater of untreated or partially treated wastes includes municipal, industrial and agricultural wastes. It includes several physical, inorganic, organic, biological and hazardous contaminants. Metcalf and Eddy [7] present a list of typical concentrations of Organics in untreated domestic wastewater. The list, as shown in Table 6, includes BOD, COD, TOC, O&G. The latter includes Oil & grease, which are insoluble in water. They and their byproducts, include a wide variety of contaminants. They can reduce aquatic organisms' ability to reproduce and survive. Dumped oil or oil spills, through breakup or overturning of oil tankers, in the sea, are an example of the turmoil that such a spill can create. Although a majority of oil spills occur occasionally, but they receive considerable attention on account of the obvious environmental damage. This is manifested by the

dead as well as oiled seabirds and marine mammals, together with acute impacts that such episodes leave particularly at the aesthetic and hygienic sense of the community living on the sea side. There are several industries that discharge specific oil and grease related and other hazardous effluents, the description of which is beyond the scope of this paper.

TABLE 5: NATIONAL STANDARDS FOR DRINKING WATER QUALITY

A. Physical

Properties / Parameters	Standards Values	Properties / Parameters	Standard Values
Colour	≤ 15 TCU	Total hardness as	< 500 mg/L
Taste	Non Objectionable/Acceptable	$CaCO_3$	
Odour	Non Objectionable/Acceptable	TDS	< 1000
Turbidity	< 5. NTU	pH	6.5 – 8.5

B. Chemical Parameters

• **Inorganic**	**mg/Litre**	**Inorganic**	**mg/Litre**
Aluminium (Al) mg/L	≤ 0.2	Cadmium (Cd)	0.01
Antimony (Sb)	≤ 0.005 (P)	Chloride (Cl)	< 250
Arsenic (As)	≤ 0.05 (P)	Chromium (Cr)	≤ 0.05
Barium (Ba)	0.7	Copper (Cu)	2
Boron (B)	0.3	Nitrate (NO_3)*	≤ 3 (P)
Cyanide (CN)	≤ 0.05	Nitrate (NO_2)*	≤ 3 (P)
Fluoride (F)*	≤ 1.5	Selenium (Se)	0.01 (P)
Lead (Pb)	≤ 0.05	Residual chlorine	0.2-0.5 at consumer end 0.5-1.5 at source
Manganese (Mn)	≤ 0.5	Zinc (Zn)	5.0
Mercury (Hg)	≤ 0.001		
Nickel (Ni)	≤ 0.02		

• **Organic**	**mg/Litre**	**Organic**	**mg/Litre**
•			
Pesticides mg/L	Not found	Polynuclear aromatic hydrocarbons (as PAH g/l	Not found
Phenolic compounds (as Phenols) mg/L	Not found		

• **Radioactive**	**mg/Litre**	**Radioactive**	**mg/Litre**
Alpha Emitters bq/l or pCi	0.1	Beta emitters	1

C. Bacterial

Properties / Parameters	Standards Values	Properties / Parameters	Standard Values
All water intended for drinking (e.Coli or Thermotolerant Coliform bacteria)	Must not be detectable in any 100 ml sample	Treated water in the distribution system (E. coli or Thermotolerant Coliform and total Coliform bacteria)	Must not be detectable in any 100 ml sample

TABLE 6: TYPICAL ORGANICS IN DOMESTIC WASTEWATERS

Constituents	Unit	Typical Concentrations		
		Low	Medium	High
BOD (biochemical oxygen demand	mg/L	110	190	350
COD (chemical oxygen demand)	mg/L	250	430	800
TOC (total organic carbon)	mg/L	80	140	260
O&G (oil and grease)	mg/L	50	90	100

Since, wastewater may contain various potentially hazardous components, the municipal authorities must be observant of the collection and disposal of wastewater. Table 7, presents an alphabetically sorted list of these pollutants, together with, the proposed standards set by the National Environmental Quality Standards of Pakistan, as quoted by Ahmed [2] and Ejaz et al [3]. The latter give an assessment of effluent streams discharging into River Ravi in Lahore, Pakistan.

TABLE 7: LIST OF PROPOSED STANDARDS FOR WASTEWATER

Parameters	Proposed Standards
Ammonia (mg/L)	40
BOD Days (mg/L)	80
COD (mg/L)	150
Chloride as Cl (mg/L)	1000
Cadmium (mg/L)	0.1
Chromium (Trivalent & Hexavalent) (mg/L)	1.0
Copper (mg/L)	1.0
Chlorine (mg/L)	1.0
Detergents (mg/L) Modified Benzene Alkyl Sulphae MBAS	10.0
Fluoride as F (mg/L)	10.0
Iron (mg/L)	2.0
Lead (mg/L)	0.5
Manganese (mg/L)	1.5
Mercury (mg/L)	0.01
Nickel (mg/L)	1.0
Oil and Grease (mg/L)	10
Phenolic Compounds as Phenol (mg/L)	0.1
pH value	6.0-10.0
Suspended Solids (mg/L)	150
Sulphates (mg/L)	600
Sulphide (mg/L)	1.0
Temperature ^{0}C	40
Total Dissolve Solids (mg/L)	3500
Zinc (mg/L)	5.0

The River receives heavy loads of untreated domestic and industrial effluents; and is, therefore, acting as a wastewater carrier. Its waters are used for irrigation and livestock and other purposes. This is in contravention of the mandatory National Standards of Wastewater shown in Table 7. The same standards are also applicable to wastewater and industrial effluents discharged in Hyderabad and Karachi.

5. RESULTS & DISCUSSION

The areas around these two cities are affected by several air and water, as well as noise related environmental problems. River Indus is the main source of drinking, agricultural and industrial consumptions. It has three barrages, namely Guddu, Sukkur and Kotri in the Province of Sindh [5]. These barrages have several canals and water courses through which the water is diverted to various regions of Sindh including Hyderabad and

Karachi. The River Indus ultimately drains into the Arabian Sea, adjoining Karachi, which is the hub of industries of various kinds.

Hyderabad draws its waters from canals emerging from the Kotri barrage. However, the rural pollution, depends essentially on dug well or watercourses for drinking and domestic purposes. Similarly, the main source of water supply to Karachi is also a canal from the Kotri barrage. This canal, Known as the Kalri Baghar, feeds the famous Kenjhar Lake, which acts as a reservoir of water for Karachi.

Air & Water Pollution in Hyderabad: Most of the people **of** Hyderabad live and work in the rural areas of Sindh. For livelihood, they depend on agriculture, which is the backbone of the economy of Pakistan. River Indus, apart from scanty rain fall, is the main sources of their survival. The air in the rural areas is essentially clean and satisfies all environmental guidelines.

There is a shortage of surface water in general, and the groundwater is essentially saline, except in the neighborhood of river, and the water distributor channels spread over the area. However, the conditions of air and water in the urban areas of Hyderabad are a matter of great concern. Table 8 shows air quality data, in selected, urban areas of Hyderabad.

TABLE 8: AIR QUALITY DATA OF HYDERABAD, 2013

Site	Time	CO	CO_2	Oxides of Nitrogen			SO_2	O_3	$PM_{2.5}$	PM_{10}	Noise
				NO	NO_2	NO_x					
		(ppm)	(ppm)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ug/m^3)	(ug/m^3)	(dB)
Tilk Chari	Average	3.63	355.50	29.17	6.08	35.25	34.21	27.42	*44.54	*120.42	*70.29
	Max	4.8	372	35	11	42	38	36	*49	*128	82
	Min	2.5	329	24	0	31	30	22	*40	108	58
SITE Area	Average	1.98	294.54	18.17	5.50	23.67	18.08	15.25	*37.83	110.92	63.33
	Max	2.3	302	28	9	35	22	28	*44	*129	77
	Min	1.5	287	14	2	20	14	2	*30	95	52
Shahbaz Building	Average	2.20	294.21	22.96	5.50	28.46	17.92	15.38	*31.50	83.42	49.96
	Max	2.5	302	28	9	33	22	31	*38	89	55
	Min	1.8	287	17	3	21	14	1	*28	78	45

Comparing air quality of Hyderabad, as shown in Table 6, with the National Environmental Quality Standards for Ambient Air (Ministry of Environment, Government of Pakistan, 2010), it is noted that all except the presence of particulate matter are satisfied at all the three locations. The $PM_{2.5}$ values at Tilk Chari and Shahbaz Building are above the permissible levels. They major reason for the presence of this pollutant, is the gases emitted from heavy traffic of automobiles, consuming fossil fuels in the area. Similarly the MP_{10}, values at Shahbaz Building are also in excess of the acceptable levels. The traffic noise, particularly in the urban areas, is yet another matter of grave concern, particularly in the residential and office areas of Tilk Chari and Shahbaz Building. The highest noise level is at Tilk Chari, which is most congested residential and commercial area. However the limit of noise level at Shahbaz Building is very close to the upper limit, and needs to be reduced to an acceptable limit. Surprisingly, the level of noise at the Site Industrial area is acceptable.

The results of the chemical analysis of drinking and tap water, in the eight selected urban areas of Hyderabad, are presented in Table 9. This table clearly indicates that in most of the area, the values of chemical constituents, like Arsenic, Barium, Chromium, Copper, Lead, Manganese, Mercury, Nickel, Selenium and Zinc are above the acceptable level. Similarly, the values of Nitrates and Fecal Coliforms are also not permissible. Furthermore, all the constituents, which do not satisfy the Waste Water Standards displayed in Table 9, are marked by an asterisk.

TABLE 9: DRINKING / TAP WATER TESTING DATA, HYDERABAD

	Site / Quality	Liaquat Colony	Memon Hospital	Tilk Chari, St .Mary's High School	Hali Road Opp. Police Station Site	Nazeer Hussain Hospital	Shah Gi Hotel Jail Road	Govt. Elementary College	Kali Mori
Physical Parameters	Taste	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok
	Odour	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok
	Turbidity (NTU)	*6.19	*11.6	0.95	*12	0.43	*14.5	3.39	*20.7
	TDS (mg/L)	462	472	489	467	495	480	590	*7280
	Conductivity (µS/cm)	764	787	815	778	825	799	903	*12140
	pH	8.15	8.11	8.03	8.04	7.7	7.82	8.36	*8.73
	Hardness (mg/L)	195	200	197	190	200	194	210	1778
Fecal CFU/100 ml	E.Coli	*4	*2	*5	*2	*4	*2	*5	*20
	Fecal Coliform	*10	*25	*10	*15	*35	*45	*54	*95
	Total Cliform	*14	*27	*15	*17	*39	*47	*59	*115
Misc. Mg/L (ppm)	Flouride	0.43	0.65	0.41	0.25	0.50	0.50	0.58	0.83
	Chloride	126.10	101.50	113.83	108.13	127.50	124.85	98.48	*6005.13
	Nitrate	*10.53	*4.03	*6.90	*5.13	*5.50	*4.90	*4.50	*151.35
	Sulphate	119.40	133.35	103.28	129.03	133.48	136.15	125.93	850.23
Chemical Constituents µg/l (ppb)	Arsenic (AS)	*16.50	*15.34	*16.34	*13.89	*15.63	*17.29	*16.92	*35.96
	Barium (Ba)	*122.23	*137.74	*108.37	*114.88	*149.29	*119.45	*128.05	*87.64
	Cadmium (Cd)	ND	ND	ND	0.14	ND	ND	ND	0.51
	Chromium (Cr)	ND	*8.07	ND	ND	ND	ND	ND	*8.84
	Copper (Cu)	*13.94	*12.85	*14.38	*47.77	*16.01	*3.29	*19.87	*39.34
	Iron (Fe)	8.32	19.03	13.42	8.81	9.67	10.96	7.92	22.53
	Lead (Pb)	*0.11	*1.61	*0.07	*187.56	*0.78	*0.24	*2.49	*0.57
	Manganese (Mn)	*30.35	*92.79	*49.65	*37.48	*36.14	*50.63	*28.78	*64.11
	Mercury (Hg)	*0.04	*0.16	*0.03	*0.81	*0.04	*0.05	*0.08	*0.11
	Nickel (Nil)	*3.86	*11.92	*5.63	*12.52	*4.83	*5.87	*19.58	*47.17
	Selenium (Se)	*7.27	*8.21	*10.38	*8.37	*8.94	*8.48	*7.41	*55.78
	Silver (Ag)	0.00	0.08	0.01	1.01	0.00	ND	0.03	0.60
	Zinc (Zn)	*8.77	*7.40	*8.79	*21.70	*10.34	*1.94	*2.08	*1.19

Similarly, Table 10 shows, the analysis of Wastewater, generally disposed of in the city. The values of most of the metal ions, such as Chromium, Nickel, Iron, Manganese, Lead and the Zinc are higher than the recommended concentrations specified by the National Environmental Quality Standards of Pakistan. The values of TSS, COD and BOD are also very high. All these constituents are identified by an asterisk in the table.

TABLE 10: WASTE WATER DATA OF SELECTED SITES IN HYDERABAD 2013

Site / Quality	Veterinary Hospital, Hyderabad	Sray Ghat,, Hyderabad
pH	8.22	8.14
TSS	*421	*270
TDS (mg/L)	1127	856
BOD	*292	*153
COD	*540	*260
Nitrate (NO_3^-) mg/L (ppm)	16	8
Sulphate (SO_4^{2-}) mg/L) (ppm)	254	193
Sulphide (S^{2-})	0.57	0.42
NH3	27	14
Oil/Grease	8	3
Chlorine	0.41	*0.62
Phenolic compounds (as Phenols)	0.07	0.01
Chloride	724	496
Fluoride	3.2	4.6
Silver (Ag) µg/l (ppb)	0.93	1.24
Copper (Cu) µg/l (ppb)	*254.5	*107.21
Nickel (Ni) µg/l (ppb)	*73.54	*21.79
Zinc (Zn) µg/l (ppb)	*35.62	*115.47
Iron (Fe) µg/l (ppb)	*42.58	*11.27
Manganese (Mn) µg/l (ppb)	*375.20	*112.16
Cobalt (Co) µg/l (ppb)	25.81	9.46
Barium (Ba) µg/l (ppb)	423.50	93.16
Chromium (Cr) µg/l (ppb)	*27.07	*42.33
Arsenic (As) µg/l (ppb)	12.01	2.37
Selenium (Se) µg/l (ppb)	82.14	ND
Cadmium (Cd) µg/l (ppb)	ND	*2.39
Mercury (Hg) µg/l (ppb)	*0.37	*0.62
Lead (pb) µg/l (ppb)	*77.68	*25.90

Air & Water Pollution in Karachi: Karachi is the port city of Pakistan. It faces the Arabian Sea in the southwest. It the capital of the Province of Sindh; and in terms of population, Karachi is the largest city of Pakistan; and is also the hub of socioeconomic activity, and industrial outfits. The air and drinking water, as well as the waste water together with industrial effluents are highly polluted. Table 11 depicts the Air Quality of Karachi.

TABLE 11: AIR QUALITY DATA OF KARACHI

Site	Time	CO (ppm)	CO_2 (ppm)	Oxides of Nitrogen			SO_2 (ppb)	Ozone (ppb)	PM_{10} ($\mu g/m^{-3}$)	$PM_{2.5}$ ($\mu g/m3$)	Noise (dB)
				NO (ppb)	NO_2 (ppb)	NO_x (ppb)					
Clifton	Mean	2.97	342.85	44.31	12.86	57.16	16.90	9.18	64.06	*26.72	56.56
	Max	4.66	395	89	18	103	25	30	78	*32	66
	Min	1.76	312	25	10	37	10	1	50	*20	50
II Chundrigar	Mean	3.50	309.47	20.27	9.86	30.12	24.74	15.43	81.93	*33.41	*68.64
	Max	5.2	338	43	16	50	39	30	101	*44	89
	Min	2.1	38	-1	5	12	8	6	65	*25	54
Garden Police HQ	Mean	3.50	338.61	38.85	10.24	49.08	26.82	20.93	97.86	*35.79	*69.08
	Max	4.6	375	48	19	63	32	38	128	*50	79
	Min	2	315	29	5	34	16	5	61	*26	55
SUPARCO	Mean	2.95	286.98	23.12	32.97	56.09	32.85	35.46	94.34	*30.74	58.89
	Max	35	378	35.3	52.8	73.7	51	60	118	*46	72
	Min	1.7	51	17.4	8.7	32.1	23	25	9	*22	50
Korangi	Mean	3.20	446.22	44.31	12.86	57.16	22.11	29.22	82.12	*25.28	68.18
	Max	4.3	521	89	18	103	37	39	*152	*36	80
	Min	2.3	398	25	10	37	10	20	52	*16	52
SITE Area	Mean	3.06	429.98	45.66	10.00	55.66	25.21	29.93	119.22	*57.53	67.30
	Max	4.3	524	85	16	95	46	236	*167	*130	78
	Min	2	325	31	5	37	8	3	75	*20	52
Nazimabad	Mean	3.30	344.43	80.41	14.04	94.45	24.57	13.28	94.33	*62.08	*68.46
	Max	4.1	395	203	19	220	41	33	*130	*130	81
	Min	2.8	308	20	7	31	12	0.8	62	*25	55
Civic Centre	Mean	3.11	348.23	21.91	14.42	36.33	15.69	61.24	4.39	*90.95	35.94
	Max	4.4	420	27	26	46	19	76	25.7	*127	55
	Min	2.3	325	19	10	30	12	50	0.4	*70	20
Baloch Colony	Mean	3.92	457.73	22.66	40.22	62.88	35.16	14.37	99.98	*43.94	*80.41
	Max	6.2	507	34.6	64.4	84.9	41.9	36	*123	*67	149
	Min	2.3	426	17.1	10.6	33.5	21	1	79	*24	51
Karimabad	Mean	3.86	334.37	42.49	11.45	53.82	19.92	14.64	117.40	*69.02	*66.52
	Max	5.2	398	85	16	98	30	29	*154	*156	79
	Min	2.5	312	24	6	36	12	6	73	*24	53

In comparison to Air Quality Standards specified in Table 3, it is observed that in all the sites of Karachi the $dB_{2.5}$ values related to respirable particulate matter are above the specified acceptable limits. However, the respirable MP_{10} particulate matter is high in Korangi, Site area, Nazimabad, Baloch colony and Karimabad. This and other studies [6] clearly indicates that Karachi has a serious problem of excessive amounts of traffic emitting smoke through vehicular and industrial sources. Furthermore the sources of traffic noise in Karachi are also damaging to ears, particularly in areas, such as Chundrigar Road, Garden Police HQ, Nazimabad, Baloch colony and Karimabad

Table 12, presents a summary of the drinking and tape water supplied to the residents of Karachi. There are altogether 9 locations, well spread over Karachi, from which the samples were selected.

TABLE 12: DRINKING / TAP WATER TESTING DATA, KARACHI

Quality \ Site		Civic Center	Jaccob Lines	Sector-33 Korangi	Saudabad, Malir	Rashedabad	North Nazimabad	Kemari	Bin Qasim	Orangi Town
Physical Parameters	Taste	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok
	Odour	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok
	Turbidity (NTU)	0.62	0.44	0.89	1.09	1.39	2.3	2.1	0.92	1.49
	TDS (mg/L)	542	*1112	565	802	412	556	515	734	840
	Conductivity (µS/cm)	902	*1852	942	1335	689	927	856	1267	1350
	pH	8.02	7.36	7.65	7.32	7.24	8.25	7.68	7.8	7.8
	Hardness (mg/L)	210	350	201	411	206	208	262	190	280
Fecal CFU/100 ml	E.Coli	*3	*5	*8	0	*3	*5	*3	*4	*12
	Fecal Coliform	*22	*35	*65	*35	*32	*10	*12	*15	*35
	Total Cliform	*25	*40	*73	*35	*35	*15	*15	*19	*47
Misc. Mg/L (ppm)	Flouride	0.7	*1.85	0.6	0.42	0.58	0.53	0.42	0.48	0.35
	Chloride	*305.5	*588.1	*360.6	*424.5	*256.9	*340.4	206.73	142.65	*250.36
	Nitrate	2.57	*125.25	2.65	*85.53	*20.17	*4.87	*9.03	1.70	2.47
	Sulphate	256.65	396.4	267.08	332.78	335.73	245.68	149.28	197.38	65.47
Chemicals Constituents µg/l (ppb)	Arsenic (AS)	ND	ND	ND	ND	ND	ND	*13.77	*13.06	ND
	Barium (Ba)	*51.28	*31.36	*46.38	*50.45	*59.12	*36.74	*156.28	*195.53	*60.24
	Cadmium (Cd)	*0.74	*0.16	*0.00	ND	ND	ND	ND	*0.11	*1.11
	Chromium (Cr)	*37.69	ND	ND	ND	ND	ND	ND	ND	ND
	Copper (Cu)	*239.61	*291.16	*31.02	*158.58	*13.12	*14.55	*115.13	*83.61	*80.23
	Iron Fe)	38.33	11.18	3.98	3.28	1.31	0.59	11.13	8.43	5.27
	Lead (Pb)	*4.07	*0.23	*0.22	ND	ND	ND	ND	*1.21	*0.83
	Manganese (Mn)	ND	*32.50	*86.90	*183.01	*152.69	*159.76	*32.60	*28.79	*89.68
	Mercury(Hg)	*0.44	*2.11	*0.55	*0.07	*0.19	ND	*0.10	*0.18	*0.12
	Nickel (Ni)	*33.28	*6.30	*2.03	*92.56	*6.54	ND	*7.49	*22.71	*11.99
	Selenium (Se)	*8.78	*14.03	*6.52	*10.81	*7.34	*5.10	*10.18	*6.02	*0.89
	Silver (Ag)	ND	0.02	ND	ND	0.78	ND	ND	0.09	0.07
	Zinc (Zn)	*1074.1	*197.58	*21.40	*44.37	*5.20	*10.88	*71.93	*39.10	*16.22

The presence of Ecoliforms and Arsenic in drinking water supplies are a matter great hygienic concern. The same is true for excessive concentrations of metallic elements. All these are marked b an asterisk in the table.

Similar situation is depicted by the analysis of wastewater. The results of the analysis are shown in Table 13. The amounts of BOD, COD, and TSS are exceedingly high. Similarly, the concentrations of metallic elements of Copper, Chromium, Nickel, Manganese, Mercury, Nickel, Cadmium, Lead, and Zinc are also above the acceptable limits. Mostly, the wastewater is discharged directly into the sea. However, some of the effluents are partly treated, while the others are untreated, and eventually find their way to coastal waters. This causes coastal pollution, and degradation of the natural ecosystem of the area.

TABLE 13: WASTEWATER ANALYSIS OF KARACHI

Site / Quality	Essa Nagri	Rashedabad	Quaidabad, Bin Qasim Town	Kalaboard, Malir Town	Muzafrabad Colony Landhi Town	Drig Road Shahfaisal Town	Power House Chorangi, New Karachi	Shadman Town, North Nazmabad	Golimar, SITE	Ayesha Manzil, Gulberg Town	Zaman Town, Korangi	Maripor, Kemari Town	Akhtar Colony, Jamshed Town	Islam Chock, Orangi Town
pH	6.14	8.75	8.42	6.73	8.19	8.36	8.2	7.83	7.95	8.9	6.5	8.53	7.76	8.09
TSS	321	*452	*167	805	245	*521	*193	56	*264	42	89	*158	*203	140
TDS	590	832	478	1284	932	1393	750	802	1077	605	911	620	480	691
BOD	*215	*432	*248	*877	*389	*663	*397	*184	*309	*113	*175	*356	*278	*320
COD	*740	*1570	*670	*3300	*1100	*2250	*1420	*670	*1230	*260	*440	*760	*940	*830
Nitrate (NO_3^-)	4.6	3.2	8.4	53.7	11.9	25.6	0.9	5.7	14.2	1.6	2.4	9.8	21.5	17.3
Sulphate (SO_4^{2-})	217	396	420	*742	187	337	402	156	267	95	59	167	356	240
Sulphide (S^{2-})	0.81	0.72	0.5	*1.23	*1	0.94	0.65	0.27	0.11	0.13	0.72	0.87	0.7	0.43
NH3	9	11	17	37	*40	25	24	3	6	7	11	15	8	21
Oil/Greace	7	5.4	2.1	*14.2	3.7	*11	6.4	1.7	3	2.9	5.3	1.1	1.8	3.7
Chlorine	0.53	0.16	0.2	0.94	0.71	0.17	0.19	0.19	0.45	0.73	0.17	0.1	0.1	0.24
Phenolic compounds as Phenols	*0.08	*0.13	*0.04	*0.27	*0.1	0.05	0.04	0.07	0.09	0.09	0.08	*0.12	0.07	0.01
Chloride	659	720	503	*2770	*1240	*1510	320	456	720	291	360	624	398	510
Fluoride	1.7	2.4	1.3	5.7	2.1	5.6	0.9	0.83	3.7	1.9	1.2	2.4	1.6	0.4
Silver (Ag)	0.05	2.29	1.07	0.80	0.92	0.02	ND	0.87	0.03	0.35	0.13	0.16	ND	ND
Copper (Cu)	*168	*224	*2656	*2786	*2638	*256	*34.9	*40.3	*105	*105	*41.	*60.	*66.8	*63.
Nickel (Ni)	*9.9	*63.	*288.	*352.0	*372.5	*58.7	*11.4	*8.55	*50.	*30.	*20.	*21.4	*11.9	*11.
Zinc (Zn)	*103	*109	*1634	*1634	*1747.	*173.	*170.	*24.5	*60.	*51.	*86.	*27.2	*37.5	*34.
Iron (Fe)	*22	*174	*72.93	*205.1	*86.24	*50.1	*22.3	*21.2	*47.4	*39.6	*19.5	*20.1	*10.5	*6.5
Manganes (Mn)	*365	*360	*791.0	*2751.	*447.3	*149	*447.	*352.	*582	*603	*283	*298	*106.	*77.0
Cobalt (Co)	8.61	9.55	49.05	49.92	54.42	6.84	1.87	1.86	8.57	4.31	3.76	3.95	2.33	1.06
Barium (Ba)	78.7	294.	1653.	156.7	172.6	99.25	1828	107.	2947	106.	9069	68.6	61.6	51.9
Chromium (Cr)	*133	*834	*2954	*3135	*3338	*2629	*100.	*58.1	*124.	*127.	*102.	*100.	*53.	*37.8
Arsenic (As)	ND	0.59	8.61	8.11	10.19	ND	ND	ND	ND	ND	1.35	1.91	ND	ND
Selenium (Se)	316.	971.	751.1	589.4	615.5	289.4	842.	1054	674.	540.	922.	891.	596.	404.
Cadmium (Cd)	*5.0	*1.6	*5.74	*8.18	*10.6	*6.58	*6.46	*9.9	*7.9	*1.8	*2.8	*3.2	*5.25	*2.7
Mercury (Hg)	*2.2	*2.62	*4.28	*4.41	*4.61.	*1.57	*1.48	*7.38	*1.08	*1.9	*1.4	*1.4	*0.35	*1.75
Lead (Pb)	*124	*66.0	*189.8	*224.0	*226.2	*28.2	*15.3	*9.08	*20.7	*34.	*14.	*10.	*8.49	*36.3

The above analysis reveals that there is a mix up of municipal and industrial wastewaters in the sewerage system of Karachi. The high concentration of metallic elements signifies closeness to metal extraction industries, as well as processing of the famous leather tanneries in Karachi.

6. CONCLUSIONS & RECOMMENDATIONS

This paper, which is essentially based on the secondary data collected from reliable and authentic sources of information, scattered in files of relevant organizations; and draws conclusions on the quality of environmental pollution in the light of National and World Standards.

All kinds of pollution, witnessed in Sindh, are also common in many parts of Pakistan [9]. Suggestions for remedies for this nuisance are well spread in the international literature. For Hyderabad and Karachi, which are polluted to various degrees of deleterious elements, are of particular interest in both the places, it is pertinent to keep the air clean, devoid of excessive amounts of respirable particulate matter, and other harmful pollutants. Reducing annual average particulate matter (PM_{10}) concentrations from levels of 70 $\mu g/m^3$, to the WHO guideline level of 20 $\mu g/m^3$, could reduce air pollution-related deaths by around 15%. Furthermore, this would also reduce emissions of CO_2, the greenhouse gas, which traps the heat; and is the chief cause of climate change. It may be noted that the main source of this gas is manifested by coal power generating plants, which are the biggest source of greenhouse gas emissions.

Limitation of particulate matter and the control of green house gases will also make progress for development

goals related to sustainable development in cities and the energy sector. In this regard, WHO has projected reduction in air pollution indicators as markers of development; and further suggests on sharing information on successful approaches, on methods of exposure assessment and monitoring of health impacts of pollution. The same needs adherence in all parts of Pakistan.

Attention should, also be focused on the nuisance of harmful noise in some areas. The effect of noise varies according to working environment, in a particular area. However, some people or more sensitive than others. Normal conversation is about 55 dB. In general sounds above 85 are harmful. The severity depends on how long and how often one is exposed to them. In commercial and industrial area, the noise level ought to be restricted between 65 and 75 dB; and these limits must not be exceeded.

The drinking water ought to be hygienically safe. It should be free from Ecoliform bacteria, excessive amounts of Nitrates, Chlorides, Arsenic, Barium, Cadmium, Chromium, Copper, Lead, Manganese, Mercury Nickel, Selenium, Zinc and so forth.

The wastewater including industrial waste should be treated, and the deleterious substances be removed before disposing off the effluent. The municipal wastewater, after treatment can be used for gardening, tree plantation or agriculture. However, under no circumstances, the industrials effluents should be directly disposed of into the sea.

It is recommended that in order to circumvent some of the environmental concerns, efforts must be made to legislate and implement regulations in this context. However, in adverse conditions, the latest National Standards of Pakistan Environmental Protection Agency should be followed. But, in the absence of specific standards in this regard, the guidelines of World Health Organization, and/or United States Environmental Protection Agency should be consulted for further guidance.

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PERFORMANCE EVALUATION OF WIRELESS SENSOR NETWORK IN PRESENCE OF GRAYHOLE ATTACK

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ABSTRACT

The tremendous growth in wireless communication and digital electronics has led to the development of low-cost and low-power sensor nodes that are small in size and may communicate over short distances. Sensor nodes are deployed in hostile environment in large number, which makes their physical protection against tampering difficult or more prone to be compromised by an adversary force. By doing that, an adversary can modify the behavior of the compromised nodes and launch routing misbehavior attacks. One most common type of such attacks is grayhole attack. Adhoc On Demand Distance Vector (AODV) in its pure form does not have any mechanism to deal with such type of attack. In this paper, we simulate grayhole attack on AODV routing protocol and evaluate AODV's performance by considering different metrics and scenarios. NS2 simulator has been used to conduct simulation of grayhole attack. Our simulation results show the influence of grayhole attack on the performance of AODV which suffers from decreased delivery ratio and increased packet loss. Furthermore, some countermeasures against grayhole attack are also provided.

Keywords: Wireless sensor networks; grayhole attack; security; node misbehavior; blackhole attack; AODV

1. INTRODUCTION

Sensor networks are the type of wireless network that consist of large number of tiny sensor nodes and base stations having sensing, data processing and communicating capabilities. The sensing unit collects data about some physical phenomena such as light, sound, vibration, humidity, temperature and heat [1]. WSN may have useful applications for both civilian and military. Civilian applications of sensor networks include building automation, smart environments, monitoring the status of structures (such as bridges), robot control and guidance in automatic manufacturing environments, factory process control and automation, vehicle tracking and detection, monitoring disaster area, increasing the effectiveness of agricultural processes and water management, environmental monitoring, and health monitoring (to name a few). In the military applications, WSN can be used for surveillance, battle field monitoring, monitoring equipment and ammunition, battle damage assessment, targeting, and reconnaissance [2].

Security is a major challenging issue in wireless sensor networks applications because they are operated in public and unrestrained areas. The foremost goal of providing security is to protect the network resources against a number of attacks such as DoS attack, wormhole attack, blackhole attack, grayhole attack, routing table overflow attack, packet replication attack, and modification of packets attack [3–6]. This unattended nature of WSN makes sensor nodes vulnerable to various types of attacks such as node physical capture, selfish and malicious behavior of nodes. In this study, we address a common type of node misbehavior caused by grayhole attack. The node misbehavior caused by grayhole attack is similar to blackhole attack to some extent. However, in contrast to blackhole attack, a node under grayhole attack drops packets selectively rather than dropping all the received packets [7]. The node misbehavior issues such as blackhole and grayhole [8] are popular security threats in WSN and many researchers have proposed solutions to counter these attacks. Nevertheless, no generic and unconstrained solution exists to prevent such attacks completely [9].

In this paper, our methodology is to discuss how grayhole nodes makes use of AODV routing process and yield attack in routing packets. The performance of sensor network in the presence of several grayhole nodes is also compared. Most of the existing literature on performance evaluation of grayhole attack does not addresses the impact of an attack on a node's energy, as it is important design parameter for energy constraints

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network, specially WSN. Furthermore, some counter-measures against grayhole attack are also provided. The rest of the paper is organized as follows. Section 2 briefly provides the overview of AODV routing protocol and discusses the related work in this domain. Section 3 explains the grayhole attack mechanism and the algorithm for launching a grayhole attack. Section 4 gives the simulation model of grayhole attack. Section 5 presents the simulation results of grayhole attack with our analysis. Section 6 provides countermeasure mechanisms against grayhole attack. Section 7 concludes the paper with some potential future work.

2. AODV PROTOCOL AND THE RELATED WORK

Adhoc On Demand Distance Vector (AODV) [10] is an on-demand routing protocol that creates routes between a source and a destination on the fly (upon request by source node). AODV provides fresh enough routes and is more scalable. Two important control packets, Route Request (RREQ) and Route Reply (RREP), are used to discover a route. The process of discovering a route is shown in Figure 1.

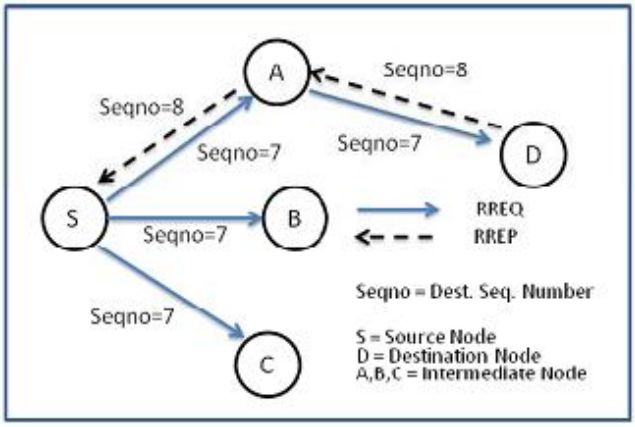

Fig. 1: AODV route discovery mechanism

RREQ and RREP contain some important attributes such as destination sequence number and hop count, which help in determining the freshness of the route. Both of these values are incremental values. Source node (node S) broadcasts the RREQ packet to all of its reachable neighbors (A, B and C) whenever it needs to establish a route with the destination. Upon reception of RREQ packet, either of the following task(s) is performed by the neighboring node(s):

i. The intermediate node responds with RREP packet to source node if it is the destination node or the node may have "*fresh route*" information to destination.

ii. The intermediate node broadcasts the RREQ packets to its neighbor nodes if it is not the destination node. It updates its routing table and marks the entry for the reverse route. This process repeats until RREQ reaches destination or a node that has a valid route to destination.

On the destination side, when the destination node (node D) receives the RREQ packet, it replies with RREP packet that is unicasted along the reverse route of intermediate nodes (node D-A-S) until it reaches RREQ originating node. At the end of RREQ-RREP cycle, a bidirectional route is established between source and destination. Node S calls AODV's *recvReply*() function to update the routing table entry for node D if any one of the following conditions is satisfied.

i. The new destination sequence number provided in RREP packet is higher than the existing one in the routing table.

ii. If both the destination sequence numbers are equal, the hop count number is checked in RREP packet to confirm if it is smaller than existing one in the routing table.

Several studies have been made which investigate the performance of WSN and MANET under node misbehavior attacks. The effects of blackhole attack on AODV protocol is studied in [11]. A node under black hole attack declares itself the most suitable node to forward packets that have shortest path to the destination, but drops all the received packets. A blackhole node exploits the weakness of route discovery mechanism (RREP-RREQ packets) of reactive protocols, such as AODV, to drop all the packets in the network. The most critical influence of this attack on the network results in significantly dropping the packet delivery ratio.

In [12–14], studies have been made to investigate the performance of MANET in presence of wormhole attack. In wormhole attack, an adversary creates a connection (called *tunnel*) between two different points in the network that are not in communication range of each other. The two colluding nodes under wormhole attack capture packets at one end (source) and tunnel them to other end (destination) and replay them. To launch

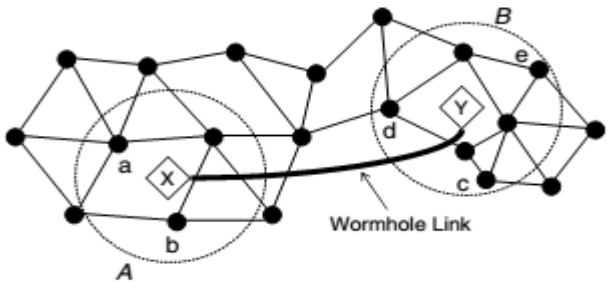

Fig. 2: A depiction of Wormhole attack [15]

wormhole attack, an adversary directly tunnels RREQ packet to the destination without increasing hop-count value. It disrupts proper routing mechanism of AODV and avoids other routes from being discovered. Once wormhole attack is established, malicious nodes may use it for launching other attacks such as packet drop attack and DoS attack. Figure 2 demonstrates a wormhole attack where two malicious nodes, X and Y, act as wormhole nodes.

X and Y replay every captured packet to each other through the tunnel linked between them. This attack propagates false information in the network and among the nodes in region A. The nodes in region A assume that the nodes in region B are their neighbors. As a result, the routing mechanism is badly affected. The authors in [12] employ *Packet Leash* and *Time of Flight* techniques to detect and prevent wormhole attack. In Packet leash, all nodes authenticate time and location information for every other node using symmetric key. In time of flight, a node estimates the round-trip time of a packet which helps in deciding whether the packets end up travelling further or return within round-trip time. The authors in [12] and [13] did not provide simulation based study to consider the effects of wormhole attack on AODV. The authors in [14] analyze the performance of AODV under wormhole attack only in terms of throughput with limited network parameters which is not sufficient to measure performance of MANET.

The authors in [7], [16], [17] investigate the performance of AODV protocol under grayhole attack. The performance is measured in terms of packet delivery ratio, packet drop ratio, throughput, normalized routing load and end-to-end delay. However, none of the work either analyzed the effect of grayhole attack in terms of consumed energy as it is most important design issue for WSN; neither provides countermeasures to defend attack.

The authors in [18] provide theoretical analysis of various node misbehavior attacks but none of the attacks is simulated on either proactive or reactive protocols to study the effects.

The authors in [19] conducted a simulation based study of SAODV for MANET to analyze the affect of grayhole attack. SAODV uses cryptographic extensions to provide authenticity and integrity of routing messages and all routing messages are digitally signed. However, the above proposal is security extensions of existing mobile ad-hoc routing protocols which is not suitable for resource constrained WSNs.

Most of the literature cited in this study relates to the MANET, but the network dynamics are different for WSN. To propose a secure routing protocol for WSN, impact of attacks must be analyzed under WSN. The secure routing protocol developed for mobile ad-hoc networks could not be directly used for wireless sensor network due to the following differences between two types of networks.

i. In most of the WSN applications, sensor nodes are static therefore topology changes are not as frequent as in mobile ad hoc networks where nodes are mobile. WSN topology may change due to some node failure or battery depletion. Therefore, secured routing protocol developed for MANET to cope with the node mobility and dynamic nature of network may contain features that are not required or are unnecessary for WSN.

ii. In WSN, the goal of sensor nodes is to send the sensed data to base station. Similarly base station could send control information to sensor nodes. Thus the communication type may be many-to-one and one-to-many. While in mobile ad hoc network, most of the communication is one-to-one. Therefore, secured routing protocol developed for one-to-one communication is not suitable for many-to-one and one-to-many communications.

iii. In MANET, the nodes are in the form of cell phones, PDAs or laptop class computes. These types of devices have much more resources (memory of hundreds or thousands of megabyte, large batteries and speedy processors) as compared to sensor nodes in WSN that are much more resource constrained. Therefore, secure ad-hoc network routing protocol that may use complex security mechanisms like public key cryptography cannot be directly used in sensor networks.

By keeping above mentioned points in mind, this work is conducted to analyze the impact of grayhole attack in WSN prior to propose a secure routing solution for WSN.

Furthermore, most of the discussed literature did not pay attention to measure the performance of a network in terms of consumed energy, neither provided counter-measures to defend grayhole attack. As WSN is a resource constraint network and energy is the most critical design parameter for providing secure solutions. Hence, it is necessary to study the impact of node misbehavior attacks on existing routing protocols to suggest a suitable secure routing protocol. In subsequent section, grayhole attack mechanism is discussed in detail.

3. GRAYHOLE ATTACK MECHANISM

In this paper, grayhole attack is considered as an attack model. In grayhole attack, a malicious node does not drop all the packets, but selectively drops the packets depending upon node-ID or packet type [20], [21]. The term "*selective*" means that the grayhole node may drop

packets of one type and forward packets of other types. For example, a grayhole node may drop packets from some set of nodes in the network, but forward packets from other set of nodes. Similarly, grayhole node may drop all TCP packets, but forward all UDP packets. In another form of grayhole attack, a grayhole node may drop packets for some time duration and act as misbehaving node, but switch to normal behavior at later time. Therefore, detection of grayhole nodes becomes very difficult.

Let us assume that a compromised node behaves like a grayhole node in the network and is denoted by *M*. The objective of node *M* is to drop packets for some time duration. The probability of dropping packets by node *M* is denoted by $P(M)$ and the probability of normal nodes (*N*) in the network is denoted by $P(N)$. The probability for the occurrence of grayhole attack in WSN is given by equation 1.

$$P(M) = \frac{P\left(\frac{M}{N}\right) * P(N)}{P(M)} \quad \ldots (1)$$

Algorithm-I depicts the algorithm for launching a grayhole attack. AODV code in NS2 has been modified to simulate grayhole attack in WSN. Initially, grayhole node behaves normally and sends genuine RREP message to the node that initiated RREQ message. Afterwards, grayhole node behaves maliciously and begins dropping packets.

Algorithm – I: Launching Grayhole Attack

```
if (Packet Type_AODV)
{
if(RREQ) {

if(I am the source or previously seen it) {
Drop the Packet
}

else if (No Attack)
{
Resolve the Route;
SendRouteReply;
else if (GrayHoleAttack) {
//Gray hole will send a genuine reply
Resolve the Route;
SendRouteReply;
}
}
}
else
{
Handle it in Normal way
}
}
else if  (it is a packet which I am originating) {
Handle it in Normal way
}
else {
//it is the packet I am forwarding
if (No Attack) {
Handle it in Normal way
}
}
else if(GrayHoleAttack) {
//Maliciously dropping the packet
Drop the Packet
}
```

4. SIMULATION MODEL

NS2 [22] is an event-driven simulator and has proved to be valuable in analyzing the dynamic nature of networks. NS2 has achieved remarkable reputation in network and communication research community due to its modular nature and flexible design. NS2 simulator has been extensively used to analyze the performance of AODV protocol in the presence of grayhole nodes.

Our evaluations are based on the simulation of variable number of sensor nodes (10, 20 and 30 nodes) as shown in Figure 3(a), 3(b) and 3(c) respectively. The nodes form a wireless senor network over a rectangular region (500×500 m). We also vary the number of grayhole nodes in the network to analyze the resulting effects.

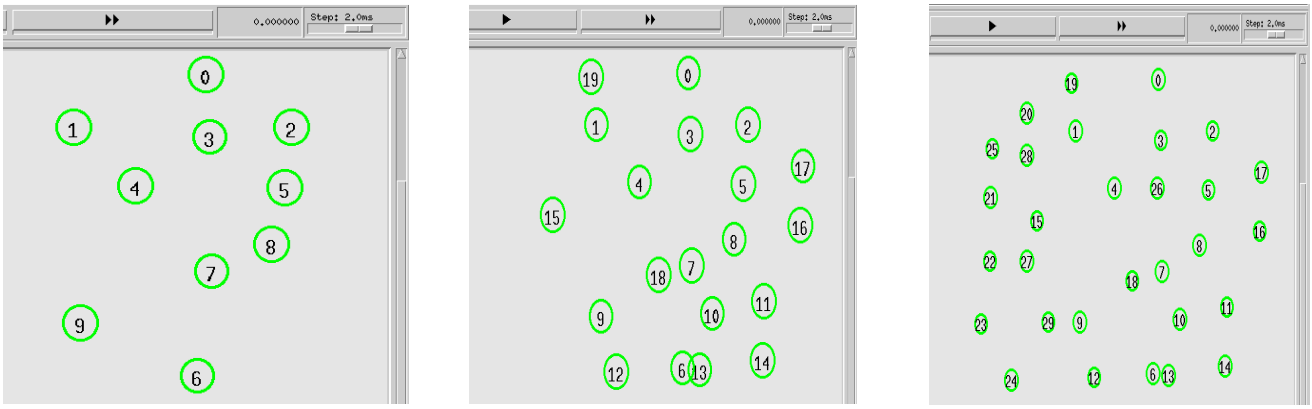

Fig. 3: (a) (b) (c)

Table 1 lists the parameter settings for our simulation environment.

TABLE 1: SIMULATION PARAMETERS

Simulation parameters	Values
Simulation Area	500 x 500 m
Routing protocol	AODV
Simulation Time	500 sec
Number of nodes	10, 20, 30
Number of grayhole nodes	0, 1, 2
Transport layer protocol	UDP
MAC	IEEE 802.15.4
Application layer traffic	CBR
Packet size	50 bytes

5. SIMULATION RESULTS

Performance of AODV protocol is measured in terms of packet delivery ratio, average end-to-end delay, number of packets dropped and average energy consumed. The performance is analyzed by using different simulation scenarios as mentioned below.

i. When there are 10 nodes in the network, with and without compromised nodes (grayhole nodes).

ii. When there are 20 nodes in the network, with and without compromised nodes (grayhole nodes).

iii. When there are 30 nodes in the network, with and without compromised nodes (grayhole nodes).

Figure 4 shows how the packet delivery ratio is affected in the presence of grayhole nodes. It is evident from the results that as the number of grayhole nodes increase in the network, packet delivery ratio decreases, leaving less number of packets to reach destination. Additionally, the grayhole nodes exhibit dual behavior. Sometimes, a grayhole node behaves like a normal node and obeys the routing rules. But at other time, it violates the rules of routing protocol by dropping packets in a random fashion. As a result, it does not drop all the received packets as contrast to blackhole attack where compromised nodes drop all the received packets. When there is no grayhole node in the network, PDR is almost 100% in all three scenarios. When grayhole nodes become part of the network, PDR drops to 32%, 21% and 10%, respectively, for three scenarios.

Figure 5 shows the result of average end-to-end delay for normal and compromised AODV. The simulation results depict that when there are no compromised nodes in the

network, it takes no time for the packet to reach destination. As the number of compromised nodes increase in the network, average end-to-end delay also increases as compromised nodes flood out false routing information in the network which prevent data packets to reach intended destination. If we compare the results of the three scenarios, we find that average end-to-end delay is significantly higher when there are more grayhole nodes in the network. It is almost increased by 80% in case of the third scenario.

Figure 6 shows how the packet drop ratio is affected with and without grayhole nodes. It is observed from the results that as the node density increases, packet drop ratio also increases. AODV in its normal form also drops some of the RREQ packets due to unavailability of a fresh route. The inherent feature of grayhole attack is to drop the packets randomly. One of the limitations with existing AODV is that it only generate single path while transferring packets to destination. If a grayhole node becomes the part of selected route, it drops packets randomly. Similarly, if number of grayhole nodes increases and becomes 1-hop neighbor of source node, it gets more leverage to be part of a chosen route. The number of packets dropped in the third scenario is significantly higher as compared to other two scenarios due to the aforementioned reason.

Figure 7 shows the result of average energy consumption for both AODV and compromised AODV. It is observed from the results that as the density of malicious nodes increases in the network, average energy consumption also increases due to adverse effects of grayhole attack on route discovery and route resolve mechanisms of AODV. Energy consumption is directly related to the number of transmitted and received messages either data or control. When a node comes under grayhole attack, it violates normal route discovery mechanism of AODV and generates increased number of RREQ and RREP packets which in results increase overall energy consumption of network.

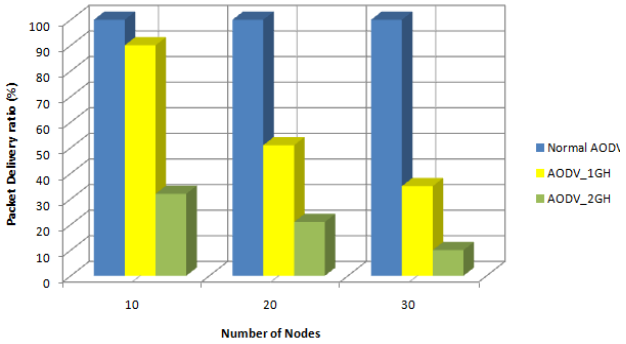

Fig. 4: Number of nodes vs. packet delivery ratio

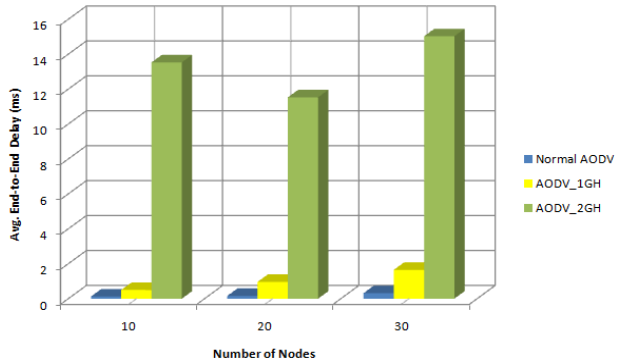

Fig. 5: Number of nodes vs avg. end-to-end delay

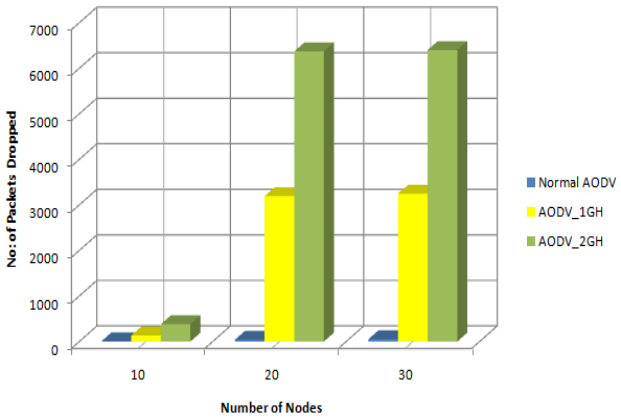

Fig. 6: Number of nodes vs. number of dropped packets

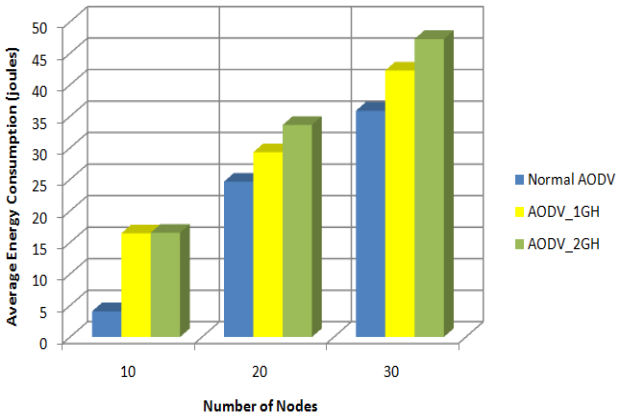

Fig. 7: Number of nodes vs. average energy consumption

6. COUNTERMEASURE AGAINST GRAYHOLE ATTACK

Routing in WSN is a cooperative process where routing information must be shared between all nodes on the route to destination. There might be a strong case that some malicious or misbehaving nodes (grayhole nodes) might exist on discovered route and may not fulfill the desired rules and regulations of the protocol. Nonetheless, some countermeasures are available as follows:

i. A number of attacks can be prevented if malicious nodes are prevented from participating in the routing process. Authentication methods can be used to determine whether the sensor node can participate in routing. SEAD [23] and Ariadne [24] are secure routing schemes based on authentication mechanism.

ii. The effect of grayhole attack may be minimized by employing multi-path routing approach [25], as packets may be routed through other available paths. However, this approach is feasible for only minimizing the impact of an attack but does not prevent attacks.

iii. Promiscuous mode [26] and IDS solutions [27] can be used to monitor the behavior of all neighboring nodes whether they behave normally or maliciously. If some malicious behavior is observed, IDS may trigger some action, for example, may alert neighboring nodes about the malicious activity.

iv. Trust and reputation based systems (TRMs) [28] may be used to detect and exclude malicious nodes. These systems facilitate the nodes to predict the behavior of other nodes and provide secure mutual interaction.

v. Game theory based approaches [29] are also useful in dealing with misbehaving nodes. These approaches assume that some greedy actions are performed by malicious nodes to gain better performance such as leveraging the operating point, "Nash Equilibrium" and higher share of bandwidth.

vi. The behavior of malicious nodes can also be identified by checking the sequence number of packets. If abnormal increase in the sequence number is identified, the particular node is considered as a misbehaving node.

vii. Some reward and punitive mechanisms may be incorporated in secure routing protocols so that the nodes complying with the protocol may be provided incentives, otherwise nodes may be punished.

7. CONCLUSION

In this paper, we analyzed the performance of AODV grayhole attacks. We compared AODV with compromised AODV in terms of packet delivery ratio, end-to-end delay, packet drop ratio and average energy consumption. Simulation results show how badly grayhole attack affects the performance of AODV. As the number of grayhole nodes increases in the network, the packet drop ratio and end-to-end delay also increases, while drastically decreasing the packet delivery ratio. This study would provide a great help for researcher conducting their research on route misbehavior attacks in sensor networks. During implementation of grayhole attack on AODV, some of the weaknesses of AODV protocols are highlighted. Simulation results also proved the same. Our future work in this direction will focus on implementing other node misbehavior attacks, such as blackhole attack and wormhole attack in WSN and providing efficient and trust-aware routing mechanism to counter such attacks. The major objective in the design of the proposed scheme is to conserve energy while routing packets that most of the existing trust-aware schemes lack.

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PREVENTING SPIT WITH NAIVE BAYES IN VOIP COMMUNICATION

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ABSTRACT

Spams over Internet telephony is a serious threat to consumers and enterprises. In comparison to e-mail spams, voice spams have drastic effects. It consumes time and resources of the victim for example telemarketing. To counter this problem, we propose a two-step solution with analysis and detection to such threats. In first step, we extract the useful data from VoIP calls to organize and to get the input for our detection phase using bloom filter. In second phase, we examine the data obtained during the first step using Naive Bayes (NB). The efficiency of NB is analyzed by simulations. The results show that our proposed technique for voice spam delivers a high level of accuracy.

Keywords: *VoIP, SIP Network, security, SPIT, DoS*

1. INTRODUCTION

Voice over Internet Protocol (VoIP) is a rapidly growing Internet service. Due to its remarkable flexibility, feasible implementation, and low-cost connectivity to international telephones, it has become extremely popular among end-users and communication engineers [1-4]. However, in spite of its immense benefit, this technology contains certain drawbacks also [5] [6]. Session Initiation Protocol (SIP) [7], which is one of the widely used protocol for VoIP services, is vulnerable to many types of attacks. Apart from this, there are also different types of attacks targeting VoIP protocols [8] [9], such as DoS attacks, call hijacking, toll fraud, SPam over Internet Telephony (SPIT) and phishing. SPIT is one of the most serious threats to IP telephony.

Internet telephony is vulnerable to spam calls due to its low cost. Voice over IP systems, like e-mail and other Internet applications, are susceptible to abuse by malicious parties to initiate unsolicited and unwanted communications for telemarketing. Apparently, attackers generate a number of machine automated calls to launch a DoS attack. SPIT is similar to the email spaming problem which many Internet users face quite often. Although email spam will still be a big challenge in the future. The numerous solutions [10-15] proposed over the last few years have helped to mitigate the problem significantly.

Many of the well-known techniques which are used for email spam detection fail completely in the context of VoIP due to many reasons. First, an email usually arrives at a server before it is finally downloaded by the user. Such a mail server can apply many filtering strategies. For instance, it can check whether the text body of the email mentions certain products. In contrast, recognizing human voices and to determine whether the message is spam or not is still a very difficult task. Additionally, the recipient of a call only learns about the subject of the message when someone is actually listening to it. Also from a user's perspective, SPIT is quite different from e-mail spam. Although a spam email is nuisance, it is typically easy to delete such an email. But it can be very un-productive if a regular email from a friend is considered spam and not delivered to a user's inbox. Having said that, it may be tolerable if an email spam filter yields a large ratio of false negatives, but the filter should avoid false positives completely [16].

The work presented in this paper is related to the analysis and detection of threats encountered in Internet telephony. We record a large number of VoIP calls and extract certain input features for spam analysis using bloom filter. The results obtained from the bloom filter are further used as inputs to a Naïve Bayes (NB) classifier for spam detection.

The rest of the paper is organized as follows. Section 2 discusses the related work in the domain of spam detection. Section 3 describes our proposed framework for SPIT detection. Section 4 gives a brief overview of the data analysis through bloom filter. Section 5 describes the spam detection using Naïve Bayes classifier. Section 6 discusses the performance evaluation of the proposed technique. Section 7 concludes the paper.

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2. RELATED WORK

The relevant literature about spam detection demonstrates various techniques. In [17], SPIT detection is done through human telephony communication patterns. Turing test is used to differentiate between human and computer botnets. The two human communication patterns are discussed which are double-talk and call-start pattern. In double-talk, the fraction of time in which both caller and callee are in talking mode is checked. In start pattern, the proposed scheme checks the starting pattern by asking questions having very short answers. If the callee replies with a long answer for the question which has short answer expected, the Turing test will declare it a SPIT. The limitation of this technique is that it can detect spams in only machine generated calls.

The authors in [18] propose a local centric approach based on signaling protocol analysis to counter SPIT. For detection purpose, they consider few facts, e.g., unidirectional spammers, validity of signaling routing data, termination of calls by the same conversation parties, and spammer does not call the same destination for some fraction of time. This solution detects external spammers on a recipient side. The counters are maintained for call setup and call termination in different time stamps. The simultaneous deviation of these counters indicate the spammers' activity with respect to certain probabilities. However, false positives may lead this method to consider legitimate callers as SPIT.

In [19], authors propose an AntiSPIT method based on a blacklist. This module takes input from Call Detail Record (CDR) and decides whether to put the caller in a black list or not. Although this method is simple, it could block legitimate callers too.

The technique proposed in [20] uses a decoy to catch the spammers without their knowledge. In fact, this technique puts a decoy system in front of a server. The spammers treat the decoy as a server and their status are stored in the decoy. This solution is implemented in SIP Express Router (SER). The method is suitable for the IP Multimedia System (IMS) with strong authentication to avoid spoofing. However, this scheme performs well in the situation where two or more decoys are hit by a spammer.

The authors in [21] compare different types of Naive Bayes to get the best choice of Naive Bayes for e-mail spams. Many machine learning algorithms are used for e-mail spam filtering, e.g., support vector machines, boosting and Naïve Bayes classifier. The authors present a comparison between different Naive Bayes classifiers including multi-variate Bernoulli Naive Bayes, multinomial Naive Bayes, TF attribute, boolean attribute, Multi-variate Gauss Naive Bayes, and flexible Bayes. According to this work, the best results are obtained by the flexible Bayes and multinomial Naive Bayes with boolean attributes.

The initial platform to use Naive Bayes in intrusion detection systems for VoIP threats is proposed in [22]. The detection process in this technique keeps track of request intensity, error response, number of destinations, SIP methods and response distribution of VoIP. However, this work can be further extended to detect SPIT.

In [23], the consequences of SPIT attacks are highlighted. The first consequence described is *space consumption* due to voice messages. Second, employees' disturbance in companies and the last one is a user's service complaint. In [24-27], different solutions are proposed for some specific scenarios.

3. PROPOSED SOLUTION FOR SPIT DETECTION

We consider the properties of various VoIP calls to detect SPIT. The high-level overview of our scheme is depicted in Figure 1.

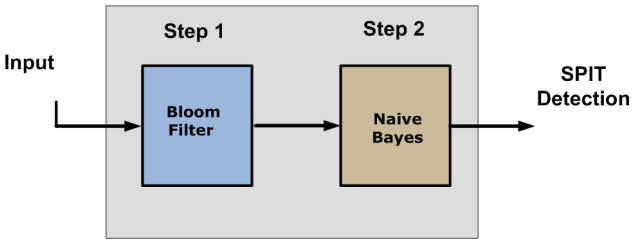

Fig.1: Two-step scheme for SPIT detection

We calculate a call-completion-ratio by comparing the number of call initiation, successful acknowledgements and termination. The length of a call is measured by analyzing the call duration. Furthermore, nature of the calls is checked to confirm whether they are machine generated or (genuine) human calls. Our approach also detects the abnormally large number of calls (machine recorded or human) which exhaust the server resources and result in a Denial of Service (DoS) at victim's side.

4. ANALYSIS THROUGH BLOOM FILTERS

We use bloom filter in the first step of our proposed technique as described in Figure 2 and Figure 3. In this step, we need to gather the information regarding the callers. This step serves as an input to step 2 in which we use Naive Bayes to predict the probability of calls being SPIT. The bloom filter is a space-efficient technique used for probabilistic dataset for testing whether the element is a member of set or not. An empty bloom filter is a bit array of m bits, all set to 0. There must also be k different hash functions defined, each of which maps or hashes some set element to one of the m array positions with a uniform distribution.

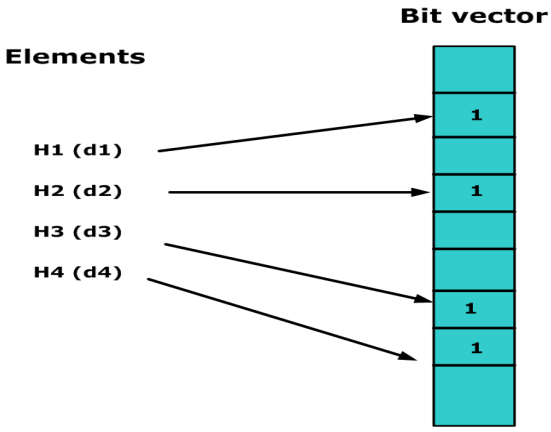

Fig. 2: Generic structure of Bloom filter

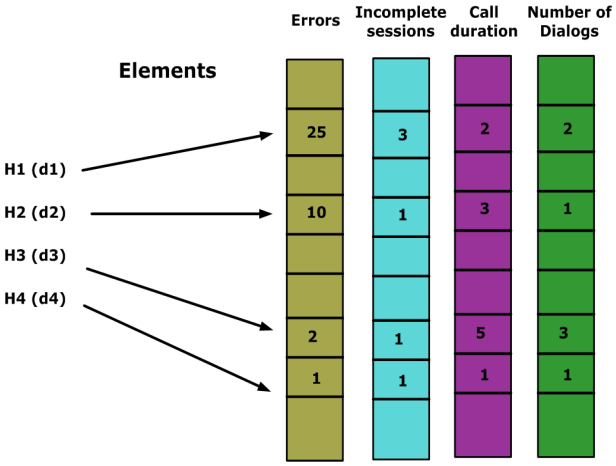

Fig. 3: Bloom filter modified for our proposed technique

To add an element in the bloom filter's array, we feed it to each of the *k* hash functions to get *k* array positions. We set the bits at all these positions to 1. Bloom filters have a strong space advantage over other data structures for representing sets, such as self-balancing binary search trees, hash tables, simple arrays or linked lists.

Table 1 shows the statistics of the calls analysis with respect to their behavior. We count the number of requests and number of responses through bloom filter. This helps us to check the incomplete sessions of calls. We also count the probability of waiting calls, ongoing traffic sessions and number of maximum dialogues. These parameters help us to specify the respective probabilities to detect the SPIT calls. The bloom filter is used for this data collection.

We calculate the probabilities of different frequently used SIP methods. These probabilities are shown in Table 2. This table shows the methods which are necessary for call completion, call cancellation, acknowledgement and registration. These probabilities help us to find the SPIT calls used as input in the second step of our proposed technique. Table 3 shows the probabilities of error response type. In SIP responses, the error could be client error, server error, global error, redirection, successful or provisional response. This step is based on the traffic analysis, and later we use this data to the next step of our proposed scheme.

TABLE 1: SIP CALL DATA

	Number of Requests	Number of Responses	Calls Waiting	RTP Open ports	Maximum no: of Dialogues
0 -10	1	---	---	0.8	1
> 10	0	---	---	0.2	0
0 - 4	---	0.2	---	---	---
> 4	---	0.8	---	---	---
0 - 7	---	---	0	---	---
> 7	---	---	1	---	---

TABLE 2 : SIP METHODS FOR SPIT

INVITE	REGISTER	ACK	CANCEL	BYE
0.40	0.00	0.40	0.00	0.20

TABLE 3 : SIP ERROR RESPONSES

1xx	2xx	3xx	4xx	5xx	6xx
0.30	0.00	0.05	0.20	0.20	0.05

5. NAIVE BAYES CLASSIFIER

A Naive Bayes classifier is a simple probabilistic classifier based on Bayes theorem [28] with strong independence assumptions. Naive Bayes classifier assumes that the presence of a particular feature of a class is unrelated to the presence of any other feature, given the class variable. The success of Naive Bayes relies on the dependencies. Even if these features depend on each other or on the existence of other features, a Naive Bayes

classifier considers all of these properties to independently contribute to the probability of an item. Equation 1 shows the probabilistic model of Naïve Bayes classifier.

$$p(H \mid e) = \frac{p(e \mid H)p(H)}{P(e)} \quad (1)$$

In equation 1, $p(H \mid e)$ represents the probability of instance e being in class H (in our case this represents the probability of a call being legitimate or malicious), $p(e \mid H)$ is the probability of generating instance e given class H, $p(H)$ is the probability of occurrence of class H, and $p(e)$ is the probability of occurrence of instance e.

Depending on the precise nature of the probability model, a Naive Bayes classifier can be trained very efficiently by a supervised learning algorithm. In many practical applications, parameter estimation for Naive Bayes models uses the method of maximum likelihood. In spite of its simple design and apparently over-simplified assumptions, Naive Bayes classifier performs quite well in many complex real-world situations. Some analysis of the Bayesian classification [28] shows that there are some theoretical reasons for the apparently unreasonable efficacy of Naive Bayes classifiers. However, a comprehensive comparison with other classification methods [29] shows that Bayes classification is outperformed by more current approaches, such as boosted trees or random forests. However, the main advantage of the Naive Bayes classifier is that it only requires a small amount of training data (means and variances of the variables) to estimate the parameters necessary for classification. Since independent variables are assumed, only the variances of the variables for each class needs to be determined and not the entire co-variance matrix.The training is quite easy to implement and just requires the (prior) conditional properties calculated from the offline data analysis.

6. PERFORMANCE EVALUATION

We use Weka [30], a suit of machine learning software written in Java, for the performance evaluation of our proposed technique. It is a data mining tool used for data pre-processing, classification, regression, clustering, association rules, and visualization.

We generate random data to check the records of VoIP calls to analyze SPIT. The gathered data includes total number of requests, responses, waiting calls, etc. We further use bloom filter to classify the SIP call data. We generate margin curves which show the difference between the probability calculated for the actual class and the probabilities calculated for the other classes. Margin curves also show the threshold curves of YES/NO (legitimate/malicious) class. The points illustrating prediction tradeoffs can be obtained by varying the threshold values between classes such as cost curves and cost-benefit analysis of YES and NO. This is particularly useful for the analysis of predictive analytic outcomes. The Naive Bayes classifier is applied to the data retrieved from the bloom filter. Figure 4 depicts margin curve of Naive Bayes. Figure 5 and Figure 6 show threshold curve of YES and threshold curve of NO, respectively. After comparing training data and actual data, Naive Bayes calculates the probability of the calls being SPIT based on the given information and predicts the future probabilities. Thus Naive Bayes classifier is able to detect the SPIT calls through the calculated probability based on the given SIP data. Figure 7 and Figures 8 depict cost-benefit analysis of YES and NO. Figures 9 shows cost analysis of YES and Figure 10 shows cost analysis of NO.

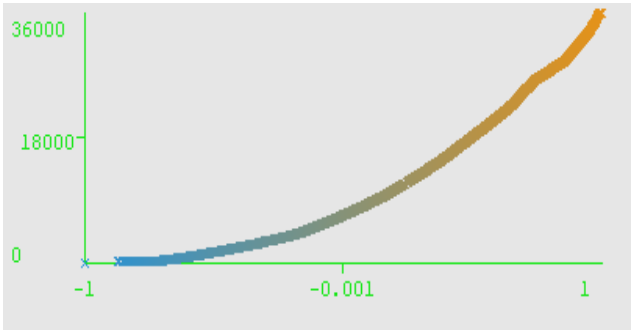

Fig. 4 : Naive Bayes Margin curves

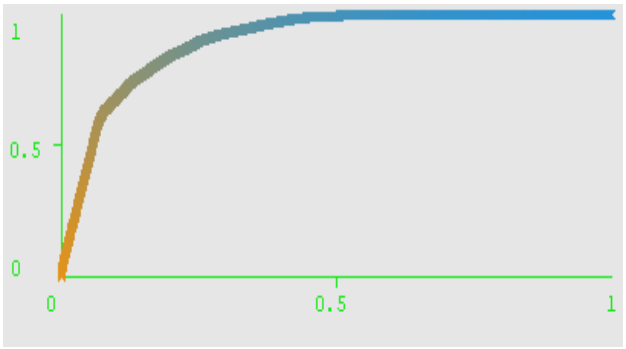

Fig.5: Naive Bayes threshold curve of YES

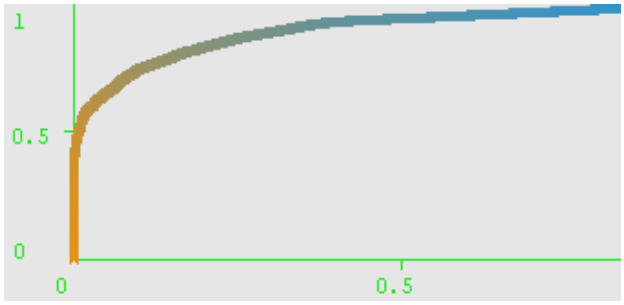

Fig. 6: Naive Bayes threshold curve of NO

Fig. 7: Naive Bayes cost-benefit analysis of YES

Fig. 8: Naive Bayes cost-benefit analysis of NO

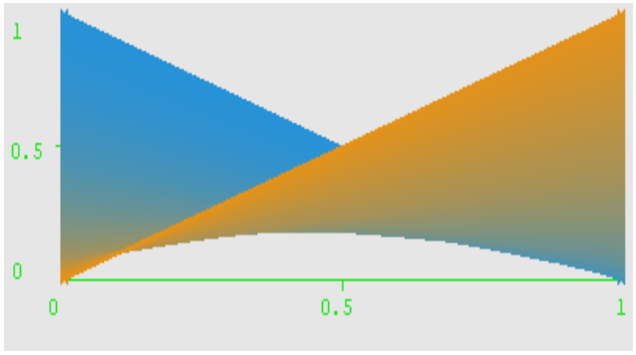

Fig. 9 : Naive Bayes cost analysis of Yes

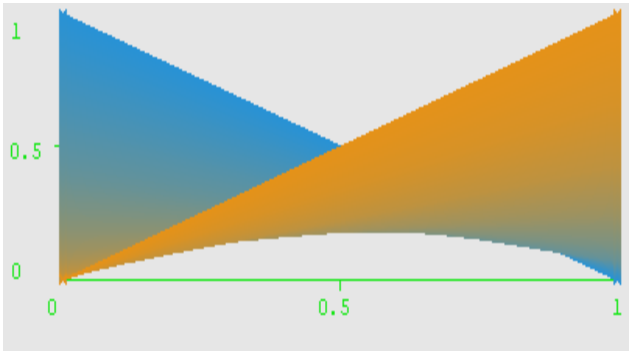

Fig. 10: Naive Bayes cost analysis of No

The proposed technique is easy to configure and does not require a special architecture or an additional hardware on the servers. It is cheaper than other proposed techniques in the sense that most of the existing solutions require Intruder Detection Systems (IDS), firewalls and detection devices at both server and client side. The proposed solution is memory-efficient due to the usage of Bloom filter. Future prediction through Naive Bayes works well to block SPIT. Few solutions have been proposed [31-35] for this problem, but they are less efficient than our proposed scheme as shown in our performance evaluation.

8. CONCLUSION

SPIT is a growing threat to SIP based VoIP systems keeping in view that the email spam filtering is out of context in VoIP [35-39]. SPIT are harmful for the organizations and for the individuals too. In this paper, we have proposed a two-step solution for spam detection. The first step arranges the SIP data through a bloom filter, while the second step classifies the data to be legitimate or spam using a Naive Bayes classifier. We calculate the probability of the SIP calls being SPIT through a Naive Bayes classifier. At the same time, Naive Bayes helps to predict the future probability of a call being SPIT. The margin curve, cost curve and cost-benefit analysis verify the efficiency of Naive Bayes in our proposed technique. In future, we aim to compare different types of Naïve Bayes classifiers to further improve the accuracy of our proposed technique.

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EXPERIMENTAL STUDY OF DESALINATION TECHNOLOGIES AND TIMER-BASED SOLAR PV TRACKING SYSTEM

Saleem Raza*, K.C. Mukwana*, M. M. Tunio*

ABSTRACT

In this study the performance of solar desalination technology and timer based solar PV tracking system were analyzed. Solar energy has been used as an alternate source of energy for desalination. The performance of hexagonal basin dome type desalination unit has been studied. The experiments were conducted during the hottest months of the year i.e. May, June and July. The hexagonal basin dome type desalination unit was tested to investigate its performance in terms of the quantity of water distilled during the day and the quality of distilled water. It was observed that pH value was reduced from 9.1 to 6.2, total hardness reduced from 320 ppm to 38 ppm and TDS was reduced from 3640 ppm to 225 ppm which was much lower than standard/famous mineral water available in the market. In this study analysis of timer based solar PV tracking system was also conducted to provide maximum solar potential for the solar desalination. With this, the desalination unit produced distilled water at much lower cost than other types of solar equipment. Laboratory tests clearly show that the water after distillation could be used for any purpose. It was observed that this system is very simple, cost effective and also have capability to maintain the peak power of PV panel due to solar tracking system.

Keywords: *Solar desalination, Solar PV tracking, Hexagonal basin, Distillation, Desalination units*

1. INTRODUCTION

Pakistan is God gifted with renewable energy resources, such as hydel, solar, wind, geothermal and bio-mass. Hydropower source of energy is well known in Pakistan. The estimated hydro potential in Pakistan is about 50,000 MW. Up till now about 6595 MW has been developed. Small to medium size hydro power plants offer the greatest renewable energy potential for Pakistan. More importantly Pakistan geographically lies in highest solar insulation region in the world and has more than 300 clear days. The solar potential is estimated over 10,000 MW. Possibilities also exist in promoting greater use of wind, solar and biomass projects [1].

The wind potential is estimated up to 50,000 MW. Urban areas generate over 5500 tons of solid waste per day. About 56.9 million animals (buffaloes, cows) in Pakistan, can generate 21.35 million M^3 of biogas and 36.0 million tons of bio fertilizer per day. This indicates that Pakistan has huge potential of renewable energy resources [2].

1.1 APPLICATIONS OF SOLAR ENERGY

Solar distillation is a process, in which solar energy is trapped and used to evaporate impure or salty water. Water is life, among the basic need of food and air. Human beings have been dependent on rivers, lakes and underground reservoirs for acquiring fresh water. However, the pollution of rivers and lakes by industrial effluent and sewage has caused scarcity of fresh water in many towns and villages near lakes and rivers, so safe drinking water is an essential requirement for supporting life [3].

At various places, saline water is available in underground or in the oceans. This water can be distilled and made clean and safe from contaminants. Devices which produce potable water by utilizing solar heat energy, is called "solar water still". Distillation of saline water or brackish water is good method to obtain fresh and pure water. Distillation of saline water is an attractive method due to its simple technology [4].

Wide ranging applications are there of solar energy given by various researchers [5, 6], some of them are enlisted below:

- Solar water heating
- Solar air heater
- Solar space heating
- Solar distillation
- Heating of swimming pool by solar energy
- Solar pumping
- Solar cooking
- Solar furnaces
- Solar green houses
- Solar thermal power plants
- Solar photovoltaic system

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3. METHODOLOGY

3.1 HEXAGONAL TOMB SOLAR STILL

An experimental study was conducted on "Hexagonal Tomb Solar Still" fabricated in mechanical engineering workshop of the university by using indigenous material as shown in Figure No. 1. This solar still was tested to investigate its performance by considering various parameters like pH, TDS, E.C, and total hardness. The samples of water collected from different locations were used for desalination purpose and condensate was tested in laboratory.

The project timer based solar photovoltaic tracking system was fabricated in Energy and Environment Engineering Department of Quaid-e-Awam University of Engineering, Science and Technology. All the manufacturing process was carried out in Mechanical Engineering Workshop on the lathe machine such as (drilling, facing, threading, boring etc) and other process such as welding, polishing, cutting, assembly etc.

Fig. No. 1: Hexagonal Tomb Solar Still

3.2 SOLAR TRACKER

A solar tracker as shown in Figure No. 2 is a device for orienting a day lighting reflector, solar photovoltaic panel or concentrating solar reflector or lens toward the sun [8]. The sun's position in the sky varies both with the seasons and time of day as the sun moves across the sky. Solar powered equipment works best when pointed at the sun, so as solar tracker can increase the effectiveness of such equipment over any fixed position. There are many types of solar trackers, of varying costs, sophistication and performance. One well known type of solar tracker is the heliostat, a movable mirror that reflects the moving sun to a fixed location, but many other approaches are used [9, 10, 11].

Fig. No. 2: Solar tracker

3.3 TRACKER MOUNT TYPES

Solar trackers may be active or passive and may be single axis or dual axis. Single axis trackers usually use a polar mount for maximum solar efficiency. Single axis trackers usually have a manual elevation (axis tilt) adjustment on a second axis which is adjusted on regular intervals throughout the year. Compared to a fixed mount, a single axis tracker increases annual output by approximately 30% and a dual axis tracker an additional 6%. There are two types of dual axis trackers, polar and altitude azimuth [12].

The project "timer base photovoltaic solar tracking system" was designed, fabricated and tested in the Energy and Environment Engineering Department of Quaid-e-Awam University of Engineering, Science and Technology, Nawabshah. The project is placed on the roof of Energy and Environment Engineering Department and the observations and results were taken in the Energy Laboratory.

4. EXPERIMENTAL WORK

Three water samples A, B and C were collected. The parameters analyzed were pH, EC, TDS and total hardness. The analysis results of sample water obtained before the desalination process are given in table 1. The graphical presentation of analyzed result of each parameter is shown in Fig 3, Fig 4, Fig 5 and Fig 6.

TABLE 1: CHEMICAL COMPOSITION OF SAMPLE WATER BEFORE DESALINATION

Sample	pH	EC µs/cm	TDS (ppm)	Total hardness $CaCO_3$ mg/ltr
A	8.4	1.91	1337	269
B	9.1	5.20	3640	320
C	9.2	4.45	3115	263

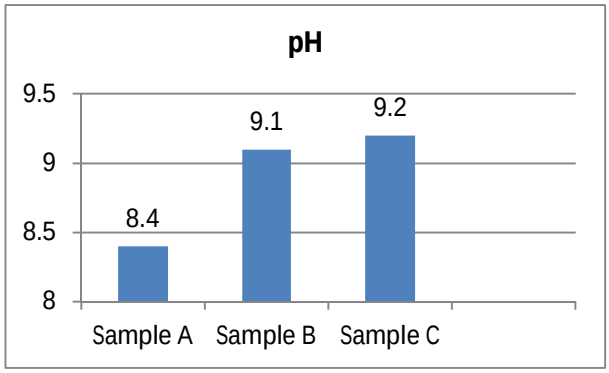

Fig 3: Graphical presentation of pH analyzed in water samples A, B and C

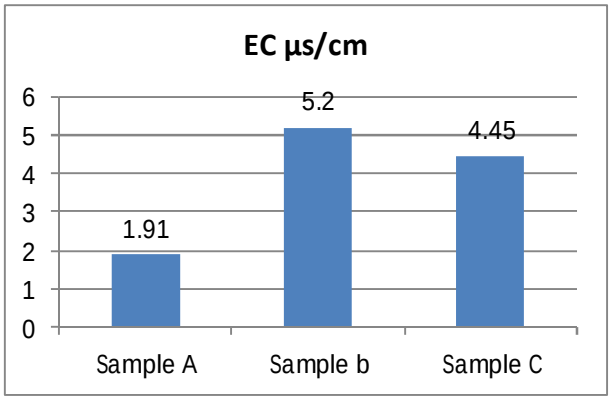

Fig 4: Graphical presentation of EC analyzed in water samples A, B and C

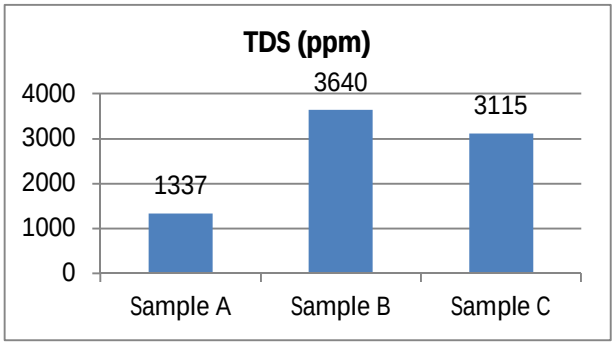

Fig 5: Graphical presentation of TDS analyzed in water samples A, B and C

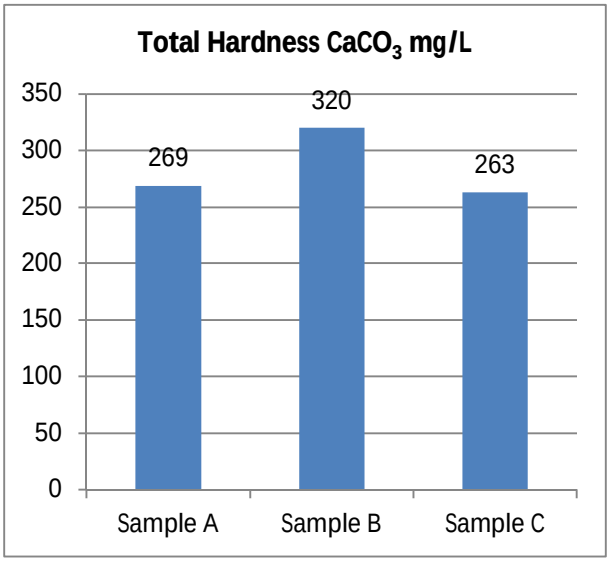

Fig 6: Graphical presentation of total hardness analyzed in water samples A, B and C

The collected water sample was processed through desalination process. After desalination process the water was analyzed again and the obtained results were compared with the previous results. The comparison of each parameter is given in table 2. The comparison is also represented in Fig. 7, Fig. 8 and Fig. 9. The reason of this decrease in levels of pH, E.C, TDS and Total Hardness is due to desalination process. With desalination process majority of impurities or pollutants are filtered or trapped and clean water is received.

TABLE 2: SAMPLE WATER PARAMETERS BEFORE AND AFTER DESALINATION

Parameter	**Before Desalination**	**After Desalination**
pH	9.1	6.1
E.C	5.20 µs/cm	0.31 µs/cm
TDS	3640 ppm	225 ppm
Total Hardness	320 mg/L	38 mg/L

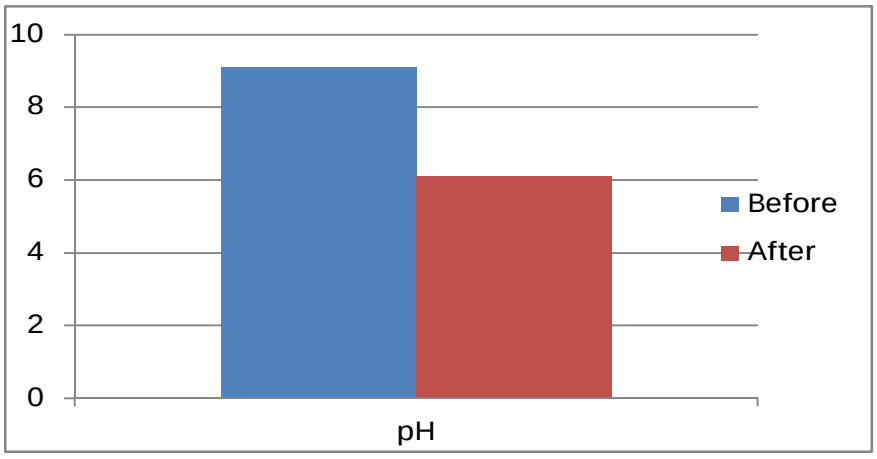

Fig. 7: Comparison of pH before and after Desalination

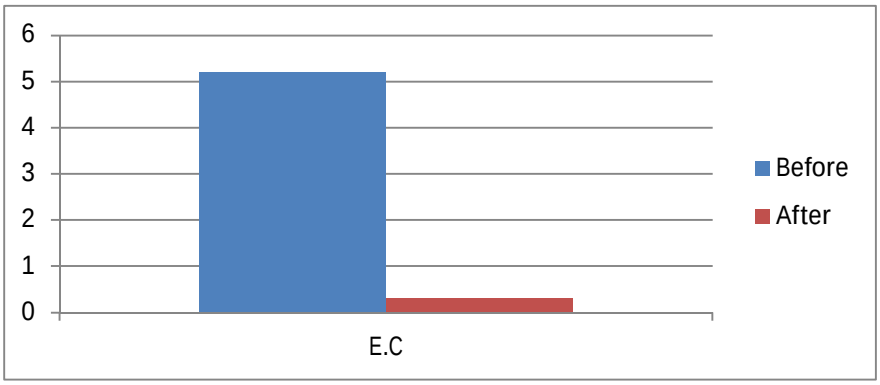

Fig. 8: Comparison of E.C (µs/cm) before and after Desalination

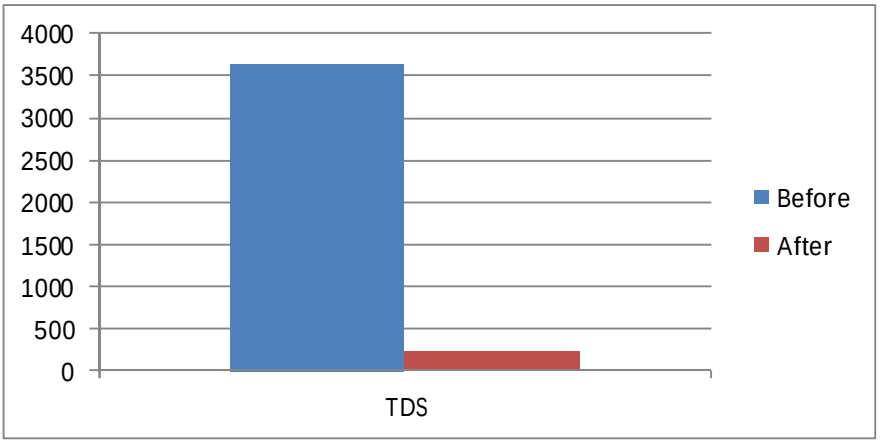

Fig 9: Comparison of TDS (ppm) before and after Desalination

In the end of research the comparison of desalinated water was also made with the mineral water brands. The results obtained are shown in table 3. The fig. 10 shows the comparison of these mineral water brands water quality and desalinated water.

TABLE 3: COMPARISON BETWEEN SOLAR STILL DISTILLED WATER AND BOTTLED MINERAL WATER

Parameter	SOLAR STILL	NESTLE	SUPER DEW DROPS
pH	6.1	6.5	7.0
E.C µs/cm	0.31	0.31	0.2
TDS ppm	225	162	120

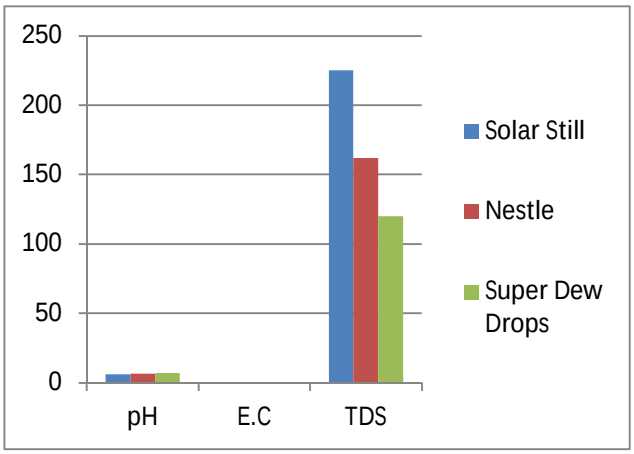

Fig. 10: Comparison of mineral water brands water quality and desalinated water.

TABLE 4: COMPARISON OF TIMER BASED SOLAR PHOTOVOLTAIC TRACKING SYSTEM WITH NON TRACKING SYSTEM

Load	Time Duration	PV Output						Battery Performance						Battery Charging			Battery Temp (°C)	
		Voltage (V)		Ampere (A)		Watt (W)		Voltage (V)		Ampere (A)		Watt (W)						
		W_0T*	W_0T	W_0T	W_0T	W_0T	W_0T	W_0T	W_0T	W_0T	W_0T	W_0T	W_0T	initial	W_0T	W_0T	W_0T	W_0T
Load-1	9:30	19.5	19.5	1.4	1.4	27.3	27.3	14.6	14.6	14.6	490	7154	7154	99	99	99	20	20
Load-2	9:40-10:02	19.1	19.1	1.6	1.7	30.56	32.47	13.5	13,5	13.5	490	6615	6615	99	99	99	21	20
Load-3	10:10-10:30	19.0	19.2	2.2	2.2	41.8	42.24	12.4	12.5	12.5	490	6076	6125	99	41	44	21	20
Load-4	11:06-11:26	18.6	19.2	2.6	2.7	48.36	51.84	11.4	11.6	11.6	490	5586	5684	99	15	19	26	23
Load-5	13:15-15:35	18.8	19.2	2.7	2.7	50.76	51.84	11.4	11.5	11.5	490	5586	5635	99	13	16	26	23

W_0T* = Without tracking system
W_0T = With tracking system
Load -1 = Without any load
Load -2 = Watt energy saver
load -3 = 2 energy saver of 11 watt and 18 watt
load-4 = Incandescent lamp of 100 watt
load-5 = 1 Incandescent lamp of 100 watt & 1 Energy saver of 11 watt

5. RESULT AND DISCUSSION

The research findings show that water is purified to the satisfactory level and comparable to the mineral water available in the market such as Nestle and Super Dew drops. The TDS was reduced from 3640 ppm to 225 ppm and pH value was reduced from 9.1 to 6.2. The hardness level of the distilled water was also reduced to the satisfactory level irrespective of the initial hardness. The overall performance of hexagonal solar still seems to be quite promising. Laboratory tests clearly show that the water after distillation could be used for any purpose.

In this research study the performance of solar desalination technologies and timer based Solar PV tracking system were analyzed. Solar energy has been used as the most prominent of alternate sources of energy for desalination. The performance of Hexagonal basin and Dome type desalination unit has been studied. The unit was tested to investigate its performance in terms of the quantity of water distilled during the day and the quality of distilled water. These desalination units have produced distilled water at a cost per unit of product lower than other types of solar equipment.

In this study analysis of timer based solar PV tracking system was also conducted. The results are shown in table 4. It was observed that this system is very simple, cost effective and also have capability to maintain the peak power of PV panel. This system was found useful

for increasing the charging of battery and maintained the battery temperature. It was found that by using this tracking system the output/efficiency of PV panel and life of battery was also increased.

6. CONCLUSION

The hexagonal basin type solar still has produced distilled water which turns potable as evident from the obtained test results at a cost per unit of product lower than other types of solar equipment. The priority water quality parameters like pH, TDS, E.C and total hardness are decreased up to the permissible level. The model of timer based solar tracking system further enhances the potential of desalination.

It was found that timer based solar tracking system has better efficiency than without tracking system or stationary photovoltaic system. The time and angle of the sun can easily be set from this simple method. It is also observed that by using timer based solar tracking system the battery is frequently charged than that in the stationary photovoltaic panel. By using timer based solar tracking system, the battery temperature was also decreased than that of stationary photovoltaic panel.

In remote areas, where potable water is rare or not available, solar still can provide one of the possible solutions of this problem of potable water. Solar desalination units are technologically the simplest systems today.

7. ACKNOWLEDGEMENT

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8. REFERENCES

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