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Industrial Waste Water Treatment Using Natural Filtration and Solar Distillation Methods

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ABSTRACT

The need of fresh water is vital for human survival and fulfillment of demand has become serious concern in countries having limited water resources. Large amount of water from industries is wasted daily all over the world, which can be reused by proper water treatment. This present work discusses the methods of waste water treatment using filtration and solar distillation methodology. The samples of industrial waste water were collected from chemical and fertilizer industry in Kota, Rajasthan. The pH, TDS and dissolved oxygen values of waste water samples and water after treatment was tested and results of different waste water samples are reported. Ammonia, cement and carbide waste water samples having TDS 310,510 and 268 PPM were treated using filtration and solar distillation methods. The treated water after filtration had TDS 274,460 and 208 PPM respectively. The treated water after solar distillation had TDS 107, 288 and 98 PPM. The obtained values of TDS, pH, and dissolved oxygen after combined treatment of filtration and distillation are close to standard values required for potable water.

Keywords: Filtration, solar distillation, total dissolved solids, waste water, water treatment

1. INTRODUCTION

About seventy percent of the earth is covered with water but only one percent of it is potable water. This one percent water resource is renewed by rainfall and other methods. Demand of fresh water per capita is increasing day to day and available resources are limited and this will create big crises in future for the world. Due to rapid enhancement in population exploitation of natural resources and degradation in environment is happening all over the world. To fulfill needs of large population industrial development is scaled up by all countries that is creating a large amount of industrial waste water daily. This industrial waste water should be treated and reused in different needs to reduce load on natural water resources [1]. The most available natural resources of water are ground water, surface water and rain water [2]. Salinity of surface water is increasing due to intrusion of seawater near coastal areas. It leads to higher amount of nitrate and pesticide in surface water supply chain [3]. Industrial waste water basically includes chemical waste, sewage water and other wastes from various manufacturing processes [4]. The major contaminants in waste water are suspended solids, nutrients, organic and inorganic compounds and heavy and toxic metals. This waste water mixed with natural resources not only affects human life but also has adverse effects on aquatic ecosystem. Due to long term direct or indirect contact of such wastes may cause health issues and it may lead towards serious diseases [5].

Waste water treatment method depends on various factors like kind of pollutant presence in waste water, characterization of waste water and selection of treatment technology [6]. The conventional method includes chemical process treatment and which may lead to further chemical waste. General methods are coagulation, filtration, incineration, ozonation, chlorination, chemical oxidation, flocculation, adsorption, reverse osmosis, ion exchange, distillation, electrolysis, etc. [7]. After waste water treatment, product water can be used in industries in various activities like heating, cooling, as solvent, as carrier of raw material and for manufacturing goods. The quality of water after water treatment should be close to the freshwater quality as possible. According to American Public Health Association, water quality must be expressed in terms of use as well with the sensory, physical, biological and chemical parameters[8].

Any kind of biological, physical or chemical substance present in water leads to reduced water quality. After treatment waste water should be tested in laboratory for quality check. Water having some contaminants and not appropriate for drinking purpose can be used in washing, bathing or irrigation purpose. Diseases like diarrhea, cholera, organ damage, mal-nutrition are spreading in under developed countries due to poor supply of fresh water [9-11].

Aravind M. A. and Rahna L. stated on their result that coir pith is effective in removing of the BOD, COD and helps to bring down the conductivity of waste water [12]. Shivang Sharma et. al. claimed in their study that rice husk is a low cost material which can be used in efficient bacterial deactivation process [13]. R. Priyanka and Sri M. Vagish collected water samples from Mandakki Bhatti, Davangere, Karnataka area and used natural filtration process using coconut shell, activated carbon, rice husk, sand and pebbles on a simple glass made filter design. In the filtered output water sample testing results they got 5.7 mg/L dissolved oxygen (D.O.), 7.1 pH value and 382 PPM total dissolved solids (TDS) values which are near to standard values required for potable water [14]. Sadon, F. N. et al explained in their work that rice husk has ability to filter heavy metals like Fe, Mn, Zn, Cu, Cd, and Pb with 90 to 100% efficiency. It can also be used to absorb different kind of dyeing agent during filtration process [15]. A. Carmalin Sophia et. al. experimental results explained that rice husk carbon is highly efficient compared to others in removal of E.coli with around 99% efficiency [16]. V. Kiruba Devi et. al. used solar distillation for waste water treatment and by testing of output samples they concluded that the values of D.O., pH, TDS are near for reuse the water in industrial or other purpose [17]. R. Asadi et. al. used industrial and sanitary waste water samples with solar distillation for waste water treatment process. They stated in their results that solar still is helpful technology to removing organic and inorganic contaminants from waste water with low cost. It can also remove bacteria from waste water [18].

Present work is an attempt to investigate the effectiveness of natural filtration and solar distillation in a combined manner for industrial waste water treatment. This work is different from the previous works as it includes both the methods for waste water treatment. It uses natural form of rice and coconut husk fiber for filtration process and more efficient design of solar distillation still with pyramid shape. Here details of the experiments and the results obtained related to pH, TDS and dissolved oxygen are reported and compared.

2. WASTE WATER TREATMENT EXPERIMENTAL SETUPS

The present work focused on study of industrial wastewater treatment by natural filters and solar distillation. Three different samples were taken from industrial units and were treated with help of natural filters and solar distillation stills. Various parameters such as pH, dissolved oxygen and total dissolved solids were determined at different steps. For natural filters the materials used were rice husk, activated carbon and coconut fibres. For solar distillation, pyramid shaped solar distillation still has been used as yield of pyramid solar still is

better than double slope solar still. The experiments have been conducted on the waste water taken to first observe the effect of filtration and then as a second step solar distillation of the filtered water was done.

2.1. Filtration

It is a process of removing contamination from waste water using physical, chemical and biological process. The filtered water can be used as drinking water, irrigation purpose, swimming and ponds water and other general domestic and commercial work as per quality requirement. The major filters we generally use are activated carbon filter, reverse osmosis, alkaline/water ionizer, UV filter and infrared filter.



Fig. 1. Activated carbon, rice husk fibre and coconut fibre respectively

In this experiment setup activated carbon, rice husk fibers and coconut husk fibers are used for filtration. Granular activated carbon (GAC) is generally used for removal of residual disinfectants and organic contaminant from water supply. This helps to improve tastes and reduce health hazards. Due to the multifunctional nature of this technique it is widely used. Natural fibers like rice husk and coconut husk are generally used in polymer industries[19].

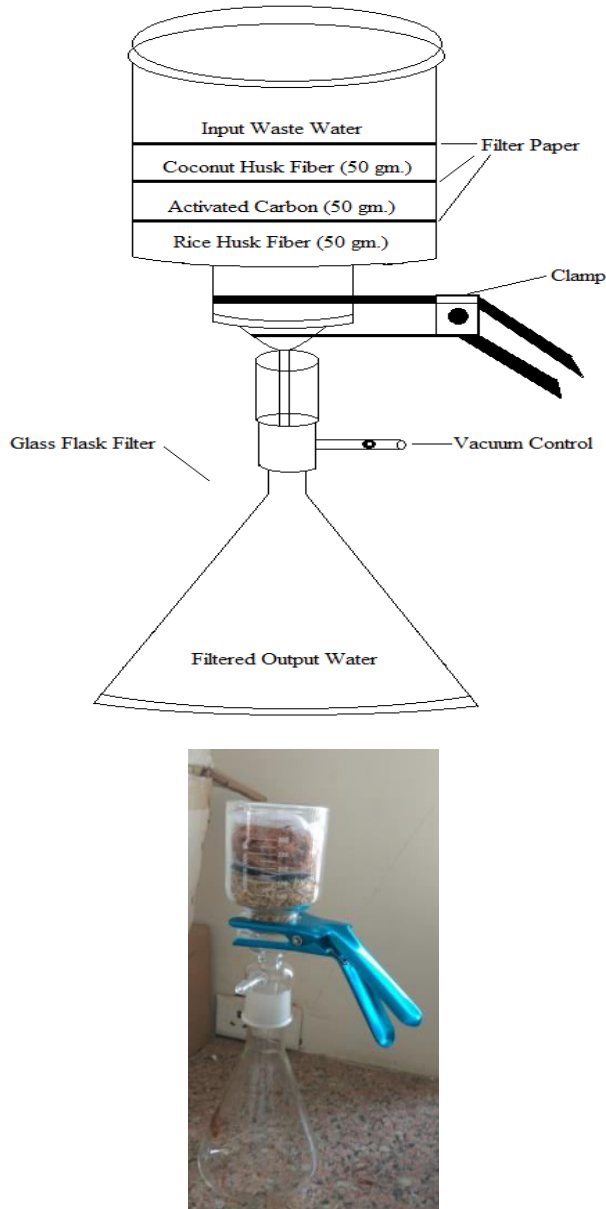


Fig. 2. Schematic and actual image of waste water filtration using activated carbon, rice and coconut husk fiber

The waste water samples of ammonia, cement and carbide from chemical and fertilizer industry at Kota, Rajasthan are used for the experimental work. 100 ml sample of water is taken for testing. 50gm. of each activated carbon, rice husk and coconut husk fiber is used as natural filter. The results of the values before and after filtration are shown in table 1.

Table 1. Experiment observation of filtration water treatment

Sr. No.	Waste Water Sample	Before Filtration Reading			After Filtration Reading		
		TDS (PPM)	pH	D.O. (mg/L)	TDS (PPM)	pH	D.O. (mg/L)
1	Ammonia (NH ₃)	310	8.70	1.3	274	8.30	2.5
2	Cement	510	10.40	2.5	460	10.10	5.4
3	Carbide	268	10.62	3.6	208	10.30	5.9

2.2. Solar Distillation

Solar distillation helps to get purified water from waste water. This is one of the best choices of water purification in remote areas where other option availability is rare. This distilled water with adequate level of qualities can also be used in batteries and hospitals. In the solar distillation process water is evaporated by absorbing solar radiation and separated from dissolved solids. Further, it is condensed and collected as potable water.

In general dissolved solids, water hardness (calcium, magnesium and other mineral compounds), molybdenum and selenium, nitrates and chlorides, arsenic, fluorides and heavy metals etc. can be removed efficiently using solar distillation approach [20]. The removal efficiency of bacteria and viruses using solar distillation is up to 99.9%. It should be considered that volatile organic compounds like petrol and alcoholic compounds cannot be removed as efficiently as others. In such case activated carbon filter process is recommended [21].

The same waste water samples of ammonia, cement and carboid from chemical industry in Kota, Rajasthan are used for this experimental work. The output distilled water is collected in separate bottles and then samples of each experiment are tested to get TDS, pH, D.O. (dissolved oxygen) values. Solar radiation and temperature is measured using pyranometer and digital thermometer. The experimental observations related to solar distillation are presented in table 3.

Table 2. Design parameters of solar distillation still

Sr. No	Parameter	Pyramid type Solar water distillation
1.	Base area of inner box	50 cm × 50 cm
2.	Aperture area of inner box	46 cm × 46 cm
3.	Base area of outer box	50.2 cm × 50.2 cm
4.	Aperture area of outer box	3025 cm ²
5.	Height of inner box	15 cm
6.	Height of inner box with absorber plate	15 cm
7.	Height of outer box	15.2 cm
8.	Height of glass center from absorber surface	30 cm
9.	Glass inclination angle	30°

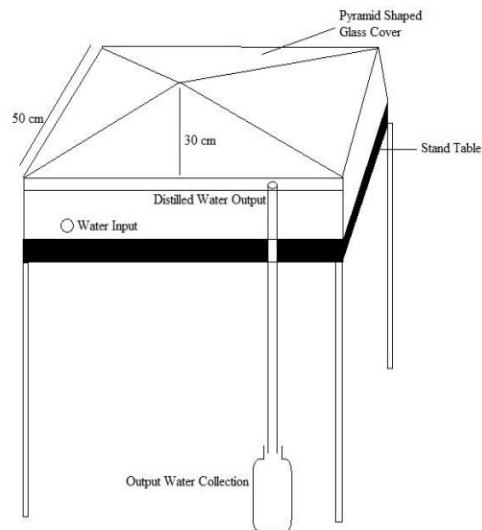


Fig. 3. Schematic of distillation still and distillation of waste water after filtration

Table 3. Experimental observations for distillation of waste water after filtration

Sr. No.	Temp. (°C)	Waste Water Sample	Waste Water Sample Reading			After Distillation Reading		
			TDS (PPM)	pH	D.O. (mg/L)	TDS (PPM)	pH	D.O. (mg/L)
1	30.2	Ammonia	310	8.70	1.3	107.00	7.70	2.80
2	30.3	Cement	510	10.40	2.5	288.00	8.50	7.90
3	30.5	Carbide	268	10.62	3.6	98.00	7.90	9.90

3. RESULTS AND DISCUSSION

Results obtained from both experimental set-ups for the ammonia, cement and carbide waste water samples are presented below in fig. 4, 5 and 6. From Fig.4, 5 and 6 it can be seen that the the TDS and pH value is reduced and D.O. value is increased after water treatment by filtration and distillation.

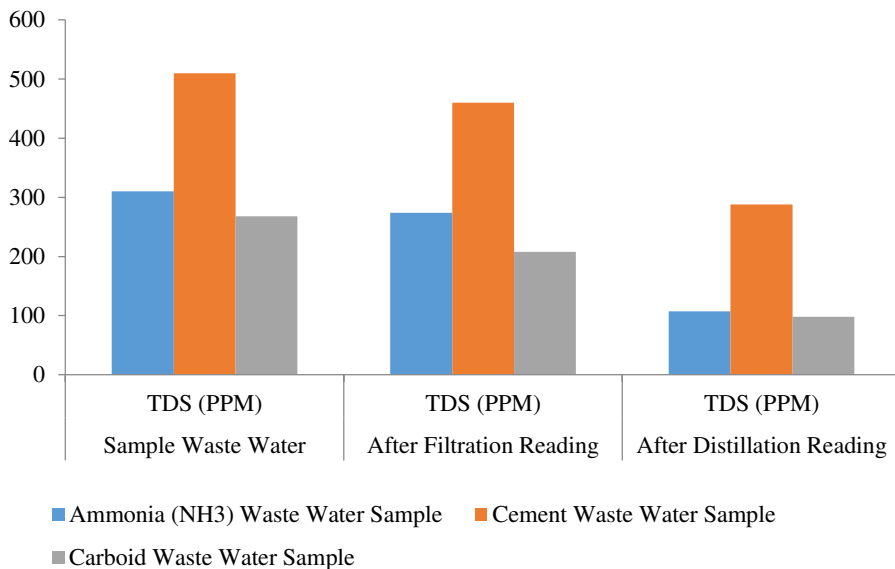


Fig. 4. Comparative TDS value before and after water treatment

It can be seen that for ammonia waste water sample the initial value of TDS was 310 ppm, pH was 8.7 pH and D.O. was 1.30 Mg/l. After natural filtration the value was 274 ppm, 8.30 pH and 2.50 Mg/L and after solar still distillation the value became 107 ppm, 7.70 pH and 2.80 Mg/L. Overall the Total Dissolved Solid value reduced to 34.50 %. For cement waste water sample TDS was 510 ppm, pH was 10.40 pH and D.O. was 2.50 Mg/L. After natural filtration the value was 460 ppm, 10.10 pH and 5.40 Mg/L after solar still distillation the value became 288 ppm, 8.50 pH, 7.90 Mg/L. Overall the Total Dissolved Solid

value reduced to 56.5 %. For carbide waste water sample initially TDS was 268 ppm, pH was 10.62 pH and D.O. was 3.60 Mg/L. After natural filtration the value was 208 ppm, 10.30 pH and 5.90 Mg/L and after solar still distillation the value became 98 ppm, 7.90 pH and 9.90 Mg/L. Overall the Total Dissolved Solid value reduced to 36.56 % .

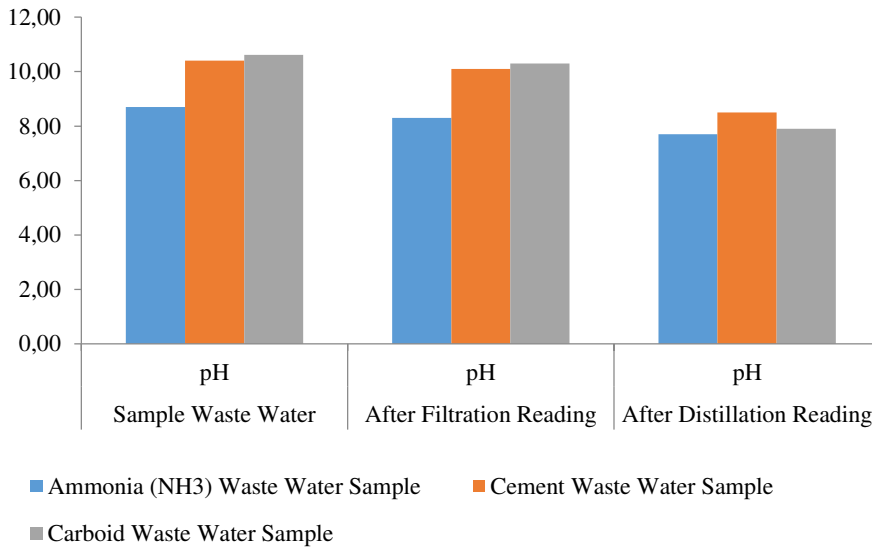


Fig. 5. Comparative pH value before and after water treatment

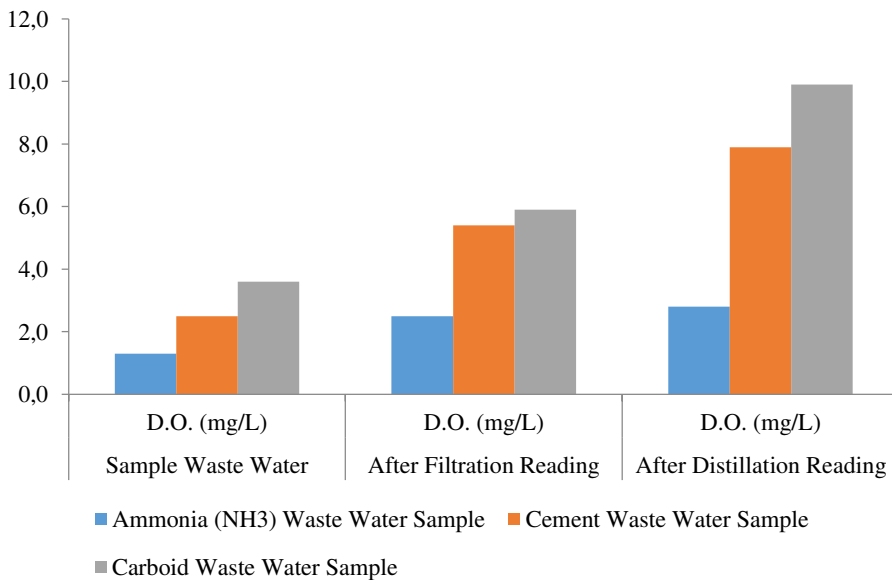


Fig. 6. Comparative D.O. value before and after water treatment

4. CONCLUSIONS

The results of the experiment show that natural filtration and solar distillation is helpful in waste water treatment. The Total Dissolved Solid (TDS) value reduced by 34.50 % for ammonia plant waste water, Total Dissolved Solid value reduced by 56.5 % for cement waste water, and Total Dissolved Solid value reduced by 36.56 % for carbide plant waste water. The obtained values of TDS, pH, and dissolved oxygen after combined treatment of filtration and distillation are quite close to standard values required for potable water. The results indicate that the combined use of natural filtration and solar distillation can prove to be a promising option for waste water treatment. This research will help to lay down the foundation of future work in the field of waste water treatment; further work is required for estimation of yield and time duration for up scaling of the system.

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