Deployment of Solar Energy in Reconditioning the Grey Water

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Abstract: ***The applicability and efficiency of solar energy in the treatment of Grey water (Sullage water) was investigated. The study reveals about the comparison of standard water quality parameters with grey water treated by harnessing the solar energy. The core objective of this paper aims in treating the grey water at low cost by designing and experimenting a lab scale solar distillation unit. Initially the grey water was collected from a domestic house drain (100 litres approximately) and preserved under laboratory condition. In parallel two solar distillation units (with and without Fresnel lenses (FL) arrangements) was designed and constructed to treat the collected grey water. The tests were performed under three different conditions by filling 25%, 50% and 100% of grew water (by volume) in the solar distillation units. A comparison was made to assess the performance of Solar Distillation Units (SDU). Results revel that the SDU aided with FL perform better than the one without FL arrangement.***

Keywords: Grey water, Solar Distillation Unit (SDU), Fresnel lenses (FL)

1. Introduction

Solar drive power can simply be defined as energy from the sun. The sun is considered to be a synthesis reactor. Its continuous fusion reaction is in control for the heat energy exuded by it. This exuded energy can transportable vast distances to nearby planets such as earth or planets millions of light years away. It emits 4×10^{26} W of energy of which only 1.7×10^{17} W reaches the earth. This means that the earth takes less than one billion of the suns power output. The sun is humankind's oldest energy source. Researchers and engineers have sought to use the supremacy of sunlight for a wide range of heating, lighting and manufacturing solicitations.

Water refinement is a typical mechanical or physical split - up method which is achieved by evaporation and condensation processes. Solar distillation contains the use of solar energy to achieve distillation. In simple solar water stills, a solar collector (Glass or Fresnel lens radiator) which traps the solar radiation and converts it to heat is used to evaporate the water contained in the distillation chamber of the still. The evaporated water as a result of saturation in the chamber condenses on the trapping side where the condensed water now passes through a collection pipe to the distillate storage tank.

The simplest design of a single basin solar still consists of an airtight, sloping transparent cover which encloses a black painted basin with waste water. Water evaporates after being heated up with the absorbed solar energy by the basin. Condensation occurred in the inner surface of the sloping cover and then distilled water is collected at the lower end of the cover. Despite its technical simplicity and relatively less maintenance requirement, solar still is not widely used due to the low productivity per unit installation area, normally 1~5 L/m 2/d for a single basin still. Consequently, large areas of land are required for the installation of solar still.
Factors affecting the productivity of a basin type solar still include absorption area, water depth, inlet water temperature, water - glass cover temperature difference, etc. Study research has been given by Ying Zhang et al. (2018). Extensive modifications have been carried out to improve the productivity of solar stills. The objectives of modifications are basically to enhance water evaporation in the basin, condensation on the cover or to recover latent heat of evaporation. One of the modifications which done in this study is the Addition of Fresnel Lens Radiator (FLR) to increase the productivity of treated water (see figure 1.4). Research has been done by Vinay Kommagoni et al. (2021).
Water costs of conventional fuel- based distillation technologies was estimated at \$ 4.7 - 5.7/m3 (365 - 443 INR), as per the investigated study of Ayoub et al. But this treatment method lies in the lower range of renewable energy - based distillation techniques. In view of the low productivity, solar still is only recommended for small scale commercial application with the capacity of less than 10 m^3 /d to supply freshwater for fisherman, small islands and small villages in remote areas. Except for the efforts in performance improvement, to keep the simplicity, low maintenance and low - cost feature of solar still is also of vital importance.

Thus, the solar still with FLR should not be a future focus. As pilot or real plants has not been reported in recent years, real application studies should be conducted to further demonstrate and evaluate the applicability and economic feasibility of this technology in the present world.

2. Materials and Methods

The solar still basin (Fig 1) design is similar to that of the previous studies conducted by the authors on "Application of solar energy in water treatment process: A review".

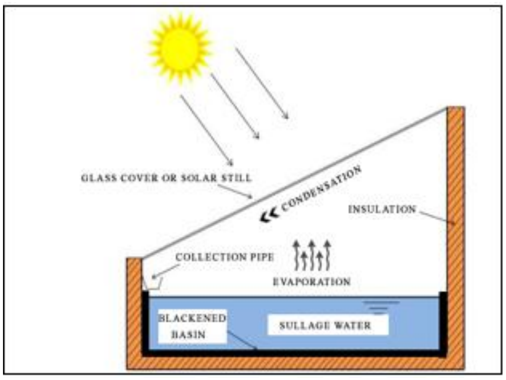

Figure 1: Solar still diagram

The basin is made up of insulation as wooden box with Thermal coal coated at inner side. (To avoid the escape of heat from the kit) and holds a 30° inclined glass solar still placed at top (Fig 1).

To act as a path for condensation of the evaporated water and a way to reach bottom, a collection pipe is attached to collect the treated water. More similar another unit (Fig 2) was made with addition of Fresnel Lens (FLU) and adjustable stand to attain the focal length for maximum efficiency.

Figure 2: Solar Distillation (without FLR)

Figure 3: Solar Distillations (with FLR)

The experiment was carried out for a period 20 days. As stated earlier the grey water was filled at 3 different volumes in the SDU's (25%, 50% and 100%) in the 2 units. The temperature at 3 different points (Ambient, inside SDU's and on the still glass surface) were recorded with the aid of a thermometer with high degree of measurements (- 50°c to +300°c) is used.

3. Results and Discussion

The figures given in these sections explain the pictorial representation of obtained readings. The graphical representation the temperature of water cross the still temperature at a particular point; i. e., the still temperature is low at morning and evening but high at noon that which creates a gradual curve which shows the rise and fall in still temperature. The temperature of ambience shows similar response as same as still temperature. But, the water temperature doesn't coincide with it at any point.

On the other hand, the water temperature also lowers at morning and evening but higher in noon. But at a particular point of fall in still temperature (i. e., at evening – due to sunset), the water temperature crosses and rises above the still temperature. However, the water temperature is lower than that of still temperature at that point it starts rising above the still temperature by kept the heat within it.

Experimentation in SDU without FL

The Graphical representation of temperature variations and bar diagram representing the average temperatures are as follows;

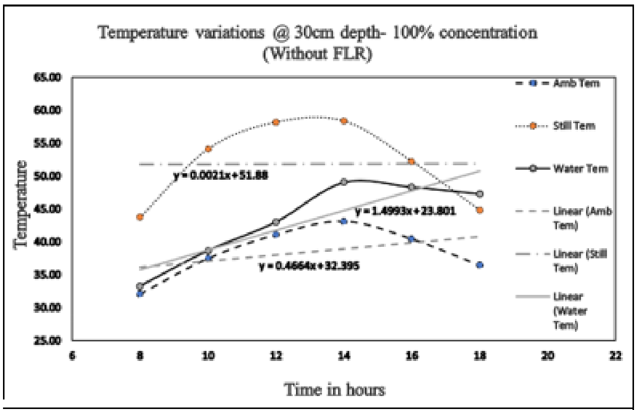

Figure 4: Temperature variations

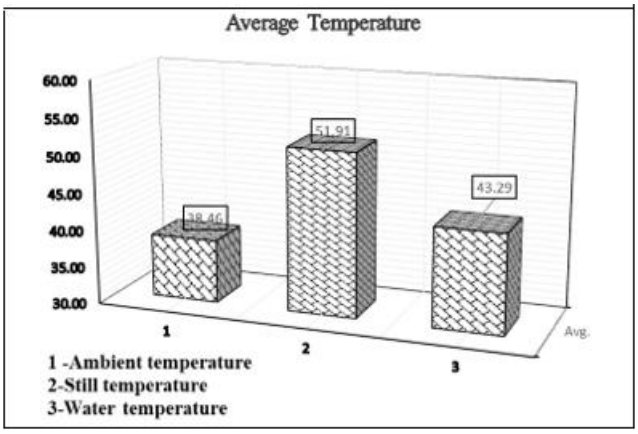

Figure 5: Average temperature variations

The above figure shows the entire temperature variations at constant time intervals. Figure 4 represents the temperatures of ambience, still and water at 100% loading in the unit; and the average of day 1 and day 2. The efficiency increase from

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day 1 to day 2 is 24%. The overall efficiency of this section 1 is 2.8%. Figure 5 contains the temperatures of ambience, still and water at 20 cm depth – 100% concentration; and the average of day 3 & day 4. The efficiency decreases from day 3 to day 4 is only 21 %. The overall efficiency of this section 2 is 0.9%.

The Figures 4 & 5 shows the Graphical representation of temperature variations at constat time intervals and Bar diagram representing the average temperatures of Ambience, Temperature inside the still and the water temperature respectively, of section 1.

Figure 6 and 7 shows the pictorial representation of the readings obtained in FLU unit.

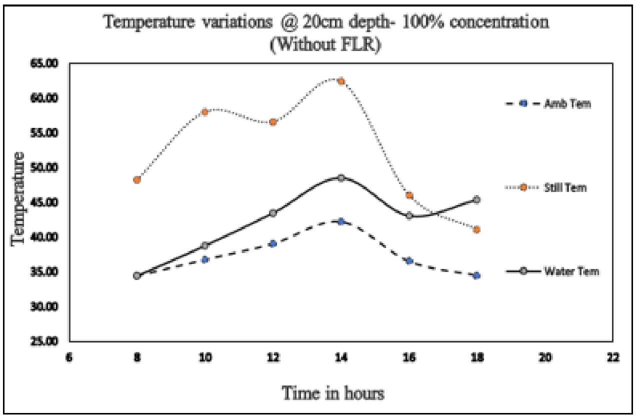

Figure 6: Temperature variations

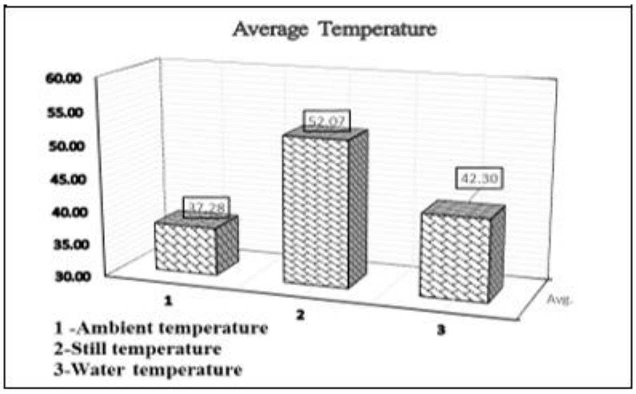

Figure 7: Average temperature variations

The above figure shows the entire temperature variations at constant time intervals. Section 3 contains the temperatures of ambience, still and water at 10cm depth – 100% concentration; and the average of day 5 & day 6. The efficiency increase from day 5 to day 6 is only 5 %. The overall efficiency of this section 3 is 2 %. From these data monitored, we optimized that Section 1 - 30cm depth gives more efficiency other than section 3 & 4.

By experimenting the second set of this study, we tested the Sullage water at various concentrations. And taken the readings of section 1 for section 4, because of their similarity. Section 4 contains the temperatures of ambience, still and water at 30cm depth – 100% concentration; and the average of day 1 & day 2. The efficiency decreases from day 1 to day 2 is 24 %. The overall efficiency of this section 4 is 2.8 %.

The table 4.2 shows the entire temperature variations at constant time intervals. Section 3 contains the temperatures of ambience, still and water at 10cm depth – 100% concentration; and the average of day 5 & day 6. The efficiency increase from day 5 to day 6 is only 5 %. The overall efficiency of this section 3 is 2 %. From these data monitored, we optimized that Section 1 - 30cm depth gives more efficiency other than section 3 & 4.

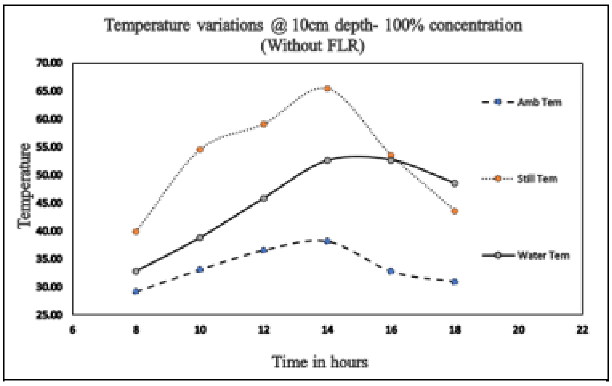

Figure 8: Temperature variations

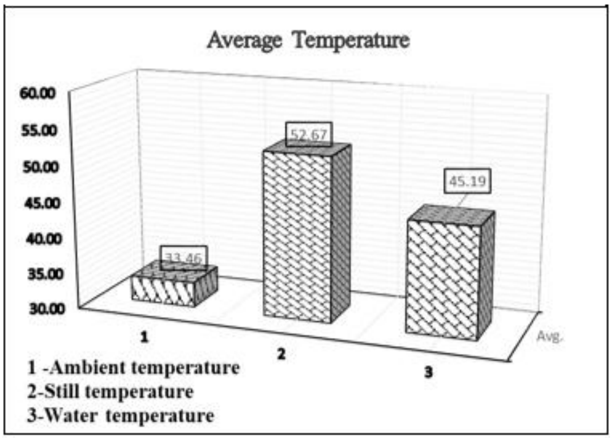

Figure 9: Average temperature variations

By experimenting the second set of this study, we tested the Sullage water at various concentrations. And taken the readings of section 1 for section 4, because of their similarity. Section 4 contains the temperatures of ambience, still and water at 30cm depth – 100% concentration; and the average of day 1 & day 2. The efficiency decreases from day 1 to day 2 is 24 %. The overall efficiency of this section 4 is 2.8 %.

Experimentation in SDU with FL

The Figures 8 and 9 shows the Graphical representation of temperature variations at constant time intervals and Bar diagram representing the average temperatures of Ambience, Temperature inside the still and the water temperature respectively, of section 7.

The Graphical representation of temperature variations and bar diagram representing the average temperatures of section 7 are as follows;

By experimenting the Third set of this study, by testing the sullage water with FLR to increase efficiency. The procedures are same as that of all and tested it with 100% concentration at 30 cm depth.

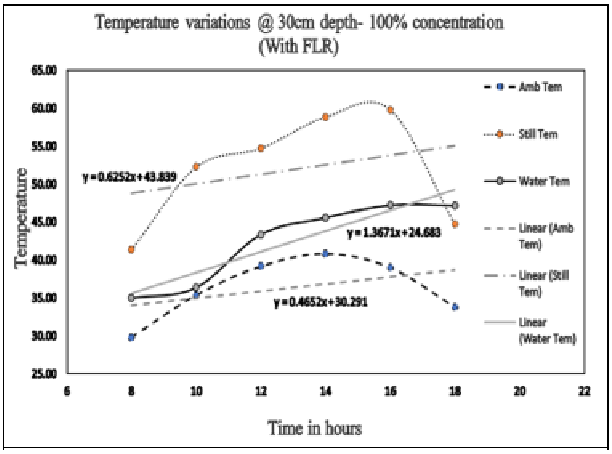

Figure 10: Temperature variations

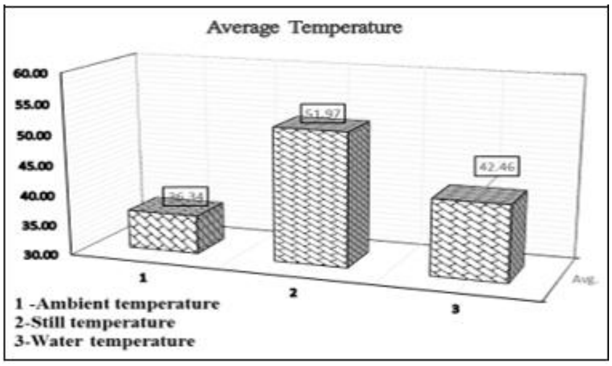

Figure 11: Average temperature variations

The figure 10 and 11 shows the entire temperature variations at constant time intervals. Section 7 contains the temperatures of ambience, still and water at 30 cm depth – 100 % concentration; and the average of day 11 to day 16. The efficiency increase from day 11 to day 16 is 31 %. The overall efficiency of this section 7 is 3.5%.

As comparison with the experimentation without FLR at same depth & concentration (i. e., 30cm depth – 100% concentration), the experimentation with FLR at same depth & concentration gives more efficiency. And the percentage change between them is about,

% change = [(Final - Initial) / Initial] x 100
= [(923 - 630) / 630] x 100
= 0.465 x 100
= 46.5 %
% change = 47 %

Quality of water treaded

The table 4.5, 4.6 & 4.7 shows the parameters monitored at this study and shows the variations or result before and after treatment. The pH of the treated water is slightly increases and greater than that of raw sample taken. The increase in pH is due to the low quantity of treated water, like the acid rainfall at volcanic regions. If the quantity of treated water increases, the pH decreases. The other parameters such as Electrical conductivity, TDS and Turbidity are decreases after treatment. The decrease in Electrical conductivity, TDS and Turbidity are discussed below;

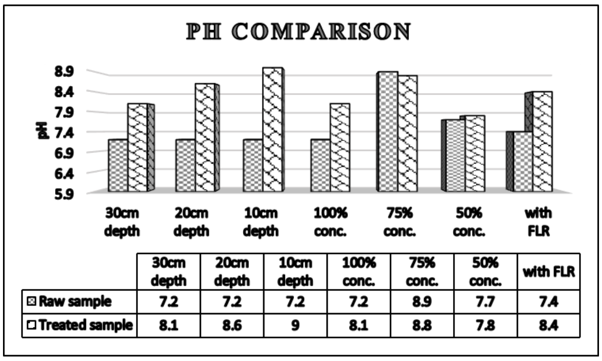

Figure 12: Temperature variations

At section 1, the increase in pH is about 13%. And 19%, 25%, 11%, 13% & 14% at section 2, 3, 4, 5, 6 & 7 respectively.

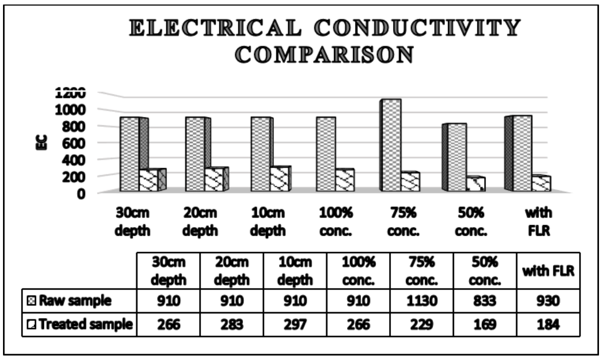

Figure 13: Temperature variations

The decrease in EC is about 71%, 69%, 67%, 71%, 80%, 80% & 80% at section 1, 2, 3, 4, 5, 6 & 7 respectively. The decrease in Turbidity is about 88%, 93%, 92%, 88%, 93%, 96% & 98% at section 1, 2, 3, 4, 5, 6 & 7 respectively.

The treated water quality parameters were picoted and compared with the raw grey water is given in the Figures 12, 13, 14 and 15 respectively. It shows the diagrammatic comparison between raw and treated water, of pH, EC, TDS & Turbidity respectively. The average percentage of increase in pH is 12 %, decrease in EC is 74%, TDS is 75% and Turbidity is 93%. The increase in pH will reduce if the quantity of treated water is more.

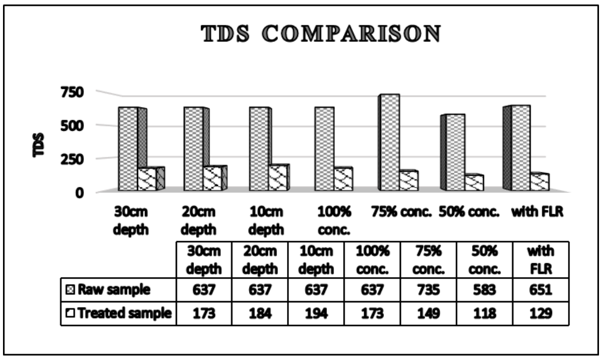

Figure 14: Temperature variations

The decrease in TDS is about 73%, 71%, 70%, 73%, 80%, 80% & 80% at section 1, 2, 3, 4, 5, 6 & 7 respectively.

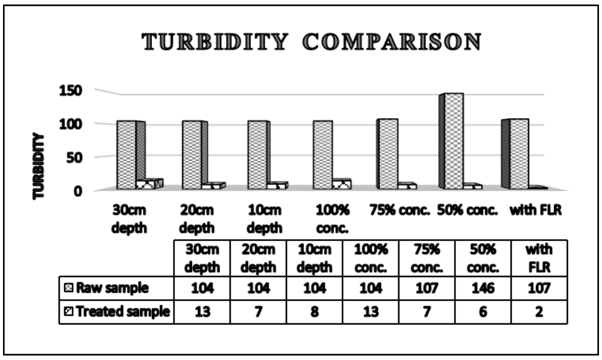

Figure 15: Temperature variations

Figure 16: Comparison of Raw and Treated water

Figure 16 shows the comparison of raw sullage taken and the treated water obtained. The other physical parameters such as Temperature, colour, taste and odour of the treated water are good and acceptable.

4. Conclusion

The experimental study concluded that, the waste water treatment using solar distillation process can be useful for small scale water treatment plants by increasing the surface area and by placing an effective Fresnel lens radiator suitable for that surface area to attain tolerable efficiency. The objectives of this study such as: to treat the waste water at low cost, to reduce the pollution load in disposal waste water, to ensure the availability of treated water for reuse at low cost with any harmful effects on any sources; are successfully attained. Moreover, also helps in creating a clean, healthy and wealthy environment by reducing the pollution load; reduces ground water contamination. By providing a proper waste water management, it can prevent the water borne diseases spreads and thus improve the standards of treated water quality at extremely low cost and without the emissions of fossil fuels and other greenhouse gases.

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