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Fabrication of solar water distillation system

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Abstract
The purpose of this project is to fabricate a solar water distillation system that can purify the water, which is impure by using a systematic arrangement must have low cost for manufacturing and works based on renewable energy of solar. There is less amount of water only left on earth that is safe to drink without purification after 20-25 years from today. 99% of Earth's water is in a solid state and other impure form and the remaining is in liquid form. Due to this reason, water purification is necessary. Because of this, purposes the solar still is constructed which will convert the impure water into pure water using the renewable solar energy. The incoming solar radiation from the sun is heating the water, which placed in the basin in impure form, and this water gets evaporated and condensed into pure drinkable water.

Index Terms*— *Distillation system, Polluted water, Purification, Solar energy.

I. Introduction

The one of the methods to purify the polluted water called solar water distillation system and it can be call as solar still. It is a system used to distillation of water. In my project I am constructed both black and white coated solar stills and find out the coating which gives more efficiency by experiments.

Single-basin solar still construction is easy, low cost and effective in distilling water with a high total dissolved salt content and bacteria removal. The average water production is about 0.5 litres per square meter per sun hour [1]. The single basin solar still can be used for water distillation. The glass at the basin used to allow the sunlight to pass through it to attain the water. The analysis made with the distillate showed that removal of salts is compatible with a distillation of common water, the values of chlorides and sulphates in distillate are at least than 2 mg/L and zero respectively. From the water, salt content was removed, which reached values greater than 80% [2].

The performance evaluation carried out on the fabricated Solar Still has shown that it can be used for the salty water desalinization. The results have shown that a high enough temperature was attained which produced evaporation and the distillate produced and that is pure can be used for drinking. The solar still having a capacity of 79355cm^3 and produces a yield of 0.39 litres [3]. This

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design comprises of two already existing methods of purifying water, such as the Solar Still and the SODIS (Solar water Disinfection). The aim and objective of this research study were achieved as an improved solar water purifier was designed and developed by improving the efficiency of the solar stills which having efficiencies between 38% and 47%. The percentage of pure water testing has an average rate of 65% [4].

Double basin solar still coupled with evacuated tubes was constructed and tested. Several experiments have done to enhance the distillate output of a solar still. The performance of alone double basin solar still was compared with that of still coupled with evacuated tubes with and without coating of black. At the result, distillate output is increased to 56% by adding vacuum tubes and 65% by adding vacuum tubes and black granite gravel in a double basin solar still [5]. The performance of an ordinary still was compared with the still coupled with evacuated tubes and found that the production of water has increased to 50.2% by introducing the evacuated tubes [6].

Comparison of different solar stills which are pyramid and stepwise basin solar still are taken with its different parameters like water temperature, glass thickness, water surface area and absorber plate, these will affect solar still productivity and efficiency, because of variable solar still designs. As a result Stepwise solar still gives much better as compared to all solar still because of its large absorption area. The stepwise solar still has higher efficiency than other solar stills [7]. The fabrication of seven solar still designs and their performance evaluation in converting brackish water into fresh water for drinking are presented with the experimental results and the maximum amount of productivity is obtained by tubular solar still coupled pyramid solar still [8].

Newly developed W-shape solar still with three channels erected on soil was economical for the average output of 2104 ml/day pure water. Concentration of total dissolved salts and ions in solar distilled water was found [9]. Both the passive solar still and active solar still accelerates more and more solar energy utilization for desalination of water in a cost effective manner. For rural people in villages, wick or capillary type passive solar still seems to be an attractive choice to get water for drinking and other domestic purposes [10].

The multistage solar desalination system with heat recovery system produces a higher yield than the normal solar still. The length of still, depth of water which impure, radiation and the temperature of inlet water are the major parameters which affect the performance of the still. Higher productivity during night time is achieved by using energy storing materials in the active solar stills [11].

The symmetrical design has more area where the occurrence of heat loss. As result, the solar still of asymmetrical shape with mirrors is a superior design with greater efficiency and higher overall water output. In conclusion, the basic asymmetrical still design is more efficient and less expensive [12]. The experiment is performed in winter season from 10:00am to 04:00pm. Time taken by the drop for trickles down to the channel is 1 hour. Time taken by drop to come out from the channel is 30 min. 14 litres impure water was poured at the beginning of the experiment. The purified water of 1.5 litres got at the end of the experiment and the condensation is occurred at 31^0C of water. Between the time periods from 11:15 am to 1:30 pm the maximum evaporation is obtained. The

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obtained maximum temperature is 53^0C at 1:30 pm and then decrease in the temperature. We have poured 12 litres of impure water and at the end of the experiment obtained 1.5 litres which is carried out in winter season [13].

The evaporation rate can be increased effectively by coating the solar still base with photo-catalyst materials, or by pre-heating the inlet water of still. The easily available GAC is one of the best photo-catalyst materials suitable for the evaporation rate enhancement in solar still. Solar pond is efficient for pre-heating the inlet water to solar still. Hence, by the combination of GAC (granular activated carbon) coating and solar-pond technology the evaporation rate can be increased and the solar still efficiency also increased [14].

Solar energy utilization in five different shapes of solar stills is taken. The glass cover of the solar still was tilted at angles of 15 degree, 25 degree, 35 degree and 45 degree. This is to find the angle for glass cover inclination. The results of the present study indicated that the double inclination solar still with a glass cover inclination of 15^0C and an inner surface area of 11645 cm^2 is the best suited among the five models which have been constructed [15]. In the single basin solar still testing is performed for 30^0 and 23^0 inclinations, As a result that 30 degree inclination of the solar still is more efficient [16].

Various glass thicknesses have been tested and proved that 4mm glass thickness is more efficient [17]. 3 solar stills with similar in dimensions were manufactured from metal attached to pyramidal glass with angle ($\alpha = 45°$) were evaluated and tested. Various amount of water is poured to find the effect of the water depth in the basin. They are (3, 6 and 9 litres). The contaminants are removed in the process of distillation [18]. The increase in the pure water output is obtained by decrease in the depth of water. The increase in absorptive of water and increase the evaporation rate of the water inside the solar still is best in black coated solar still [19].

In this paper, solar water distillation system was fabricated and the above literature survey dealing with the various design of solar water distillation system, various glass thicknesses, Tilting angles and using the various vacuum tubes are used to improve the performance of solar water distillation systems are available, but in literature survey dealing with different types coatings for the same dimensional solar water distillation system are not available. Hence two numbers of same solar water distillation systems was fabricated with two different coatings and the performance of each systems were analysed.

II. Solar Still Components

The components of a solar still from the figure 1: Wood boundary (except top surface), Glass (only on top surface), Inlet pipe, Outlet pipe, Trough for collecting the distilled water, Colour coatings (black and white), The tube connecting from outlet to pure water storage and Storage bottle.

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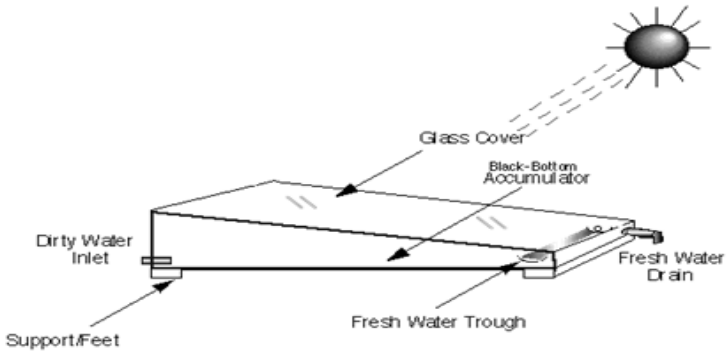

Figure 1. Components of Solar Still

III. Operation technique

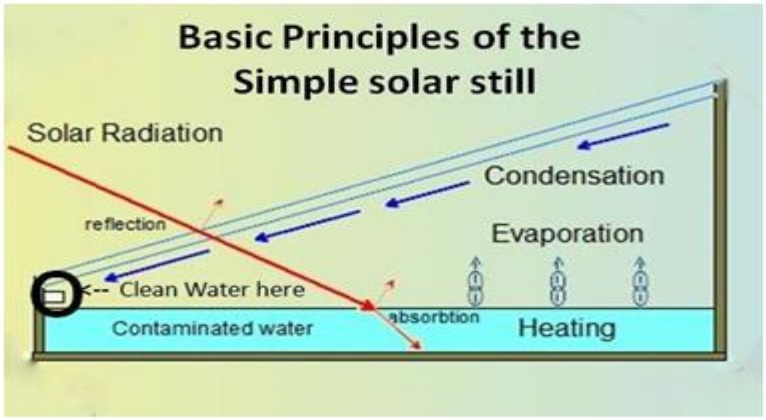

Figure 2. Solar Still Operation

The figure 2 explains about the basic operation of the single basin solar still. Water to be cleaned is poured into the still to fill at certain amount of the basin. The glass cover allows the solar radiation to passes through and it reaches the bottom of the still which is mostly absorbed by the base because the surface is coated with black colour material to increase the sun heat absorption. The water begins to heat up and the moisture content of the air trapped between the water surface and the glass cover. Due to heating water gets evaporated from the basin and condenses on the inside of the cover of the glass. In this process, the impurities that present in the initial water are settled in the base itself and only Condensed water trickles in the inclined glass cover towards downward direction to collection trough and it is stored in the bottle. Every day the basin of the solar still must be cleaned to remove the settled salt contents and impurities. By removing these only we can absorb more amount of heat energy without wastage.

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IV. Dimensions

Figure 3. Solar Still with White Coating

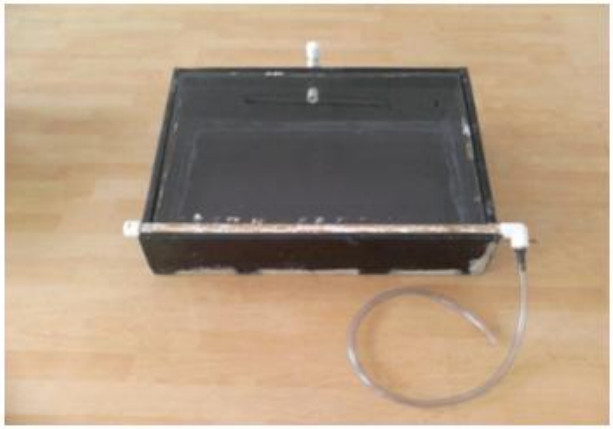

Figure 4. Solar Still with Black Coating

The constructed solar still which is coated with white (figure 3) and black (figure 4) color are tested. The two solar stills having the same dimensions. The dimensions are of wooden box and glass cover is shown in table 1.

Table 1 Wooden box and glass cover dimensions

WOODEN BOX		GLASS COVER	
Length	75 cm	Length	72 cm
Width	53.5 cm		
Height (front)	15 cm		
Height (back)	22 cm	Width	51 cm
Thickness	1.5 cm		
Diagonal	87 cm		
Top slope length	54 cm	Thickness	4 mm
Angle	15°C		

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V. Readings taken

Table 2 White solar still reading

TIME	TEMPERATURE OF WATER (°C)
09.00 AM	00
10.00 AM	20
11.00 AM	26
12.00 PM	33
01.00 PM	53
02.00 PM	49
03.00 PM	46
04.00 PM	42

Table 3 Black solar still reading

TIME	TEMPERATURE OF WATER °C
09.00 AM	00
10.00 AM	10
11.00 AM	19
12.00 PM	49
01.00 PM	76
02.00 PM	65
03.00 PM	52
04.00 PM	49

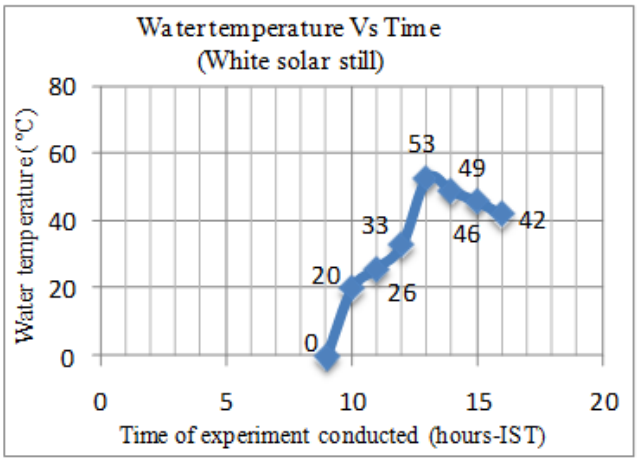

Figure 5. Temperature vs Time

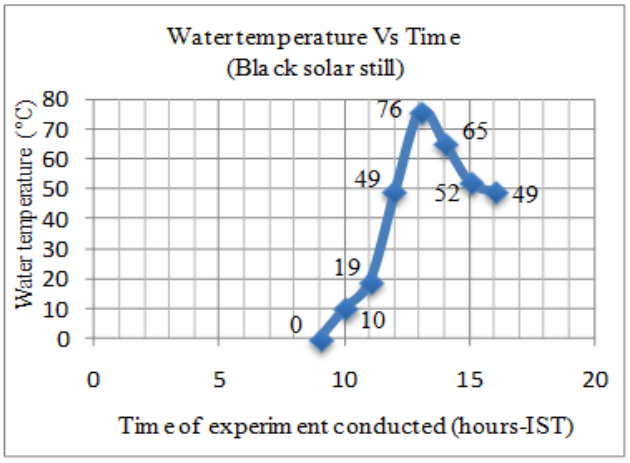

Figure 6. Temperature vs Time

The temperature of the water taken by the white and black solar stills at gradual time difference is shown in the table 2 and 3 respectively. The related graph based on the taken readings is shown in the figure 5 and 6 respectively.

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VI. Conclusion

Distillation of water using solar still basin is the most economical method to get portable drinking water. Salt, bacteria and other impurities are contaminated which are to be removed completely in the distillation process. The solar stills are best technology for living beings and environment because they do not need electricity for processing, no running water is required, lifetime is more and easy to maintain. In the experiment it has found that the black coated solar still is more effective when compared with the white coated solar still.

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