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Charperformance Analysis of Different Energy Absorbing Plates on Solar Stills

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Abstract: Solar distillation mimics nature's hydrologic water cycle by purify water through evaporation as well as condensation. It is one of the most basic purification systems available today to get high quality of drinking water and can remove non-volatile contamination from almost any water source. Solar still is a one kind of solar distillation system in which brackish or impure water converted into drinkable water. Here, three solar stills have developed by locally available materials. The first one is a conventional type and the second solar still is consists of Aluminum plate while the third one consists of Galvanized iron. Here, experiment performed to get higher distillate output from solar still. Experiments represent that, solar still consists of aluminum plate gives 30 % more output compared with conventional solar still and Galvanized iron plate inside solar still gives 12% more output compared with conventional solar still. Hence, Aluminum plate is the best plate to obtain higher distillate output from solar still.

Key words: Solar still · Al. Plate-Aluminum plate · GI. Plate-Galvanized iron plate · Distillate output

INTRODUCTION

The supply of drinking water is one of the major problems in developing countries as well as under developing countries. Clean or potable water is a basin human necessity and without water the life will be impossible. Nowadays the pollution in rivers and lakes by industrial effluents and sewage disposal resulted in scarcity of fresh water in many big cities around the world. In addition with an ever increasing population and rapid growth of industrialization, there is a great demand of fresh water, especially drinking [1].

Solar still can also work as geyser. S. H. Sengar and A K Kurchania [2] made solar geyser cum distiller (SGD) having capacity of 100 Liter designed. They got overall efficiency of SGD which was found to be 36.70 and 27.48% during winter and summer, respectively. They also got distillate water of 5 l/ m^2.day. Rasool Kalbasi and Mehdi Nasr Esfahani [3] made a passive double effect desalination system and tested in climate conditions of central states of Iran (Isfahan). They found that double effect desalination system would increase distillate output of brackish water. S. M. Radwan *et al.* [4] made experimental set up of solar still and tested in climate conditions of Egypt by taking various variables like solar insolation, different depth of water inside solar still, wind speed etc. They found that all of above variables have great impact on distillate output as well as efficiency of solar still.

Some investigators used different dyes [5-7] in solar still. They used different dyes and proved that, black dye increase the distillate output from solar still among other dyes. Inlet temperature of water can also increase the distillate output of solar still; hence, some researchers [8-10] used various external sources like flat plate collector, storage tank, etc. They showed that, there is a great improvement in solar still efficiency.

Abu Hiljeh and Rababah [11] made an experimental performance of solar still with different size of energy absorbing materials like black coal, black steel cubes. They found that there is a great improvement in distillate output of solar still from 18 to 273 % compared with conventional solar still. Some researchers have also made experiment with some solid materials or energy absorbing materials inside solar still [12].

From above literature reviews, it confirms that solar still is very important device to convert brackish water into drinkable water. Main aim of this present study is to evaluate effect of various energy absorbing plates in order to improve distillate output of solar still.

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Fig. 1: Experimental Set up of Solar stills

Table 1: Experimental instruments with accuracy and percentage errors

Instrument	Accuracy	% Error
sSolarimeter	± 1 W/m^2	0.5
Temperature Indicator	± 0.1°C	0.5
Measuring Flask	± 1 ml	1
Anemometer	± 0.1 m/s	1

Expreimental Set up: Here, all three solar stills have basin area of 1 m^2 (40 ×180 cm). The still made of iron sheets (3.0 mm thick). The whole basin surfaces coated with black paint from inside to increase the absorptivity. Also, the still insulated from the bottom to the side walls with sawdust 5 cm thick to cut the heat loss from the still to atmosphere. The insulation layer was supported by a wooden frame. The basin covered with a glass sheet 3 mm thick inclined at nearly 30° horizontally. Here, experiment conducted in climate conditions of Mehsana (23° 43' N, 72° 37') Gujarat. The whole experimental setup is kept in the south direction to receive maximum solar radiation. Here, steady state condition preferred for experiment. Fig. 1 shows experimental set up.

Feed water tank of 50×50×50 cm^3 is used to feed water to all solar stills. The feed water tank is connected to the main line which is divided into three feed water lines. A flow control valve is integrated at each line inlet to regulate the flow rate of water The experimental setup is suitably instrumented to measure the temperatures at different points of the still (brine, absorber and glass cover temperatures), total solar radiation and the amount of distillate water. The temperatures have been measured using calibrated copper constantan type thermocouples. The solar radiation intensity is measured instantaneously by a solarimeter. The digital air flow/volume meter is used to measure the wind velocity. Table 1 shows the different instruments as well as their accuracies used in this experiment.

Expremental Procedure: Experiments were carried out from 9 a.m. morning to 8 p.m. evening during July 2011. The solar radiation, atmospheric temperature, basin temperature, glass temperature and distillate water were measured every 1 hour for maintaining steady state conditions. All measurements were performed to evaluate the performance of the stills under the climate conditions Mehsana. During the experiments, the ambient climatic conditions (solar radiation, ambient temperature and wind velocity) were also measured.

Saline water in still is heated by solar radiation. The water vapor formed is condensed at the inner glass surface and the water droplets are glided along the glass. The condensed water is collected in a calibrated flask. The depth of the saline water in the solar stills is maintained constant manually using the feed water tank and control valves. Fig. 2 shows aluminum plate and galvanized iron plate used in solar still.

(a)  (b) 

Fig. 2: Plates used in solar stills (a) Aluminum Plate (b) Galvanized Iron Plate

RESULTS AND DISCISSION

Depending upon the weather conditions of Mehsana, Gujarat, wind speed is varied from 1.5 to 4.5 m/s at different days of June 2011 and solar insolation is also varied from 30 to 1200 watt/m^2.

Variation of Solar insulation versus time (h) is shown in Fig. 3. It remains same for all solar stills. Because the solar insolation incident on all solar stills equally. Fig. 4 shows basin water temperatures of all solar stills versus Time (h). It is shown that temperatures at all points increased as the time increases till a maximum value during afternoon (maximum solar radiation fall on earth surface during afternoon; hence, maximum value obtain in the afternoon). It is also observed that maximum value in basin temperature reached during period of 3:00 to 4:00 p.m. for all solar still due to great availability of solar radiation as well as warming of solar still from early morning to afternoon. It also shows that the highest temperature gained by solar still having Aluminum plate compared with solar still having GI plate as well as Conventional solar still. It is increased due to its higher thermal conductivity.

Fig. 5 shows comparison between hourly distillate outputs gained in all three solar stills like solar still having Al. plate, GI plate as well as conventional solar still. It shows that, maximum distillate output gained in the afternoon. It is observed that during starting of readings, all the readings have initial output of zero at 9:00 am; then, it increased up to 3 pm and then decreases gradually. Here, the highest distillate output produced by solar still of Al. plate (20.05 L) because it has lowest quantity of brackish water inside the solar still. So, it takes short time for evaporation as well as condensation. Solar still having GI plate has brackish water of 25.20 L and conventional solar has quantity of 29.50 L.

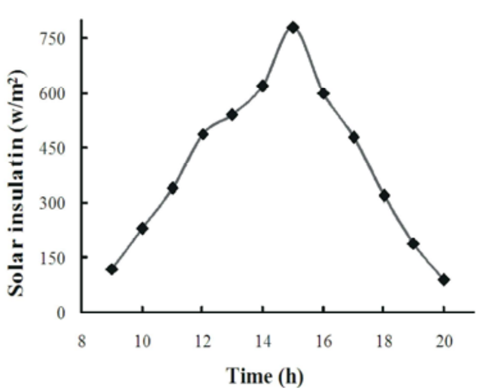

Fig. 3: Comparison of solar insolation and Time Climate conditions of Mehsana (7/06/2011)

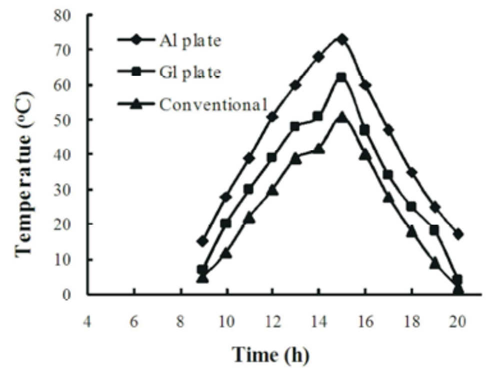

Fig. 4: Comparison of hourly variation of basin water temperature and Time at constant water depth of 40 mm in climate conditions of Mehsana.

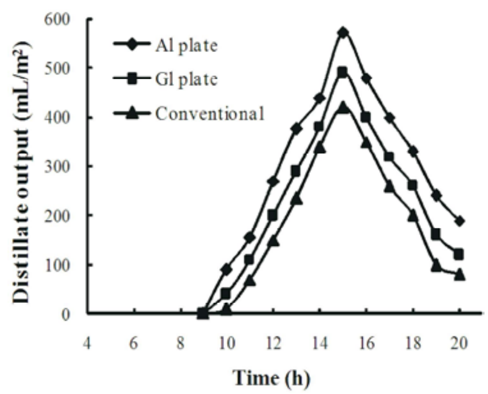

Fig. 5: Comparison of hourly variation of distillate output and Time at constant water depth of 40 mm in climate conditions of Mehsana. (07/06/2011)

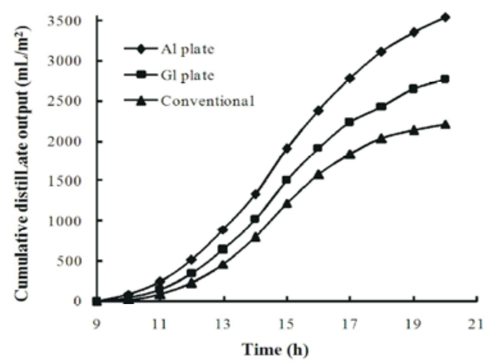

Fig. 6: Comparison cumulative distillate output and Time at constant water depth of 40 mm in climate conditions of Mehsana. (07/06/2011)

From the quantity of brackish water inside the solar stills, it is shown that, due to large amount of brackish water inside the conventional solar still, it require highest time for evaporation as well as condensation. Hence, quantity of distillate output produced from conventional solar still is lower than others.

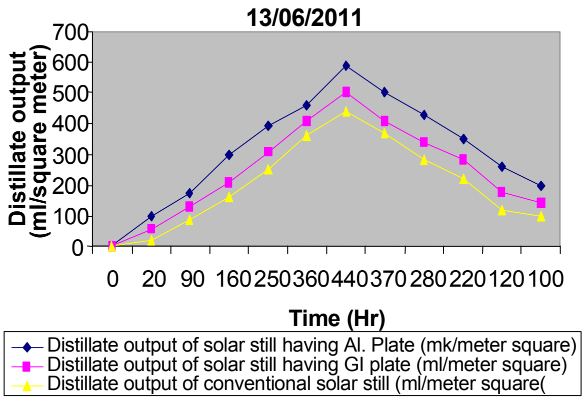

Fig. 7: Comparison of hourly variation of distillate output and Time at constant water depth of 40 mm in climate conditions of Mehsana. (13/06/2011)

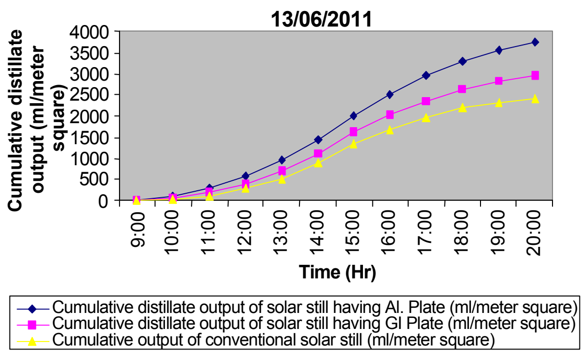

Fig. 8: Comparison cumulative distillate output and Time at constant water depth of 40 mm in climate conditions of Mehsana. (13/06/2011*)*

Table 2: Comparison of tested solar stills of 40 mm depth of water as well as 30 L storage of brackish water in solar stills

Date	Conventional Solar still	Solar still having GI Plate	Solar Still having Al. Plate
Distillate output at water depth of 40 mm and Quantity of water 30 L			
7/06/2011	2300	2600	3212
13/06/2011	2410	2970	3500
Total	4710	5570	6712

Fig. 6 shows comparison of accumulated distillate water versus time for all solar stills. It is shown that, the highest accumulated distillate water gained by solar still having Aluminum plate and the least gained by conventional solar still. Here, hourly distillate output gained by Aluminum plate solar still is more compared with Galvanized iron plate as well as conventional solar still. Figs. 7 and 8 explain hourly distillate output as well as cumulative distillate output during 13/06/2011.

Table 2 represents the comparison of solar stills at two particular days of June 2011. Here, 40 mm depth of water and feed tank of 30 Liter taken for experiment with solar stills. It shows that, highest distillate output obtained by Al. Plate Solar still compared with GI Solar still and conventional solar still. Total distillate output obtained by Al. solar still was 6712 ml, GI solar still was 5570 and conventional solar still was 4710 ml. It shows that, improvement of distillate output of 30% in Al. solar still and 12 % in GI Solar still compared with conventional Solar still.

CONCLUSION

Solar still is very simple and cheap solar operated system to convert brackish water into drinkable water. In present Experiment, use of various energy absorbing plates, which increases the evaporation rate and condensation rate and hence distillate output of solar is investigated. It gives following good points in conclusion.

- Solar intensity is directly proportional to distillate output of solar still; hence distillate output increases from 9: 00 am to 3: 00 pm; then, gradually decreases due to less direct radiation from sun in all three experimented solar stills.
- Aluminum plate has good thermal conductivity compared with Galvenized Iron (GI) plate as well as Conventional solar still absorber; hence, distillate output of solar still having Al. plate is more compared with solar still having GI plate.
- Cumulative distillate output of solar still having Al. plate found more compared with solar still having GI plate and conventional solar.
- Total distillate output of experimented days of June, 2011 found more productive in case of solar still having Al. plate compared with solar still having GI. Plate and conventional solar still. Therefore, total distillate output of solar still having Al. plate obtained 6712 ml, Solar still having GI plate of 5570 and convention solar still of 4710.
- An increase in distillate output was found to be 30 % for solar still having Al. plate and 12% for solar still having GI plate compared with conventional solar still.

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