

Comparative Study of Concentrator Type Solar Still with Solar Still with Biomass Heater Source

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ABSTRACT: In this analysis a single basin type solar along with concentrator type solar still and single basin still with biomass heater was fabricated and tested for desalination of water with various water depths, sensible heat, latent heat and porous materials operated almost on same heat inputs. A concentrator with heat exchanger is designed in a conventional type solar still to act as temperature booster. This collector was experimented in solar mode for comparison with biomass heater attached with still. The collector tray was of dimension 1m² and 3 mm thick G.I. Sheet was painted black and was attached with heat exchanger pipe. The inclination of the glass is 30°. Different water depths of 2cm, 3cm, 4cm were maintained in the still and productivity rates are analyzed. To enhance productivity of the still, sensible heat storage materials such as iron pieces, were placed inside the still. In order to improve capillary effects wicks were placed on the basin. Latent heat materials like wax was packed in the container and placed inside the still. Maximum evaporation rate was found for 2cm water depth 2150 ml/m²/hr with The maximum evaporation rate for 4cm depth was 1040ml/m²/hr. For the various packing materials used highest evaporation rate is obtained for 2cm water depth with iron scarp, wick, wax in the biomass coupled still. Maximum payback period was achieved for still coupled with biomass heat source.

KEYWORDS: concentrator, solar still, Sensible, latent, porous heat storage medium, Depth Variation. Biomass, Biomass boiler, heat exchanger

I. INTRODUCTION

Huge amount of water is required for different industrial processes, only a fraction of the same is incorporated in their products and lost by evaporation the rest finds its way into the watercourses as waste water and contributed to natural bodies of water. Industrial waste either joins the stream or other natural water directly. Many attentions are given in India on treatment of waste water. One of the best and most inexpensive methods to solve those problems are by solar distillation method. The solar stills have many advantages than other methods of desalination. Rai et al. (1990) experimentally studied the diverse manners of operation of still coupled with the flat plate collector. From this study the productivity decreases with the salt concentration Badran & Tahaneih (2005) studied the effect of coupling a flat plate solar collector to increase the productivity. Other parameters like water depth, direction of still and solar radiation were studied. Showed that the output of still increased by 36% using a flat plate collector since the saline water fed to the basin becomes preheated in the collector and hence quick evaporation occurs. Bassam & Hamzeh (2003) have done the experimental study of a solar still with sponge cubes in basin. The performance of a solar still with different size sponge cubes placed in the basin was studied experimentally. The increase in distillate production of the still was ranged from 18% to 27.3% compared to an identical still without sponge cubes under the same conditions. The effects

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of sponge cube size, percent volume of sponge, water depth, water salinity and the use of black coal and black steel cubes were also investigated. The study showed that the daily production of such a still can be greatly enhanced using sponge cubes. Voropolulos et al. (2004) experimentally investigated the hybrid still coupled with solar collectors the results showed that the productivity is doubled by coupling. Benon Bena & Fuller (2002) coupled a natural convection solar dryer with a biomass back up heater the analysis showed that that biomass backup drier was four times better than the solar dryer. Nakatake (2009) made a study to increase the distillate productivity by an inclined the flat plate external reflector on a tilted wick solar still. Badran [6] studied the performance of a single slope, solar still using different operation parameters and increased the productivity of the still by 29% using asphalt liner and sprinkler for glass sealing. Muafag Suleiman & Tarawneh (2007) conducted the experiment on the impression of water depth on still he also uses sprinkler for glass cooling to reduce glass cover temperature and improves productivity of 14% more than conventional still. Ashokkumar & Tiwari (1990) investigated the use of hot water in double slope heat exchanger. They established that the use of hot water increases production during off solar shine hours

II. EXPERIMENTATION

The experimental set up (Fig.1) consists of the flat plate collector and concentrator. The flat plate collector unit is enclosed in a wooden box of size 1m^2 area and a height of 0.6m in one end and 0.4m in another end made of G.I. sheet 4mm thick. The glass is fitted on the top of the wooden box to allow solar radiation. The thickness of the glass is 4mm. Thermocol is placed between the base surface and side walls of the tray to act as insulation materials. It prevents the bottom and side losses from the still a glass gutter is fitted at the bottom side of the glass to collect the desalinated water from the still. Heat exchanger pipe made of G.I having 25mm in diameter is fitted on the base of the basin. One end is attached to the concentrator and other end to the recirculation pipe. A measuring jar is placed outside the still to collect water from the gutter. Input tank is placed at height above the still which will supply saline water as a feed to the collector through a valve. The biomass heat source having 133 mm external diameter and shell thickness 12 mm and height 550 mm made of cast iron. The lower segment of the heat source is known as the furnace where biomasses are sustained into the hummer through the fuel info entryway. The burnt ashes remains are collected at the lower end and evacuated intermittently. The lower end of flame tube is linked up to the heater and the upper end is joined with the heat exchanger. The boiler is supplied with biomass manually. The heat produced from biomass moves upwards there it transfer the heat to the water in the drum. The water gets heated and enter the still through heat exchanger tubes above the tubes saline water flows in the inclined flat plate collector which takes the heat and evaporated. One end of the heat exchanger is connected to circulation pump and other end to the boiler outlet. The circulation pump is operated at constant flow rate using external power supply. For solar mode the boiler was shutdown and still was exposed to solar energy only. Before starting the experiment, the glass cover is cleaned for removing dust using cotton cloths. The thermo couples are attached at the saline water storage tank, inclined flat plate collector and in a conventional basin to measure water temperature. Thermocouple is also attached at glass surface to measure glass cover temperature saline feed. The solar radiation enters through glass surface, evaporates the water, the evaporated water reacts the bottom surface of the glass cover. Condenses and due to change of phase water vapour becomes water. The distilled water gets collected in the glass gutter from where it is collected through output tank. The remaining brackish water is removed from still and collected at collection tank Experiments are first conducted by maintaining different water depths of 2cm, 3cm. For measuring temperatures, copper – constantan thermocouples indicator and selection switch are used. Solar radiations are measured using Kipp – Zonen Pyranometer. Wind velocity is measured by vane type digital anemometer. The beaker is used to collect and measure distilled water. This still is fabricated and tested at University College of Engineering, Ramnad, India during March 2017 to May 2017.

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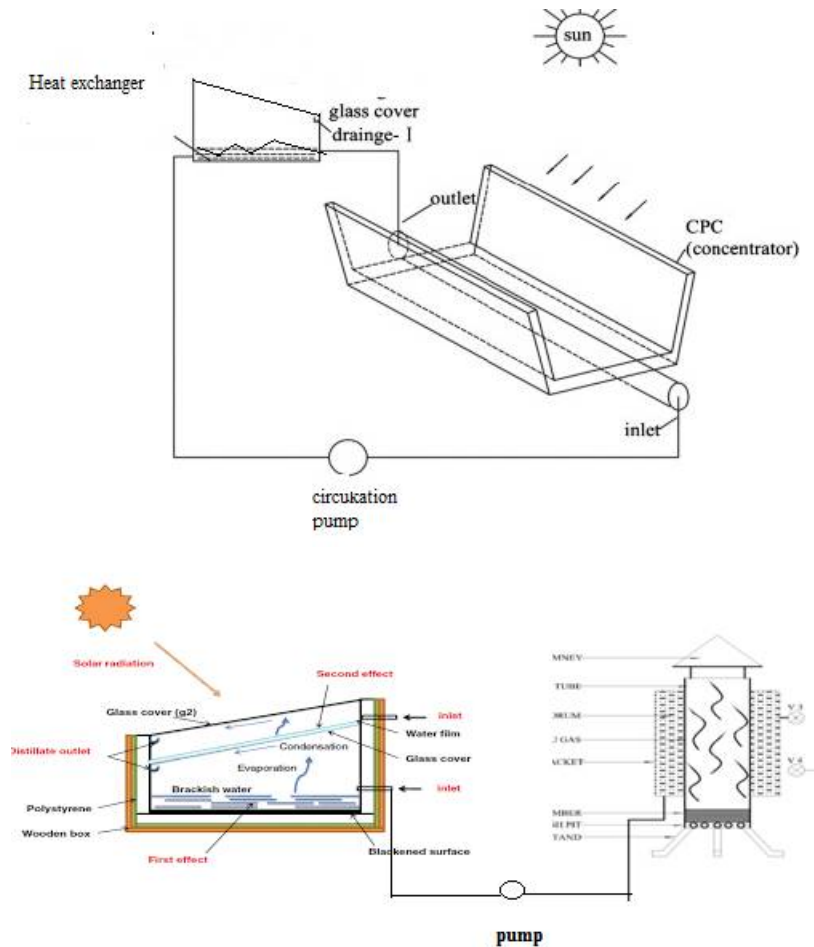


Fig.1 Experimental setup

III. RESULTS AND DISCUSSION

3.1 Effect of solar radiation on water production

The solar energy is the only source to heat the saline water in the still. The energy absorbed in the reflector is transferred to the still through a heat exchanger attached at the mid of concentrating collectors. The solar radiation slowly increases from the beginning of the experiment and reaches a maximum value of 1400 at 14hrs then decreases slowly towards the end. The solar energy increases the temperature of saline water in the still and produces a maximum output of 1370 ml/m²/hr for lowest water depth of 2cm and lowest water production is at 4cm depth (900 ml/m²). The intermediate depth produces 1090 ml/m²/hr. It was shown in Fig.2

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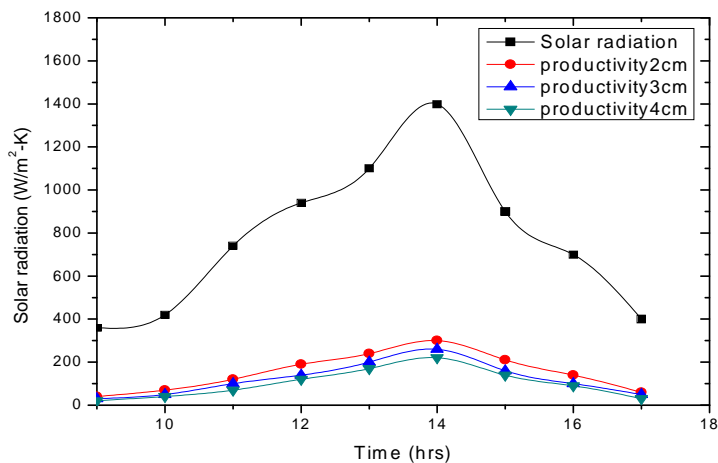


Fig.2 Effect of solar radiation on different water depths in concentrator attached still

3.2 Effect of biomass heater on productivity

The addition of biomass heater to the single basin still improves the water production from the still. Since the water is heated in the biomass heater and passed through a heat exchanger fitted with the base of the still. The biomass heat supply depends on the amount of fuel burnt inside the biomass heater so if we burnt more fuel the amount of heat supplied will increase and also increases the temperature in the still as a result more water production from the still than solar concentrator based stills. The water depth is thin layer (2cm) all the amount of heat supplied is utilized to evaporate water the productivity was 1750 ml/m²/hr for 2cm, 1490 ml/m²/hr for 3cm, 4cm depth it was 1300ml/m²/hr in all the cases the productivity was more from biomass heater still than concentrator based still. The Fig.3 shows the output

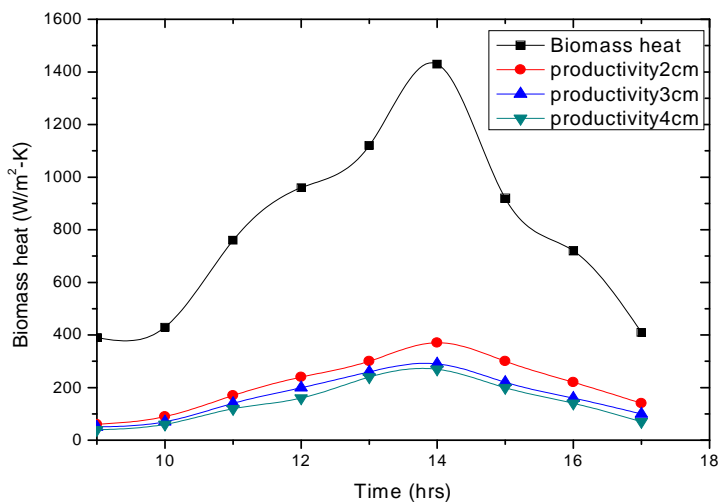


Fig.3 Effect of Biomass heat on different water depths in biomass heater attached still

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3.3 Effect of sensible material on productivity in concentrator and biomass stills

The sensible materials has the property of storing excess heat supplied into the still and helps for improving productivity from the still. The iron pieces having 100x70mm dimensions were put inside at various locations at the base of both the stills. Experimental trials were carried out with different water depths. The results clearly stated that addition of iron pieces increases 13% for 4cm ,16% for 3cm and 21% for 2cm depths than concentrator type still. The Fig 4,5 explains the effects.

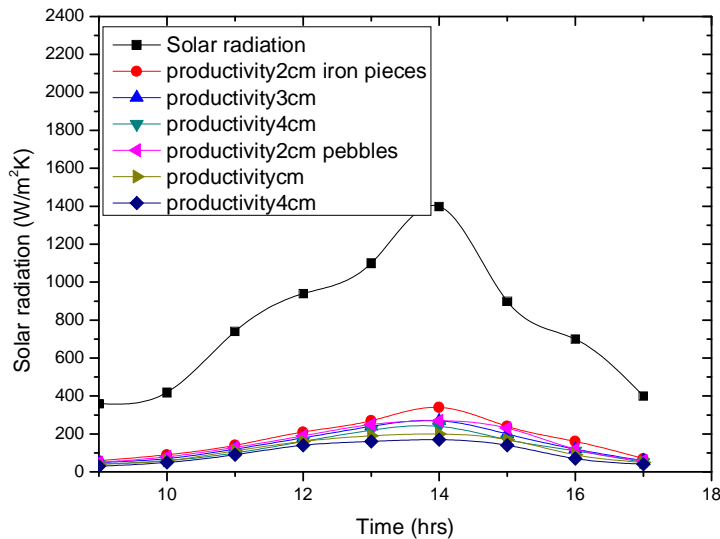


Fig.4 Effect of sensible heat materials on different water depths in reflector attached still

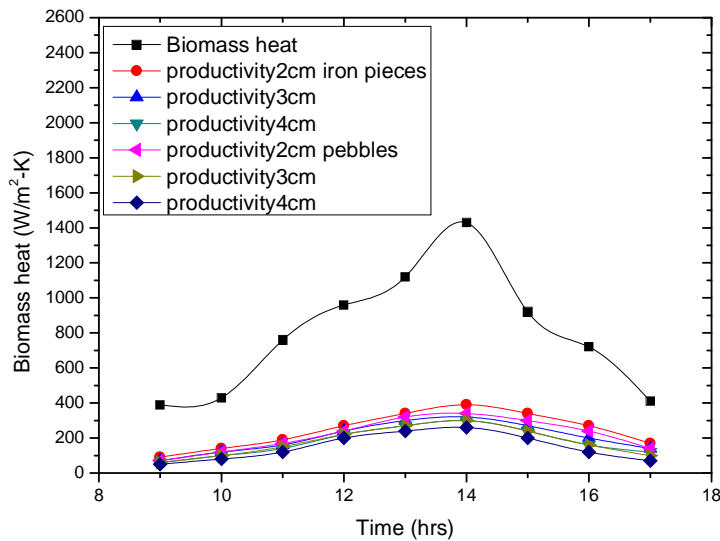


Fig.5 Effect of sensible heat materials on different water depths in biomass heater attached still

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3.4 Effect of latent material on productivity in concentrator and biomass stills

The latent heat materials has the property of storing excess heat supplied into the still and releases after the phase change supporting for improving water temperature in the still. The wax pieces having 30mm dimensions were put inside the small containers and kept at various locations at the base of both the stills. Trials were carried out for different water depths. The introduction of wax pieces increases 27% for 4cm ,33% for 3cm and 37% for 2cm depths than concentrator type still. The Fig 6,7 explains the effect of these materials. The average output from solar concentrator still was 1130ml/m²/hr and for biomass heater based still 1630ml/m²/hr.

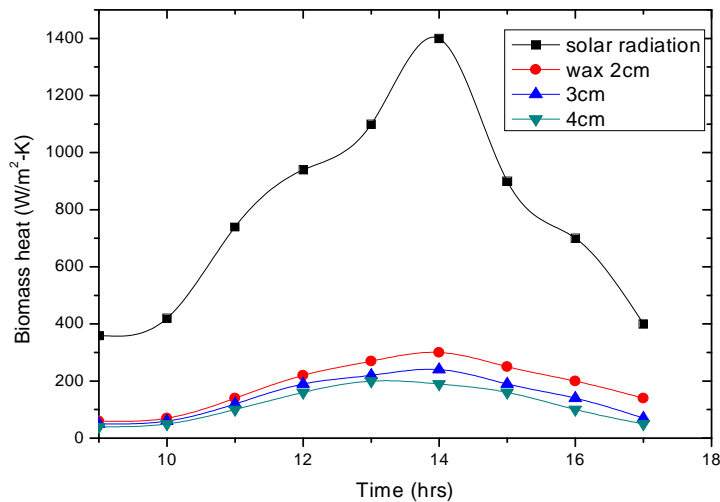


Fig.6 Effect of latent heat materials on different water depths in reflector attached still

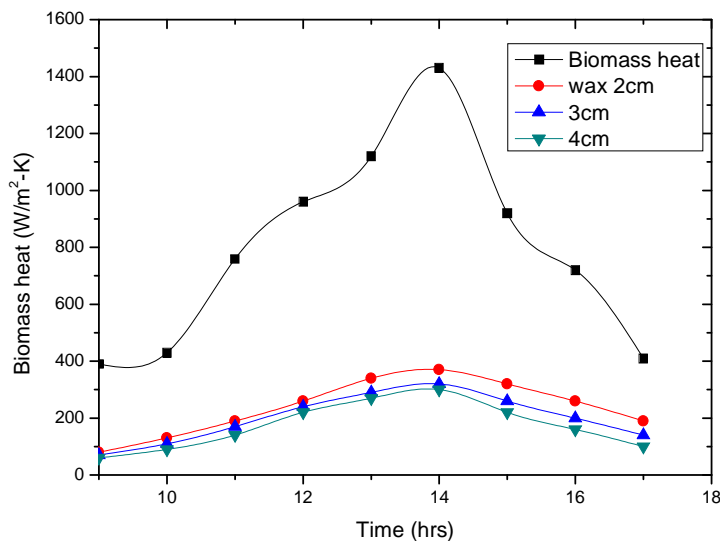


Fig.7 Effect of latent heat materials on different water depths in biomass heater attached still

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3.5 Effect of porous material on productivity in concentrator and biomass stills

The porous materials has the property of capillarity which helps to evaporate more water from the still quickly. The wick pieces were cut in 100x70mm sizes and floated on the water. Trials were taken along with wick and different water depths. The wick pieces increases the evaporation process thus more water reaches the top of the glass and get ready for condensation. Wick increases 24% for 4cm, 28% for 3cm and 32% for 2cm depths than concentrator type still. The Fig 6,7 explains the effect of these materials. The average output from solar concentrator still was 1320ml/m²/hr and for biomass heater based still 1840ml/m²/hr.

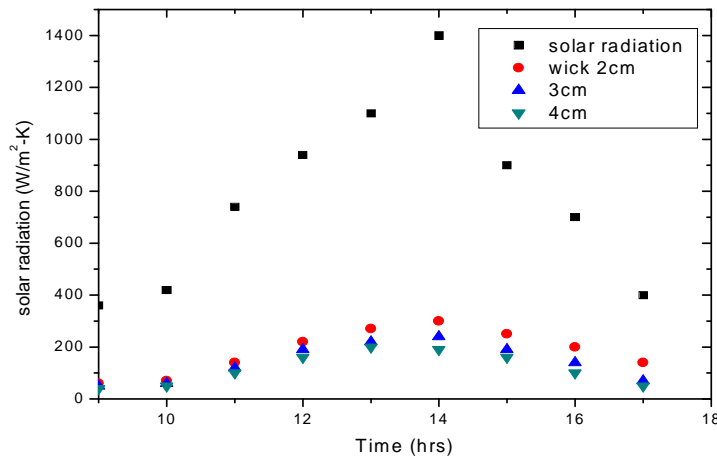


Fig.8 Effect of porous materials on different water depths in reflector attached still

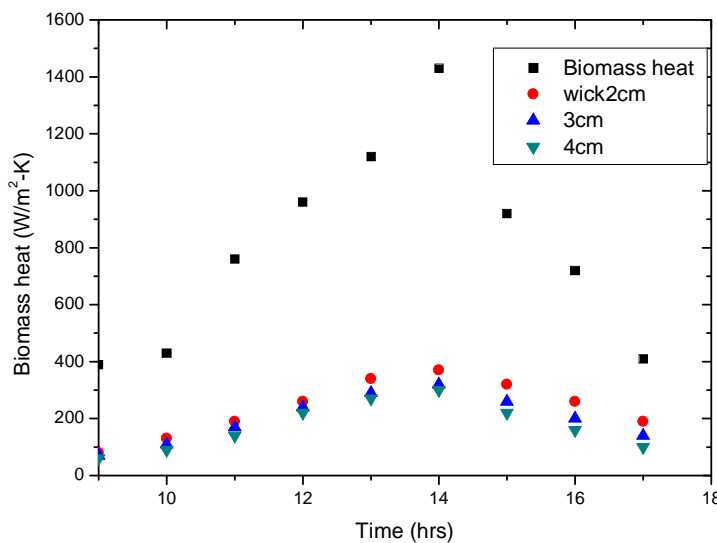


Fig.9 Effect of porous materials on different water depths in biomass heater attached still

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3.6 Economic analysis

The overall fabrication cost operating cost of both conventional and modified still is Rs.10000 .The cost of feed water is negligible. No maintenance cost. The cost per liter of distilled water is Rs.25 and the average productivity of the still is 7000 kg/m²/day. The still produced an average of 1700 kg/m². Thus the cost of water produced per day is Rs.70 for modified still and Rs.20 for conventional still.

Net earnings for still with biomass boiler

$$= \text{cost of water produced} - \text{maintenance cost}$$

$$= \text{Rs. (25-0)} = \text{Rs.25}$$

For concentrator still only it is Rs.20 and payback

$$\text{Period} = \frac{\text{Investment}}{\text{Next earnings per day}}$$

$$= 10000 / 70 = 142 \text{ days}$$

$$\text{Pay back period for conventional still} = 10000 / 20 = 500 \text{ days}$$

Taking biomass boiler into account,

$$\text{For biomass boiler mode pay back period} = 10000/90 = 114 \text{ days}$$

As shown in Figure 5 about 71% of the days are saved in the modified still compared to conventional solar still.

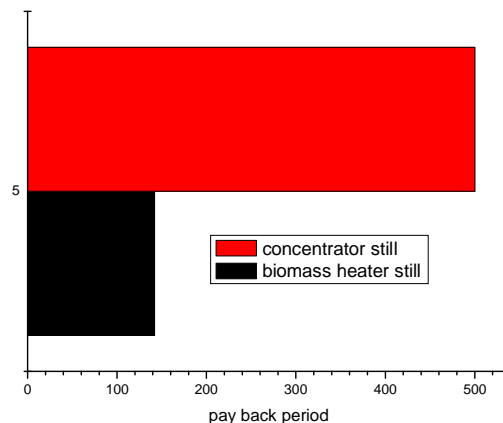


Fig.10 Comparison of payback periods

IV. CONCLUSION

The single basin still with concentrator and heat exchanger was compared with single basin still with biomass heater operated in parallel with same amount of heat input.

The results showed that,

- The still with biomass heater produces more output than concentrator based still

The output in concentrator still depend upon solar energy(radiation) which may vary from time to time. But in biomass heater energy can be increased by burning

More amount of natural fuels.

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- The cost of fuel in biomass heater is low since they are easily available biomass wastes
- Concentrator requires special attention for focusing throughout the day
- The payback periods for biomass based stills were 142 days only as they produce more output. The payback for concentrator is 500 days.
- Lower water depth in the still produces more output in both the stills and higher depths produces lower output.
- Introduction of sensible heat storage materials increases productivity in both the stills. More output is from biomass based stills
- Using wax as latent heat material increases the productivity in both type of still but it was more on biomass heater type
- Porous materials increases the evaporation rate
- The average output from biomass based still was 7000lit/m²/day and for concentrator type it was 3000lit/m²/day

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