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# Experimental Study on Built-in CDS and Its Comparative Analysis with SSSS to Produce Irrigation Quality Water in Arid Regions

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**Abstract:** The objective of this work was to study the performance as well as comparisons between two solar still configurations: the single slope solar still (SSSS) with top cover cooling and the built-in concentrator distillation system (CDS) with top cover cooling. The still basin bottom of the concentration coupled system is modified in the form of hemispherical shape. The main advantage was that the still with concentrator produced distillate yield in a shorter duration of time than was obtained for a single slope solar still for a whole day. The assembly of unit in the built-in concentrator distillation system is also small compared to single slope solar still. The water temperature of the still in concentrator-coupled system was higher than the single slope solar still. The outcome of the study is that we can attain more evaporation rate by linking the solar concentrator in the solar stills. The built-in concentrator distillation system and single slope solar still are well studied by flow the water over the top cover. The main parameters such as stills productivity and efficiency are presented. On the basis of the results, built-in concentrator distillation system was found to be more efficient than the single slope solar still.

**Key Words:** Concentrator, Distillate yield, Efficiency, Solar still

## 1. Introduction

Clean, safe and affordable water is one of the greatest challenges in rural communities, living in arid and semi-arid lands. Arid regions suffered more difficult problems to access adequate drinking water. So water is the essential part to lead the life in those particular remote areas. Desalination using solar energy has been used to balance the crisis of fresh water in those lands. Desalination of brackish water or sea water is one of the ways to meet the water demand. The main characteristic of this process is that they are friendly to the environment. Production of pure water using desalination process driven by solar energy systems is a viable solution to the water scarcity at remote areas.

Different studies attempting to improve still yield are reported, but generally enhancement of evaporation inside the still and minimization of energy losses are the two main approaches. The thermal efficiency of the unit in terms of production per day per square meter can be increased by various passive or active methods. Evaporation rate can be increased if the temperature difference between the basin and the glass cover increases. This can be achieved by either increasing the basin temperature or decreasing the cover temperature or both. Studies have been performed by the variation of evaporative heat transfer coefficients in a conventional still and in an inverted absorber solar still (Suneja and Tiwari, 1998; Abu-Arabi *et al*., 2002; Abu-Hijleh and Mousa, 1997). A comparative study reported the effect of the Algerian south-west desert climatic conditions on the performance of a single basin solar still and a similar one coupled to flat plate solar collector (Boukar and Harmim, 2001). Much research work has been done in the concentrator technology (Broman and Broman, 1996), high temperature cavity receivers (Hahm *et al*., 1999), high temperature solar distillation system (Chaouchi *et al*., 2007; Yadav and Yadav, 2004), non-focusing solar concentrators (Shaprio, 1971), 400 $m^2$ big dish (Johnston, 1995), 20 $m^2$ tiled dish (Johnston, 1995) low cost dish solar concentrator (Palavras and Bakos, 2006).

In this present study, we compared the built-in concentrator distillation system with a single slope solar still. We used water flow over the top cover for cooling purposes in both the stills. The efficiency, water collection and feasibility of the system were compared.

## 2. Materials and Methods

### 2.1. Concentrated coupled single slope solar still

The built-in concentrator distillation system was

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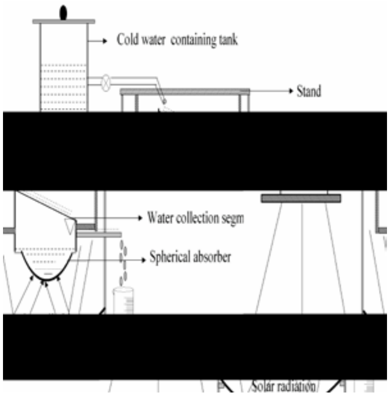


**Fig. 1. Schematic view of concentrator coupled solar still.**

constructed. The basin is modified to hemispherical shape is made up of copper of thickness 4 mm. The diameter of the hemi spherical base is 0.22 m, and this hemi spherical absorber which is attached at the bottom of the still.

The bottom and sides of the inner surface of the basin and the outer surface are blackened and ¼ inch inlet pipe is provided for water inlet. The top surface of the still is covered by a cover of area 0.25 m × 0.25 m. The top cover is made up of transparent glass sheet of thickness 2 mm of transmittance 90%. Thermocouples were used to measure the temperature inside the still. The top cover is placed over the grooves with uniform resting slope of 16°. A water collection segment is also provided at the respective place. It has a length of 0.27 m and a width of 0.025 m. This entire setup is mounted at focal of the concentrator. The experimental setup is shown in **Figure 1**.

### 2.2. Single slope solar still (SSSS)

The water storage basin of the still is designed of area 0.50 m × 0.50 m. Bottom and sides of the inner surface of the still are coated with black paint for absorbing maximum amount of intensity of solar radiation. An inlet pipe of ½ inch is used for pouring water into the still. An outer cover of the basin is made up of wood. The gap between the basin and outer cover is filled with saw dust as insulation. The top cover of the still is made by the glass of thickness 2 mm. The top cover is placed over the grooves which are provided at all sides for uniform resting. A 16º slope is maintained for top glass cover. Water Collection segment is placed at the desired position for collecting the condensed water and with dimension 0.66 m x 0.038 m × 0.015 m. The schematic representation of device is shown in **Figure 2**.

The readings were recorded during clear sunny days between 0900-1400 HRS. In the early morning basin is filled with saline water and system is perfectly sealed. Experimental data were collected at different time intervals. The potable water output of the still is frequently measured. The flow rate of the water is adjusted to the desired value

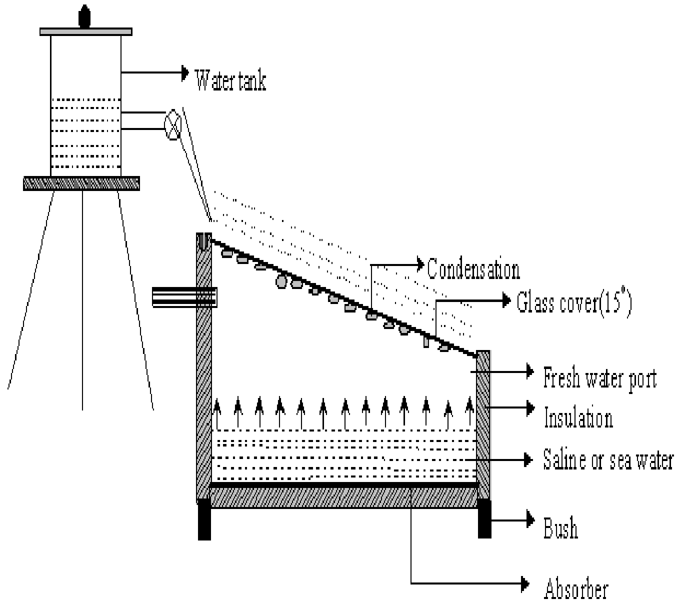


**Fig. 2. Schematic view of single slope solar still.**

during the top cover cooling process. Temperature of water, air, inner cover and outer cover temperature are also recorded at regular intervals of fifteen minutes. Precision pyrheliometer and pyranometer are used for measuring the solar radiation throughout the experiment.

## 3. Experimental Analysis

The hourly yield can be found as,

$$m_e = \frac{q_{ew} \times 3600}{L} \qquad (1)$$

Where $q_{ew}$ is the evaporative heat transfer, L is the Latent heat of vaporization.
Instantaneous efficiency is given by,

$$\eta_i = \frac{q_{ew}}{I} \qquad (2)$$

'I' refers the solar radiation.

## 4. Results and Discussion

The built-in concentrator distillation system (CDS) and single slope solar still (SSSS) were experimentally tested on several sunny days in the campus of Sri Ramakrishna Mission Vidyalaya College of Arts and Science, Coimbatore, India. Data obtained included environmental condition (solar intensity radiation, ambient temperature and humidity), design parameters (basin absorptivity and concentrator reflectivity), and operational procedure (initial saline water temperature, air temperature, inner cover and outer cover temperature) indicated

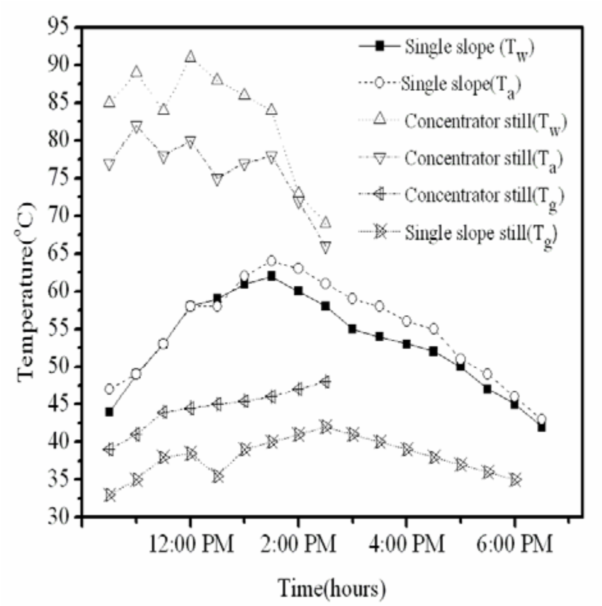


**Fig. 3. Variation of temperature with respect to time-Outer covers cooling.**

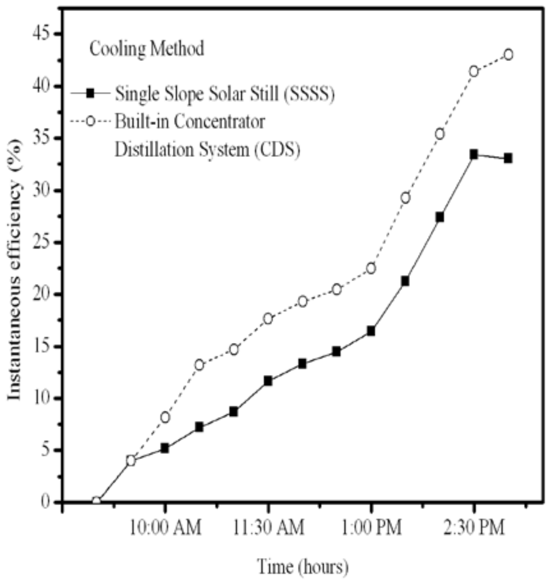


**Fig. 4. Variations of efficiency with respect with to time with outer cover cooling.**

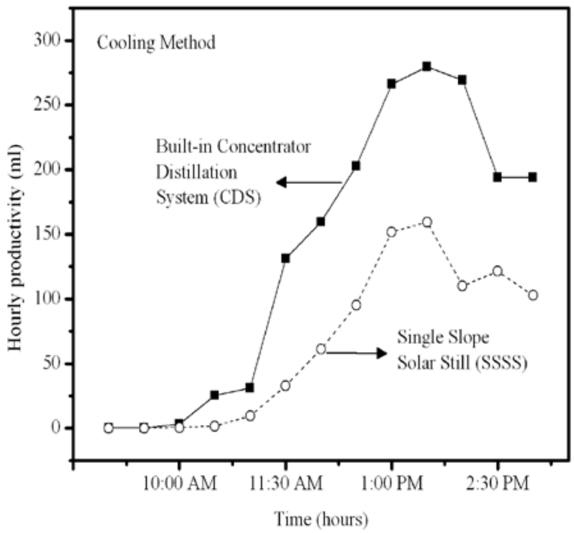


**Fig. 5. Variation of hourly distillate yield with respect to time-Outer covers cooling.**

that these decisively influence the still performance.

The variation of two different solar still temperatures is presented in **Figure 3**. As shown from the illustration, the temperatures have the same trend, as they increase in the morning hours and attain maximum values at around 2:00 p.m., and decrease in the evening hours. This is obviously due to the increasing solar incident radiation in the morning and decrease in the afternoon. The maximum water temperature measured was always between 1:00 p.m. and 2:00 p.m. was in the range of 71-91°C for hemispherical basin solar still and 34-64°C for the single slope solar still. But in the case of concentrator-coupled solar still the rise in temperature attains maximum at higher sunshine hours and the distillate yield also collected to an optimum amount. Similarly the air temperature is achieved as 68-80°C for concentrator-coupled still and 32-60°C for the single slope solar still.

Variations of efficiency of the stills are depicted in **Figure 4**. The efficiency of the concentrator-coupled solar still with outer cover cooling is in the range between 9%-42% and similarly 2%-32% for the single slope solar still with outer cover cooling.

**Figure 5** shows the variation in the hourly output of the distillate yield with respect to time. It is clear from the graphical representation that the built-in concentrator distillation system (CDS) gives the higher yield as compared to conventional solar still. The maximum of total productivity for the built-in concentrator distillation system with water flow are 1.6 litres within four hours of time. But in the case of single slope solar still the yield rate is 1.1 litres for a whole day collection (i.e., eight hours). The top cover cooling is maintained at constant flow rate for both the performance study.

The comparisons of both the studies reveals that expelled amount of distilled yield are obtained within a short period for the concentrator-coupled solar still. When the efficiency and temperature are considered, the built-in concentrator distillation system is more helpful in the distillation process and the utility would pave a new path for getting distillate water.

## 5. Conclusion

This work was carried out to evaluate the comparative performance of two different solar still configurations; single slope solar still (SSSS) and the built-in concentrator distillation system with water flow over the cover. On the basis of performance results, the concentrator-coupled solar still was found to be more efficient than the conventional one. In this case, faster evaporation takes place from water surface and quick condensing occurred at the cover by cooling effect which maintains larger temperature difference and improves condensation.

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