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# Thermal Performance on Single Basin Solar Still with Evacuated Tubes Solar Collector-A review

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***Abstract:*** *Various aspects of single basin solar still with evacuated tubes solar collector have been discussed in this paper with a focus on the use of evacuated tubes to increase the daily productivity of solar still with less heat losses. The pure water can be obtained by distillation in the simplest solar still. Various active methods have been adopted to increase the temperature of the basin so as to improve the productivity of solar still.*

***Keywords:*** *Augmentation, distillation, evacuated tubes, Solar still.*

## I. Introduction

Water is a precious natural gift and is being polluted by human activities, urbanization and industrialization. The ground water is often over exploited to meet the increasing demand of the people. Less than 1% of earth's water is available for human consumption and more than 1.2 billion people still have no access to safe drinking water. Over 50% of the world population is estimated to be residing in urban areas, and almost 50% of mega cities having population over 10 million are heavily dependent on ground water, especially in the developing countries like India .

Most of the rural people still live in absolute poverty and often lack access to clean drinking water. Nearly half of the population is illiterate, not at all aware of the waterborne diseases affecting their health. Nearly 70% of the infectious diseases in India are waterborne. Indian villages are posed with problem of overexploitation of ground water due to increasing dependence on it as other fresh water resources are dwindling fast. Various desalination techniques are used to purify the water. Solar distillation is an easy and cost effective method to provide pure drinking water in rural areas without affecting the nature. Solar distillation process is carried out both in passive and active modes. [13]

**Passive Method:** Passive solar still operates in low temperature and the daily productivity is comparatively low.

**Active method:** To increase the evaporation rate in an active mode the extra thermal energy is fed into the basin. To increase the productivity of solar still, the various active methods are being carried out by many researchers. Most of the works were based on the flat plate collector and concentrating collector.
Following are the various active methods to increase the productivity of solar still.

**Basin type solar still:** Such solar stills have been operated for farm and community use in several countries. It consists of a blackened basin containing saline water at a shallow depth, over which is a transparent air tight cover that encloses completely the space above the basin. It has a roof-like shape. The cover which is usually glass, may be of plastic is sloped towards a collection trough. Solar radiation passes through the cover and is absorbed and converted into heat in the black surface. Impure water in the basin or tray is heated and the vapor produced is condensed to purified water on the cooler interior of the roof. The transparent roof material, (mainly glass) transmits nearly all radiation falling on it and absorbs very little; hence it remains cool enough to condense the water vapor. The condensed water flows down the sloping roof and is collected in troughs at the bottom. [1], [2], [3]

**Vertical solar stills with a flat plate solar collector:** The distillation unit consists of 'n' parallel vertical plates. The first plate is insulated on its front side and the last plate is exposed to ambient. Each plate in the enclosure is covered with wetted cloth on one side. The cloth is extended into a feed through along the upper edge of each plate. Feed water in the through is then drawn onto the plate surface by capillary. Excess water moves down the plate and is conducted out of the still. The last plate is cooled by air or water. The authors found that, the distillation output increases slightly when the plate number is over 5, and it increased by about 34% and 15% when the evaporating plate numbers are 1 and 6, respectively. [4], [5].

**Solar still integrated with mini solar pond:** Solar pond is an artificially constructed pond in which significant temperature rises are caused to occur in the lower regions by preventing convection. Solar ponds are used for collection and storage of solar energy and it is used for various thermal applications like green house heating, process heat in dairy plants, power production and desalination.

The results show that, average increase in productivity, when a pond is integrated with a still is 27.6% and when pond and sponge are integrated with a still is 57.8%. Industrial effluent was used as feed for fin type single basin solar still and stepped solar still. A mini solar pond connected to the stills to enhance the productivity and tested individually. The results show that, maximum productivity of 100% was obtained when the fin type solar still was integrated with pebble and sponge. The productivity increases with increase in solar intensity and water glass temperature difference and decreases with

increase in wind velocity. Pebbles, baffle plates, fins and sponges are used in the stepped solar still for productivity augmentation. Their finding shows that, maximum productivity of 78% occurred when fins and sponges were used in the stepped solar still and also found that the productivity during night also improved when pebbles were used in the solar stills. [10], [11], [12].

There are three main types of solar stills: the box solar still, the cone solar still and the pit solar still

## II. Box Solar Stills

The box shaped solar still is fairly complex compared to the other solar stills made for obtaining pure emergency drinking water. This type of still is usually created with a box that has a slanted glass or plastic top with an insulated bottom. A set of tubes allow in impure water and let out over flow and pure distilled water. Maintaining a tight seal on a box shaped solar still is essential. Clearly, this is more of a home project for a green minded person, but having a solid understanding of how all solar stills work might come in handy when trying to construct one from scratch for emergency drinking water.

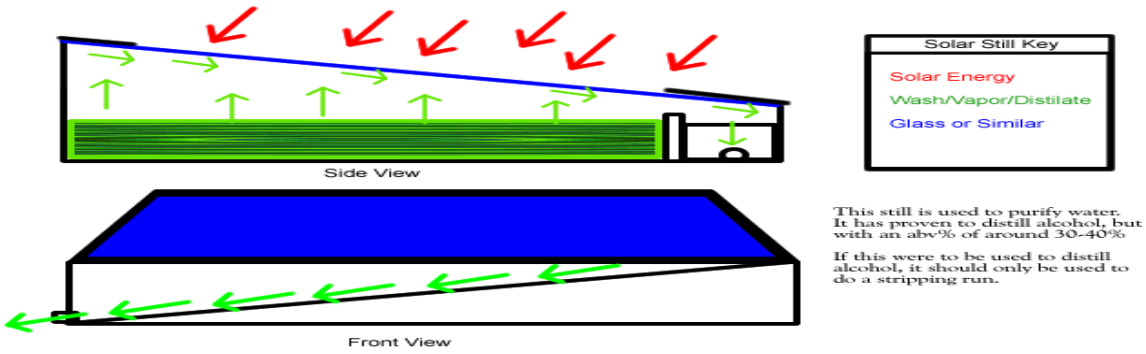


Figure 1: Box type solar still

## III. Cone Solar Still

A cone shaped solar still is a method of treating impure emergency drinking water rather than gathering it from the atmosphere. A cone is constructed out of plastic designed so that impure water in the bottom evaporates and is captured in a makeshift reservoir as it runs down the side, relieved of impurities. The Water cone is commercial solar still that allows you to distill water naturally at home or on the go with having to construct a solar still of your own. Designed as a water purification system that can generate potable water out of even brackish sea water, the Water cone is also a candidate for providing clean drinking water in developing and failed nations.

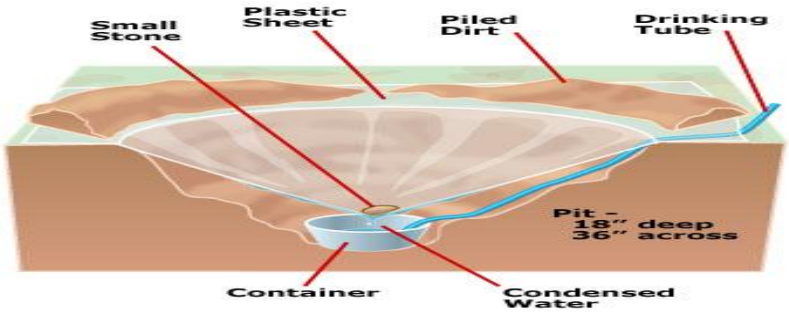


Figure 2: Cone type solar still

## IV. Pit Solar Still

Pit shaped solar stills are the simplest solar still to make and require little equipment or technical know-how. Simply dig a pit in the earth approximately two feet deep and place a Number 10 sized can at the bottom. If available, set a drinking tube in the bottom of the can leading out of the hole. Then secure a sheet of plastic over the hole a place a stone in the sheet so that it indents the sheet to just above the can's lid. So long as this solar still receives plenty of sun, it will provide a pint or more of emergency drinking water. [15]

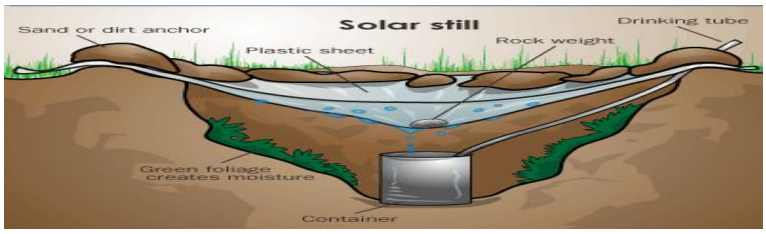


Figure 3: Pit type solar still

## V. Literature Survey

**Solar Still alone:**

- An experimental study is conducted by Bhanu Pratab Singh [1] in a single slope solar still integrated with solar water heater. It has been found that still productivity increases up to 120% when combined with solar water heater. Also, the ambient conditions are found to have direct effect on the productivity of the still. The production in night in the absence of solar radiation contributes up to 14% of the daily output due to availability of hot water as basin water with the integration of solar water heater.
- The work carried out by Ahmed Z. AL-Garni. [2] To enhance the productivity of a double slope solar still by using an immersion type water heater. The effect of using an external fan to cool the glass surface is also examined. Experiments were carried out for winter season in Saudi Arabian climatic conditions at solar still is more for low water depths, the water level in the base tank was maintained at 1cm. The experimental results showed that the productivity increased by a significant 370% when two water heaters each having 500 W capacities was used. When external cooling fan was used the productivity was found to decrease by 4% and 8% for wind speeds of 7 m/s and 9 m/s, respectively.
- V. Velmurugan, et al. [3] performed productivity enhancement of stepped solar still. For comparison purpose, the ordinary stepped solar still is tested without any modification and the average water productivity is found to be 1.01 litres per 8 hour. To improve the productivity, theoretical and experimental analyses were made for fin type, sponge type, and combination of fin and sponge type stepped solar still. When the fin and sponge type stepped solar is used, the productivity is 1.98 litres per 8 hours which is 96% more compared to the productivity of ordinary stepped solar still. The average daily water production has been found to be 80% higher than ordinary single basin solar still.

**Solar still coupled with flat plate collector:**

- Badran and Al-Tahainesh [4] presented the effect of coupling a flat plate collector on the solar still productivity. It has been found that coupling of a solar collector with a still has increased by 36%. The results showed that, the output of the still is maximum for the least water depth in the basin (2 cm). Also, the increase in water depth has decreased the productivity, while the still productivity is found to be proportional to the solar radiation intensity.
- A work is carried out by A.M. Rajesh, et al. [5] on single basin solar still integrated with a flat plate collector [FPC]. A single stage basin type solar still and a conventional flat plate collector were connected together in order to study the effect of augmentation on the still under local conditions. The still inlet was connected to a locally made fin tube collector. The unit as operated with and without coupling flat plate collector. Measurements of various parameters, temperatures, solar intensities and distilled water production were noted between 8 AM to 5 PM sunlight day.25 to 40% enhancement in the yield is observed with this system.

**Solar still coupled with parabolic concentrator:**

- Zeinab and Ashraf [6] conducted experimental and theoretical study of a solar desalination system coupled with solar parabolic through with a focal pipe and simple heat exchanger. The results show that, as time goes on, all the temperatures increase and begin to decrease after 4.00 pm with respect to the solar radiation, although the temperature values of the modified system are still higher than the conventional one. In case of the modified design, the fresh water productivity increased an average by 18%.
- Garcia Rodriguez and Gomez Camacho [7] experimentally studied the multi effect distillation system coupled to a parabolic through collector (PTC) for sea water desalination and suggested the following, (i) the annual energy production is about 23% grater for a north–south collector than for an east west one. (ii) The optimum axis height for a single collector is 298 and it is 12% higher production than a horizontal collector for an inlet/outlet thermal oil temperature of 225 $^{o}$C /300 $^{o}$C. (iii) The maximum yearly average of the daily operation time is only about 12 h/day in coastal areas in southern Spain.
- T. Arunkumar , R.Jayaprakash[8] performed Desalination Process Of Single Slope Solar Still Coupled In CPC With Crescent Absorber using two modes of operation: (1) Single slope solar still top surface open condition operating with crescent absorber, (2) Single slope solar still top surface closed condition which is operating with crescent absorber for a period of 9:00 hours to 16:00 hours. In the first modes of the operation the productivity the still 2.1 litres per day and 1.03 litres/ day for second mode of the operation. The efficiency of the first mode of study is calculated as 23.19% and 13.01% is the second mode of the still performance.
- T. Arunkumar et. al. [9] conducted experimental study on a compound parabolic concentrator tubular solar still tied with pyramid solar still. These type of behaviour is studied by using of a pyramid solar still directly coupled with compound parabolic concentrator – tubular solar still in this work. These results showed that the maximum output extracted from the proposed system as 6928 ml/m$^2$/day for with cooling. The overall efficiency of the system is calculated as 17.01% for without cooling and 21.14% for with cooling.

**Solar Still Integrated to Solar Pond:**

- Performance analysis of vapour adsorption solar still integrated with mini-solar pond for effluent treatment is done by Dr. K. Srithar [10]. To enhance the productivity, the single basin solar still was modified with activated carbon, methanol with sponge, pebbles and sand were used. The overall productivity of the still is increased by 32.32 %.

- The experimentation was carried out by V. Velmurugan; et al. [11] on solar stills integrated with a mini solar pond and found that the productivity is maximum. Optimum salinity of 80gm/kg of water was used in solar pond. Productivity of still alone was found to be 2.77 L/$m^2$ /day. And when sponge cubes is used in solar still production rate is increases by about 33%, i.e. 3.3 L/$m^2$ /day. When a mini solar pond was integrated with solar still productivity is increased by about 58%. I.e. 3.4 L/$m^2$ /day. But maximum productivity is obtained when the sponged solar still is integrated with the mini solar pond, i.e. 4.4 L/$m^2$ /day.
- Velmurugan et al. [12] experimentally investigated the possibility of enhancing the productivity of the solar stills by connecting a mini solar pond, stepped solar still and a single basin solar still in series. Pebbles, baffle plates, fins and sponges are used in the stepped solar still for productivity augmentation. Their finding shows that, maximum productivity of 78% occurred when fins and sponges were used in the stepped solar still and also found that the productivity during night also improved when pebbles were used in the solar stills.

**Solar still coupled with evacuated tube:**

- The solar still coupled with evacuated tubes were carried out by K. Sampathkumar, et al. [13] to enhance the productivity of the solar still. These experiments were conducted using tap water as feed. It was found that, after augmentation of the evacuated tubes, the daily production rate has increased by 49.7 % and it increased by 59.48% with black stones.
- Ahmed et al. [14] designed, fabricated and tested the multistage evacuated solar still system that consists of three stages stacked on the top of each other. The results show that, the maximum production of the solar still was found in the first stage and is 6 kg/$m^2$/day, 4.3 kg/ $m^2$/day in second stage and 2 kg/$m^2$/day in first stage at a vacuum pressure of 0.5 bars. Indeed, the total productivity of the solar still is affected very much by changing the internal pressure. The productivity decreased as the pressure increased due to the lower evaporation rates at the higher pressure values.

## VI. Conclusion

The forgone discussion on the use of solar still system suggests that there is a need for developing a reliable and higher productivity solar still. The review is focused on the still coupled with solar collectors, Solar still coupled with flat plate collector, solar still coupled with parabolic concentrator, Solar still integrated to Solar Pond and solar still coupled with evacuated tube are discussed and their effectiveness are compared. The review is mainly focused on production of distilled water from Single Basin Solar Still with Evacuated Tubes Solar Collector.

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