

# New Technique for Water Desalination Using Novel Solar Still And Parabolic Trough Collector

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**Abstract** -Solar energy is a prominent source of energy. The world is facing water crises and many people die by drinking unhygienic water. Water desalination using solar still is the oldest method. Numbers of researchers are working on it to improve its efficiency. This paper describes some new techniques to increase the efficiency of solar still. Solar still is made using cotta stones, which are giving a low-cost solution. This solar still giving 700 ml output in the month of February. Solar still is tested with different water mass for optimum output.20-liter mass is given the best results. Finally still is clubbed with a parabolic collector to increase efficiency. After connecting with parabolic trough collector efficiency is increased up to 64 %.The prototype is fabricated and tested at Godhra, Gujarat, India.

**Keywords** - Parabolic trough collector, Solar still, water desalination.

## 1.Introduction

India is the second largest country in the world population. Around 18 % of populations of the world live in India but India has only 4 % of the water of the world's fresh water. In India, 76 million people are without access to safe drinking water. 21 % of country diseases are water related. 70 % of the earth is covered with water but only 2% of water is fresh water and in this 1.6 % of water is in the form of ground water or in ice form. Water is the most important thing for our life to survive. Without water, we cannot survive. Water is also essential for agriculture and industrial growth. In short, water plays a very important role in the development of the country. So desalination of water must be required to convert brackish water into portable water. There are a number of technologies for water desalination. Industrial desalination technologies either use multi-phase desalination or single-phase desalination. There are two types of desalination technologies which are shown in table 1

Table 1: Desalination Technologies

Phase change process	Single phase
Multi-stage flash	Reverse osmosis
Multiple effect desalination	Electro dialysis
Vapor compression	Nano filtration
Freezing	Membrane distillation
Solar still	Forward osmosis

## 2. Literature review

Arunkumar t. et al. had a study on various solar still designs. In that experiment, the principle of pure water from salty water, using a different design of solar water desalination techniques is the same. They used a different type of solar still like spherical solar still, pyramid solar still, hemisphere solar still, double basin solar still, tubular solar still, CPC-TSS-pyramid solar still, hemisphere concentrator solar still. They used seven types of different solar still and the result of that solar still. They conclude that tubular solar still coupled pyramid solar still shows the maximum amount of productivity due to the concentrator effect and productivity of solar still depend upon the climatic parameter.[1]

Dnyaneshwarsonawane et al. had research on increasing solar still productivity by optimizing the angle of PCM embedded absorber surface. They had tried to increase the productivity of solar still using phase change material and changing the angle. They applied to phase change material at the bottom of a single basin solar still. The phase change material converse available energy and improve its utilization with the help of many resources in nature.[2]In this experiment they conclude that PCM material act as a heat source during day hrs and heat sink during night hrs. So that they had made that process continuously available thought the day. After that, they also concluded that distillate output increased by 62% by modifying the angle at 34 degrees compared with another angle.

Hanane.aburideh et al. had studied on solar still. The working principle of solar still used for water desalination with phase change water vapor. And they conclude that the seawater desalination process by distillation seems to be influenced by the different effect that has an impact on solar still.[3]

SoterisA.Kalogirou et al. had evaluated of parabolic trough collector performance or increasing efficiency. They take parabolic trough collector with an aperture area of the 14.4-meter square and concentration ratio 13.7 and the working temperature is 200 degree Celsius. The receiver pipe is made up of stainless steel with a diameter of 28mm. and the receiver pipe or focusing pipe is coated with a selective coating having absorptance of 0.93. They conclude that this type of collector is because of the concentration, used only in beam radiation. The performance obtained by estimating the efficiency at various inlet temperature. They plot graph collector efficiency against the temperature rise divided by beam solar radiation.[4]

Alpesh Mehta et al. had studied the design of the solar still. They design the single basin solar still manually and put on the terrace during winter from 10.00 AM to 5.00 PM. They had concluded that the increase in temperature and hence the evaporation is maximum in the period of 11:15 am to 1:30 pm. The maximum temperature achieved is 53<sup>0</sup>c which is at 1:30 pm. then the temperature decreases.[5]

Hemin Thakkar et al. had reviewed on solar desalination techniques. In this review, they reviewed on different techniques like multi-effect desalination system, desalination plant with pad humidifier, desalination with the separate evaporator, etc. they also used nanomaterials for increasing the output of the desalination system. They conclude that conventional solar still has limited output around 3-liter and it can be increased by active solar still. Evacuated tubes collector found impressive compared with FPC in the solar active still.[6]

Thota Sivaji did an experiment on solar still and he concludes that to solve the water scarcity problems solar desalination solar still is the best process and using two-meter square solar still basin we can get portable water for one person for a one day.[7]

Deepak.S.A et al. had experimented on solar desalination of seawater using a single-basin single sloped solar still with a parabolic concentrator. They fabricate a solar still with made up of aluminum and mounted above the parabolic concentrator. They conclude that the amount of desalinated water obtained depends mainly on solar intensity and material used for heat absorption purpose.[8]

Pamash K Lanjewar et al.had mathematical analysis of solar still with storage. They provide storage with solar still only in the day because they believe that solar still works only in day period and the storage is phase change material (PCM). From the various equation of heat balance at different parts of the solar still, are made for evaluating the temperature at that point from their experiment they concluded that maximized efficiency of solar still is around 60%.[9]

Mohammed farid et al. had studied on performance of single basin solar still. They fabricate a solar still with a galvanized sheet with thickness 1mm and basin area is having 1.5-meter square. The 6mm glass cover of the still placed at angle 11 degree. they conclude that significant increase of the still production with the decrease of water depth and also concluded that hourly measurement is particularly used in evaluating the effect of some parameter.[10]

Rameshaiah GN et al. had studied on the solar still name is green distillation they fabricate a solar still with different material like side wall was made up of acrylic material and the basin was made up of granite marble because of it is good absorber if heat, resistant to oxidation and it has good durability. After that sand layer was introduced at below the granite slab and thermocol slab is also introduced after sand layer because of high thermal resistance from their experiment they concluded that water of high purity was obtained using solar still.[11]

Ajithkumar rai et al. had studied on the effect of water depth and still orientation on the productivity of passive solar still. They fabricate a solar still with an area of 0.048 m\*0.096 m. and the cover is 3 mm glass with angle 26 degree they fill up the water up to different depth 0.015m, 0.025m, 0.035m. they observed that the highest output is obtained at a lower depth.[12]

Amermamkagh et al. had experimented on condensation rate enhancement of the inclined condenser in the solar still connected with a solar water heater. They fabricate the solar still with made up of aluminum having a volume of 0.50m\*0.50m\*0.15m and bottom side of the basin is coated with black paint.Transparent acrylic sheets were used for the sidewalls. They concluded that cotton wick material installation inside the basin increased fresh water productivity.[13]

Ravishankar et al. had studied a review of integrating solar collectors to still. In their experiment, they integrate all the collectors like flat plate collectors, concentrating collectors, pulsating heat pipe, evacuated tube collectors, thermoelectric effect, parabolic trough, solar water heater were used to improve the yield and efficiency of the solar still. From their experiment, they conclude that efficiency is improved by 137 percent using PCM material.[14]

Mohammad al-harashseh et al. had studied solar desalination using solar still enhanced by external solar collector and PCM. They fabricate the solar still using stainless steel with basin area 1meter square. Glass with thickness 1 cm covered on solar still at angle 36 degree.solar still is coupled with solar collectors and used PCM material in the solar still. From their experiment, they concluded that PCM worked to supply energy during the night time period without any change in thermal behavior and the highest daily productivity of the unit achieved experimentally was 4300 ml/day-meter square.[15]

S.Varun raj et al. had studied the design and analysis of solar still. They fabricate solar still using a galvanized iron sheet with basin area 0.5m \*1m height of 288mm and 1.4 mm thickness. The basin painted with black color . from their experiment they conclude that in higher water level, the maximum temperature of water basin water, vapor, and water is recorded in the afternoon hour between 15hrs and 18hrs.[16]

### 3. Design concept and methodology

#### 3.1. Fabrication of solar still

Selection of still material is a very important aspect for a solar still. Good selection of still material gives higher life. Fig.1 and Fig.2 show the design of solar still and real view of solar still respectively, which is installed at government engineering college, Godhara. Some researchers are made passive solar still with the help of different material like wood, plastic, m.s. sheet and others. But in wooden material, there are more chances of change in dimension because wood absorbs water particle and that water particle changes the dimension of wood after some time. In the case of plastic material, the black plastic sheet is hard to find and color on plastic is no running long life. And finally in case of m.s. sheet, there is a chance of corrosion after some time. So we choose the Cotta stone as still material. As it is corrosion less and no need of insulation. Some researchers are put calcium stone or granite stone .instead of this we fabricate completely still with the help of cotta stone. The effective basin area is 1m\*1m. the angle of solar still is 22.7 degree which is the latitude of Godhara, India

Table 2 Design parameter of solar still

Parameter	value
Area of the basin in solar still	1 m <sup>2</sup>
The outer area of solar still	1.05m * 1.05m
The inclination of the glass cover	23°

Lower end height of solar still	0.08m
Higher end height of solar still	0.51m
Transmissivity of 0.004m glass cover	0.9

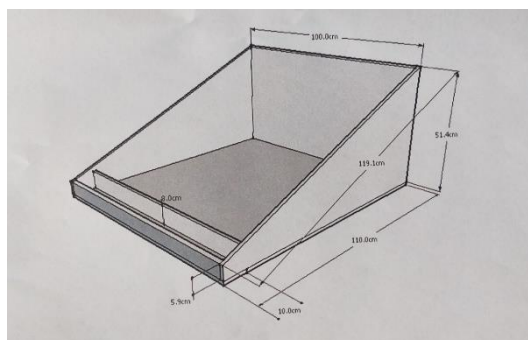


Figure 1 Design of solar still



Figure 2: Real view of solar still

### 3.2. Experimental setup of passive solar still having a varying depth of water

After completing the fabrication of solar still next step is an experiment on the solar still. Total three PT 100 temperature sensors were used, first measured temperature of water bed of still and second measure glass cover temperature, and third exposed to the atmosphere to measure ambient temperature. The output is collected through the end of the lower vertical side of the basin. A water bottle (2Kg Capacity) is insulated in the system for the inlet. New technique is used to collect portable water then convention solar still.

The first experiment we determine the depth of water still to obtain the maximum output. We added 15, 20 and 30 lit in there different days. Still working 24 Hrs. but experiment parameter was started at 10:30 AM and finished at 4:00 PM. The still varying depth of water experimented for the constant thickness of glass cover which is 0.004m. The following parameter was measure every half hour in between time of 10:30 AM to 4:00 PM. The experiments are carried out on different days of the month February 2019.

1. Water temperature
2. Inner glass cover temperature
3. Ambient temperature
4. Solar intensity
5. Distillate output

Different temperature measure by PT 100 temp sensor which is directly connected to data logger stored data in USB pen drive. Solar intensity is measured by a solar power meter, which is connected to a laptop/computer system, and finally distilled water is measured by measuring flask with capacity 1 liter.

### 3.3. Experimental setup of passive solar still without parabolic trough collector

Schematic diagram of passive solar still is shown in fig 3. Dimension and other parameter were as in table 2, there were varying depths of water. But from their experiment and result, the depth of water was 20 lit. in this experiment, the procedure was the same as case 1. The water, inside glass cover and ambient temperature were measured by PT 100 temp sensor which is connected with the data logger and solar intensity was measured by the solar power meter which was connected with the laptop computer. And distillate water was measured by measuring jar.

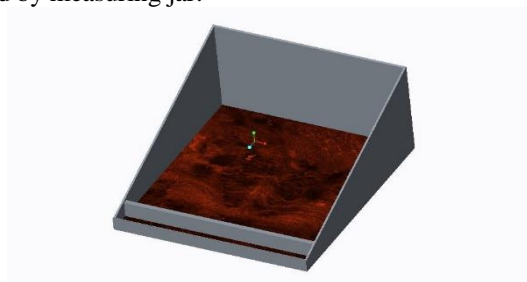


Figure 3: Design view of solar still

### 3.4. Experimental setup of passive solar still with parabolic trough collector

Generally, a distillate output of passive solar still is lower. Hence it's not widely used in the industrial and domestic purpose. There is a way of increasing the distillate output of passive solar still is the attachment of the parabolic trough collector. The PTC is made by the design described in paper by upadhyay et al.[17].The water is heated in parabolic trough collector and that hot water reaches in solar still. When hot water from parabolic trough collector come in solar still, the temperature of still water increased. The process of water evaporation is getting faster. The temperature of inside glass cover is increasing and ultimately distillate output is increased. Experimental setup of passive solar still with parabolic trough collector is shown in fig 4.



Figure 4: Solar still with PTC

## 4. Result and Discussion

### 4.1. Result of passive solar still having a varying depth of water

Result of passive solar still having a varying depth of water is shown in the below figure. This figure shows the distillate water output with varying depth of water 15 lit, 20 lit, and 30 lit. as per result the 20 lit. depth of water gives efficient output.

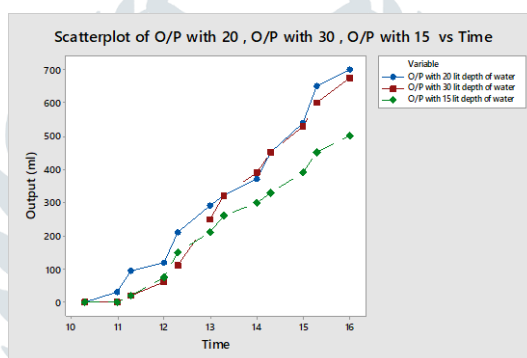


Figure 5: Graph of output vs time with varying depth of water

### 4.2. Comparison of single basin solar still without PTC and with PTC

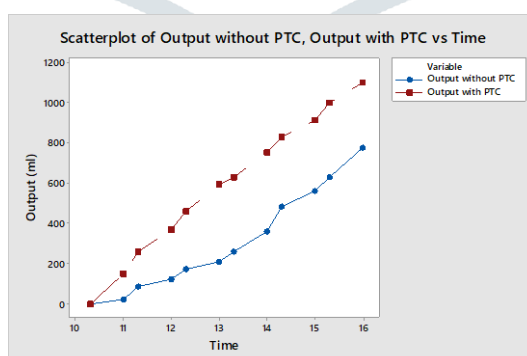


Figure 6 : Graph of output vs time for solar still without PTC and with PTC

Solar intensity is the same in both cases. It means solar intensity increase up to 13:00 or 14:00 o'clock after that solar intensity is starting decreasing. However, there is a major change in glass temperature and still water temperature. In case of without PTC, maximum water temperature is 52.4°C Maximum glass temperature is 69.5°C. But in case of with PTC, maximum still water temperature is 55.1°C and maximum glass temperature is 100.8°C. There is also a difference in distillate output. There were 64 % output increases if clubbing parabolic trough collector with single basin solar still at Godhara, India.

## Conclusion

The main conclusion from present work are

1. The output of passive solar still strongly depends upon the depth of water.

2. Passive solar still with 20 lit depth of water is found better compared with 15lit and 35 lit.
3. The integration of the parabolic trough collector with solar still increased water temperature as well as distillate output.
4. Single basin passive solar still with parabolic trough collector increased distillate output by 64% compared with conventional passive solar still.

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