

# Water Purification using a Fabricated Double Slope type Solar Still with External Reflecting Mirrors

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**ABSTRACT:** The purpose of this project is to design a water distillation system that can purify water from nearly any source, a system that is relatively cheap, portable, and depends only on renewable solar energy. The motivation for this project is the limited availability of clean water resources and the abundance of impure water available for potential conversion into potable water. In addition, there are many coastal locations where seawater is abundant but potable water is not available. Our project goal is to efficiently produce clean drinkable water from solar energy conversion. Distillation is one of many processes that can be used for water purification. This requires an energy input as heat, electricity and solar radiation can be the source of energy. When Solar energy is used for this purpose, it is known as Solar water Distillation. Solar Distillation is an attractive process to produce potable water using free of cost solar energy. This energy is used directly for evaporating water inside a device usually termed a “*Solar Still*”. Solar stills are used in cases where rain, piped, or well water is impractical, such as in remote homes or during power outages. Different versions of a still are used to desalinate seawater, in desert survival kits and for home water Purification. In this paper a double slope type solar still was fabricated for the purification of bore water and tap water in rural areas. The purity and hourly productivity of purified water were tested and are tabulated.

**KEYWORDS:** Water purification, Solar Distillation, solar energy applications, double slope type solar still.

## I. INTRODUCTION

Today fresh water demand is increasing continuously, because of the industrial development, intensified agriculture, improvement of standard of life and increase of the world population. Only about 3 % of the world water is potable and this amount is not evenly distributed on the earth. On deserts and islands where underground water is not readily obtainable and the cost of shipping the places is high it is worthwhile to take into consideration of producing potable water from saline water, using solar energy that is in abundance in deserts.

Large quantities of fresh water are required in many parts of the world for agricultural, industrial and domestic uses. Lack of fresh water is a prime factor in inhibiting regional economic development. The oceans constitute an inexhaustible source of water but are unfit for human consumption due to their salt content, in the range of 3 % to 5 %. Seawater and sometimes brackish water desalination constitute an important option for satisfying current and future demands for fresh water in arid regions. Desalination is now successfully practiced in numerous countries in the Middle East, North Africa, southern and western US, and southern Europe to meet industrial and domestic water requirements.

The supply of drinking water is a growing problem for most parts of the world. More than 80 countries, which between them have 40 % of the world's population are being suffered from this problem. In order to solve this problem, new drinking water sources should be discovered and new water desalination techniques be developed. In many countries, fossil fuel burning water desalination systems are currently used. These systems can range up to 10 ton/day

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in capacity. The main water desalination or purification methods are distillation, reverse osmosis and electro dialysis. For bigger systems, reverse osmosis and electro dialysis are more economical, but for smaller ones, simple solar stills could be preferred because of their low costs. These days, in a number of countries including West-Indian Islands, Kuwait, Saudi Arabia, Mexico and Australia, these types of distillation units exist.

Desalination has become increasingly important in providing an economically viable solution to the problem of decreasing fresh water resources. There are many factors to take into consideration to make a new technology sustainable. As we begin the 21st century, we must look towards cleaner sources of energy. Fossil fuel resources will soon be expired due to our rate of consumption. Cleaner energies such as natural gas, solar power, and photovoltaic technology must be integrated into desalination technology.

Solar desalination is a process where solar energy is used to distil fresh water from saline, brackish water for drinking purposes, charging of the batteries and medical appliances, etc. In recent years desalination of water has been one of the most important technological works undertaken in many countries. Many areas in Middle East and elsewhere have little or no natural water supplies which can be used for human consumption and, hence, depend heavily on water produced by desalination. Several methods of solar water desalination are known. Many workers indicate that the utilization of solar energy for water desalination is becoming more attractive as the cost of energy is continuously increases. Solar desalination is particularly important for locations where solar intensity is high and there is a scarcity of fresh water. The methods of solar water desalination are classified according to the way in which solar energy is used; the best-known method is the direct use of solar energy.

Small production systems as solar stills can be used if fresh water demand is low and the land is available at low cost. High fresh water demands make industrial capacity systems necessary. These systems consist of a conventional seawater distillation plant coupled to a thermal solar system. This technology is known as indirect solar desalination. Many small size systems of direct solar desalination and several pilot plants of indirect solar desalination have been designed and implemented. Nevertheless, in 1996 solar desalination was only 0.02 % of desalted water production.

Another advantage of desalination is that it will never run out its raw material. Because the facility is located right next to the ocean, and the ocean is so vast. Because of this, desalination is a drought-proof. Resource that is constantly able to produce fresh water regardless of the amount of rainfall. This is a great advantage if the desalination process is located in an agricultural area.

## II. OBJECTIVE

This work has the following objectives and contributions in the field of water purification systems using solar still:

1. To implement a methodology by which the design and selection of solar still for water purification can be made comprehensive and easy.
2. The above model is to be used in modelling and analysis for in depth study of the whole system.
3. Optimization of solar stills with respect to the performance i.e. efficiency, hourly productivity, quality, reliability, durability and most importantly the cost of different materials constituting the system.
4. Complete analysis, evaluation, and comparison of the different solar stills for water purification available in the global market, and also the ranking and optimum selection of the solar still.
5. To design and fabricate the Prototype solar still for hot water purification and its feasibility in other applications.
6. To fabricate a cost efficient solar still with the use of different alternative materials.
7. To calculate the performance of the solar still for the water purification in terms of hourly productivity, temperature of inlet water and temperature inside the still.

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## III. COMPONENTS

Solar still is a simple device which can convert available water or brackish water into portable water by using solar energy. Main components of solar still are:

1. **BASIN:** It is the part of the system in which the water to be distilled is kept. It is therefore essential that it must absorb solar energy. Hence, it is necessary that the material has *high absorptivity* or *very less reflectivity* and *very less transmittivity*. These are the criteria for selecting the basin materials.
2. **CONDENSATE CHANNEL:** It is the part of the system in which condensed water is collected. Sheet of required dimension is first cut out, and then it is folded by using the folding machine.
3. **BLACK LINER:** Solar radiation transmitted through transparent cover is absorbed in the black lining. Black bodies are good absorbers. *Black paint* is used as liner.
4. **TRANSPARENT COVER:** *Glazing glass* is used and thickness of *5 mm* is selected. The use of glass is because of its inherent property of producing greenhouse effect inside the still. Glass transmits over 90% of incident radiation in the visible range.
5. **INSULATION:** *Thermocol* is used as insulator to provide thermal resistance to the heat transfer that takes place from the system to the surrounding.
6. **SEALANT:** M seal and putty is used as sealant to make the distiller leak proof and air tight. *UV Glue* is used to join Metal to Glass. *Silicon Glue* is used to join Glass to Glass.
7. **SUPPLY AND DELIVERY SYSTEM:** Three holes are made in the basin, *one for supply* and *two for delivery*.
8. **TABLE:** *Pine wood* table is used to support whole setup. Pine wood has good surface finish. Base of *Ply wood* is used because of its good strength.
9. **SQUARE BOX:** *Wooden Square Box* is used to hold *side (threaded) stand*.
10. **REFLECTOR:** *Reflecting Mirror* is used with one side silver coated and is supported by *ply wood* to prevent its breakage.
11. **TEMPERATURE SENSOR:** *Digital LCD Probe Temp Sensor* along with its complimentary components is used. LCD of the sensor reflects temperature of following areas in °C:-
  - Temperature of incoming brackish water.
  - Temperature of outgoing potable water.
  - Temperature at the top of glass cover.

S.No.	Parameters	Double Slope
1.	Area of Basin	0.80x0.40 m <sup>2</sup>
2.	Height of Basin	0.10 m
3.	Area of Glass	0.80x0.50 m <sup>2</sup>
4.	Thickness of Glass Cover	0.003m
5.	Angle of Glass	25°
6.	Thickness of Insulation	0.01 m
7.	Height of Still from Ground	0.50m

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Vol. 6, Issue 5, May 2017

## IV. MATERIALS AND METHODS

The materials used for this type of still should have the following characteristics:

- Materials should have a long life under exposed conditions or be inexpensive enough to be replaced upon degradation.
- They should be sturdy enough to resist wind damage and slight earth movements.
- They should be nontoxic and not emit vapours or in still an unpleasant taste to the water under elevated temperatures.
- They should be able to resist corrosion from saline water and distilled water.
- They should be of a size and weight that can be conveniently packaged, and carried by local transportation.
- They should be easy to handle in the field.

Although local materials should be used whenever possible to lower initial costs and to facilitate any necessary repairs, keep in mind that solar stills made with cheap, unsteady materials will not last as long as those built with more costly, high quality material. With this in mind, you must decide whether you want to build an inexpensive and thus short-lived still that needs to be replaced or repaired every few years, or build something more durable and lasting in the hope that the distilled water it produces will be cheaper in the long run. Of the low cost stills that have been built around the world, many have been abandoned. Building a more durable still that will last 20 years or more seems to be worth the additional investment.

Choosing materials for the components in contact with the water presents a serious problem. Many plastics will give water off a substance which can be tasted or smelled in the product water, for periods of anywhere from hours to years.

## V. EXPERIMENTAL SETUP



Fig V.I: Fabricated Double Slope type Solar Still with External Reflecting Mirrors

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Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 5, May 2017

The Double slope type solar still consists of inlet and outlet water tanks, basin, transparent covers, external reflecting mirrors and supporting structure which are explained above briefly.

## VI. EXPERIMENTAL PROCEDURE

The stepwise experimental procedure which is followed during the experiment is as follows:

- Step 1:** All the components of the Solar Still were gathered and assembled together.
- Step 2:** The arrangement was placed at the open place on the clean sky days in the local cell of 78.03°E, 15.82°N at Dr.K.V. Subbareddy Institute of Technology, Kurnool.
- Step 3:** Experiments were conducted on the days which are selected in such a way that there should have clear sky conditions during the months March and April.
- Step 4:** Cleaning of the glasses and mirrors of solar still was done to remove the dust particles and moisture content. For each experiment, the glass cover was cleaned in the morning to avoid the dust deposition over the outer layer of the glass.
- Step 5:** The inlet supply tank was filled with bore water and was placed at the height of one and half meter from the solar still to create necessary pressure head caused for the flow of working fluid through copper tube.
- Step 6:** The solar still was exposed to the sun, using tracking support, 60 min before start of the experiment.
- Step 7:** The water supply was started from 08:00 am.
- Step 8:** The water was made to enter the solar still. Depth of water is maintained at constant level to increase evaporation capacity of solar still.
- Step 9:** Ambient temperature, water inlet temperature, temperature inside the solar still were noted down. Thermocouples were used to measure the temperatures of various points on the stills.
- Step 10:** The pure water was collected in the collecting jar.
- Step 11:** The purity of the collected water was tested at REGIONAL PUBLIC HEALTH LABORATORY at KURNOOL MEDICAL COLLEGE CAMPUS, KURNOOL-AP.
- Step 12:** The productivity of the solar still was estimated by collecting the pure water for every two hours from 8-00am to 6:00 pm. The purified output from the stills was collected in 500ml measuring cylinders.
- Step 13:** The same experimental procedure was repeated to purify the tap water in rural areas.

## VII. EXPERIMENTAL RESULTS

Basin is filled with 10 litres of Brackish Water and then performance of our Solar Still was checked. The result is tabulated below:-

TIME	QUANTITY OF OUTPUT WATER (ml)
08-00 TO 10-00 Hours	350
10-00 TO 12-00 Hours	550
12-00 TO 14-00 Hours	800
14-00 TO 16-00 Hours	700
16-00 TO 18-00 Hours	400

Table:VII.I Performance analysis of Solar Still

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Vol. 6, Issue 5, May 2017

Bore Water Testing Table:

S.NO.	CHEMICAL CHARACTERISTICS	At Inlet	At Outlet
1.	P <sup>H</sup> VALUE	6.9	7.0
2.	ELECTRICAL CONDUCTIVITY AT 28 <sup>0</sup> C	292	75
3.	DISSOLVED SOLID (105 <sup>0</sup> C )	193	50

Table: VII.II Bore water Inlet and outlet testing readings

Tap Water Testing Table:

S.NO.	CHEMICAL CHARACTERISTICS	At Inlet	At Outlet
1.	P <sup>H</sup> VALUE	7.9	7.8
2.	ELECTRICAL CONDUCTIVITY AT 28 <sup>0</sup> C	1453	84
3.	DISSOLVED SOLID (105 <sup>0</sup> C )	959	55

Table: VII.III Outlet bore water and tap water testing readings

### VIII. CONCLUSION

The following conclusions are drawn by the experimental analysis of the solar still for water purification

- It was observed that when the water depth increases from 0.01m to 0.03m the productivity decreased by 5%. These results show that the water mass (water depth) has an intense effect on the distillate output of the solar still system.
- Solar still productivity can also increase by use of reflector by 3%. The use of the mirror reflector will increase the temperature of the solar still basin; such an increase in the temperature is because of the improvement in solar radiation concentration.
- The increase in the solar radiation increases the productivity of the still by 15 to 32%. However the increase of the solar radiation parameter will increase the solar energy absorbed by the basin liner.
- The main disadvantage of this solar still is the low productivity or high capital cost per unit output of distillate. This could be improved by a number of actions, e.g. injecting black dye in the seawater, using internal and external mirror, using wick, reducing heat conduction through basin walls and top cover or reusing the latent heat emitted from the condensing vapour on the glass cover. Capital cost can be reduced by using different designs and new materials for construction of solar stills

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