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# Design and Construction of Solar Water Distillation System

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## ABSTRACT

There is an important need for clean, pure drinking water in many developing countries. Often Water sources are brackish (i.e. contain dissolved salts) and/or contain harmful bacteria and Therefore cannot be used for drinking. In addition, there are many coastal locations where Seawater is abundant but portable water is not available. For this reason, purification of water supplies is extremely important. With reference to this, a plant which can convert the dirty/saline water into portable water using the solar energy has been proposed and analyzed. The present work is based on purifying water through solar distillation. It is a simple yet effective means to provide drinking water in a reliable and cost-effective manner. Solar still effectively eliminate all water borne pathogens, salts, and heavy metals. Thus, immediate benefits to users by alleviating health problems associated with water-borne diseases. The TDS and pH of water samples are tested before and after the distillation, to know that the plant has actually distilled the water and reduced the TDS. The data for the experiments are collected from the test rig set up in Navsari district of Gujarat, India.

**Keywords:** Solar Still; Water Distillation; Renewable Energy; Font; Purification Analysis

## I. INTRODUCTION

Today fresh water demand is increasing continuously because of the industrial development, intensified agriculture, improvement in standard of life and increase in the world population. About 70% of the planet is covered in water, yet of all of that, only around 2% is fresh water, and of that 2%, about 1.6% is locked up in polar ice caps and glaciers. So of all of the earth‟s water, 98% is saltwater, 1.6% is polar ice caps and glaciers, and 0.4% is drinkable water from underground wells or rivers and streams. And despite the amazing amount of technological progress and advancement that the current world we live in has undergone, roughly 1 billion people, or 14.7% of the earth's population, still do not have access to clean, safe drinkable water. Therefore it is an urgent need for clean and pure drinking water in many countries.

In order to solve this problem, some new drinking water sources should be discovered and new water desalination techniques be developed. In recent years desalination of water has been one of the most important technological works undertaken in many countries. The fossil fuel burning water desalination techniques are in use since long back. These systems range up to 10 ton/day capacity. The main water desalination or purification methods are distillation, reverse osmosis and electro dialysis. Cleaner energies such as natural gas, solar thermal power and photovoltaic technology must be integrated with desalination technology. 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 and less floor area.Utilization of solar energy for water desalination is becoming more attractive as the cost of conventional fuels/energy is continuously increasing. Solar desalination is particularly important for locations where solar intensity is high and there is a scarcity of fresh water. Solar desalination is a process where solar energy is utilized to putify the fresh water from saline/brackish water for drinking purposes, in charging of the batteries, research laboratories and medical appliances etc.

After researching and investigation, we outlined our needs to be the following:

1. Efficiently produce at 2 gallons of portable water per day minimum

2. Able to purify water from virtually any source, included the ocean
3. Relatively inexpensive to remain accessible to a wide range of audiences
4. Easy to use interface
5. Intuitive setup and operation
6. Provide clean useful drinking water without the need for an external Energy source
7. Reasonably compact and portable

## II. METHODS AND MATERIAL

### 1. Principle of Desalination

Desalination is one of the most important methods of getting potable water from brackish and sea water by using the free energy supply from the sun. In nature, solar desalination produces rain when solar radiation is absorbed by the sea and causes water to evaporate. The evaporated water rises above the earth"s surface and is moved by the wind. Once this vapour cools down to its dew point, condensation occurs, and the fresh water comes down as rain as shown in Figure 1.1.

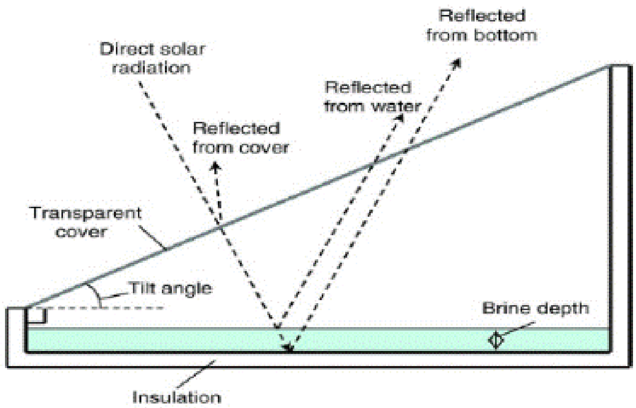


**Figure 1.1:** Solar Still Diagram

The energy required to evaporate water is the latent heat of vaporization of water. This has a value of 2260 kilojoules per kilogram (kJ/kg). This means that to produce 1 liter (i.e. 1kg since the density of water is 1kg/liter) of pure water by distilling brackish water requires a heat input of 2260kJ. This does not allow for the efficiency of the heating method, which will be less than 100%, or for any recovery of latent heat that is rejected when the water vapor is condensed.

It should be noted that, although 2260kJ/kg is required to evaporate water, to pump a kg of water through 20m head requires only 0.2kJ/kg. Distillation is therefore normally considered only where there is no local source of fresh water that can be easily pumped or lifted.

### 1.2 Total Dissolved Solids -TDS

"Dissolved solids" refer to any minerals, salts, metals, cat ions or anions dissolved in water. This includes anything present in water other than the pure water (H2O) molecule and suspended solids. (Suspended solids are any particles/substances that are neither dissolved nor settled in the water, such as wood pulp.) In general, the total dissolved solids concentration is the sum of the cat ions (positively charged) and anions (negatively charged) ions in the water. Parts per Million (ppm) is the weight-to-weight ratio of any ion to water. Conductivity is usually about 100 times the total cat ions or anions expressed as equivalents. Total dissolved solids (TDS) in ppm usually range from 0.5 to 1.0 times the electrical conductivity.

The EPA Secondary Regulations advise a maximum contamination level (MCL) of 500mg/liter (500 parts per million (ppm)) for TDS [P5]. When TDS levels exceed 1000mg/L it is generally considered unfit for human consumption. A high level of TDS is an indicator of potential concerns, and warrants further investigation.

### 1.3 Solar Radiation and Insolation

Solar insolation is the total solar radiation received on earth surface on particular time.

Solar insolation is defined as average intensity (radiation per solid angle) or the measure of solar radiation received on a surface at some time. Average insolation on the Earth's surface is approximated to be 250 W/m2 or 6 kWh/m2/day.

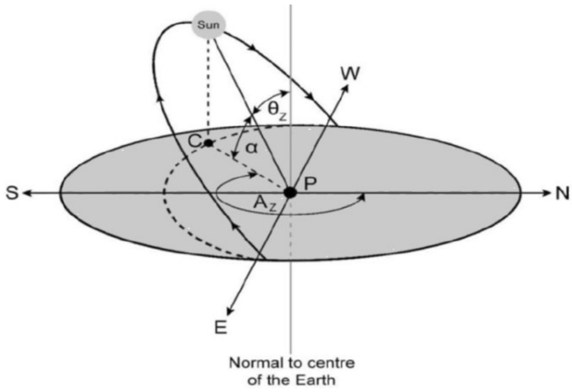

Figure 1.2: Zenith angle (Θz), the altitude angle (α), and the Azimuth Angle (Az) of the Sun when view from point P on the Earth's surface.

1 kWh/m²/day = 1,000 W x 1 hour / (1 m² x 24 hours) = 41.67 W/m²

**1.4 Solar Angles of the Location of Test-rig**

The solar insolation I(t) can be calculated by the equation,

$I(t) = S \cos \Theta z$

Where,
S = Clear day average solar insolation on a surface perpendicular to incoming solar radiation.
$\Theta z$= Zenith Angle = cos-1 (sin Ø sin δ+ cos Ø cos δ cos ω)
Ø = Latitude angle = 20°51" for Navsari
ω = Hour Angle (Angle of radiation due to time of day) = 15° (Time – 12)
δ = Solar declination angle = (23.45) sin [360 (284 + n)/365]

**2. Design of Solar Still**

Figure 2.1 shows a Single Effect Solar Still Schematic Diagram The pure water is be obtained by distillation in the simplest solar water distillation system, generally known as the "basin type solar water distillation system". It is shown schematically in figure 3. Such solar water distillation systems 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 spaces above the basin. It has a roof-like shape.

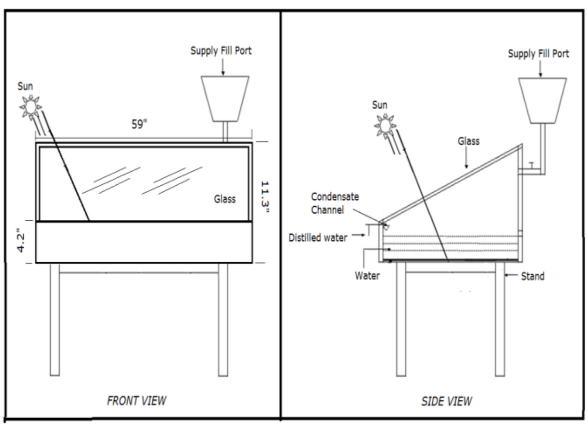


Figure 2.1: Schematic Diagram of Solar Still

The cover, which is of glass, is sloped towards a collection trough. Solar radiation passes through the cover and is absorbed and converted into heat in the black painted aluminum surface. Impure water in the basin or tray is heated and the vapour produced is condensed to purified water on the cooler interior of the glass roof. The transparent glass transmits nearly all radiation falling on it and absorbs very little; hence it remains cool enough to condense the water vapour. The condensed water flows down the sloping roof and is collected in collecting channel. Saline water can be replaced in the operation by either continuous operation or by batches. The basin type solar water distillation system has produced distilled water at a cost per unit of product lower than other types of solar equipment.

**2.1 Components of Single Effect Solar Water Distillation System**

**2.1.1 Outer Tray**

Outer tray is made of wooden tray, as per the dimensions shown in the drawing by cutting and then joining.

**2.1.2 Inner Blackened Tray**

Inner blackened tray is made of Galvanized iron, and it is painted with heat absorbing black paint on the inner side, on which water will be resting.

**2.1.3 Glazing with condensate channel**

For glazing, Toughened Glass is used. Condensate channel is made of aluminum. It is screwed on the inner side of the frame of the glazing, to collect the condensed water from the inner side of glass.

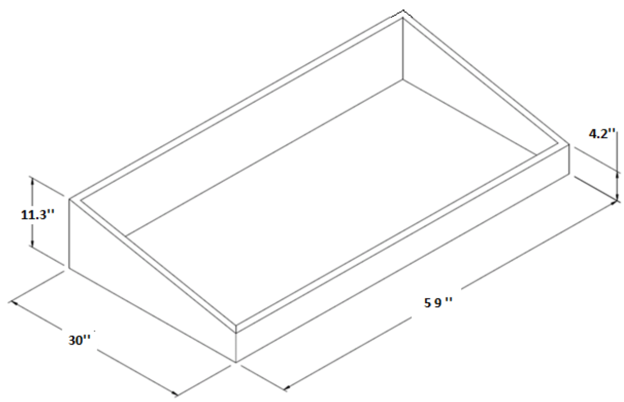


Figure 2.2: CAD model Outer Frame

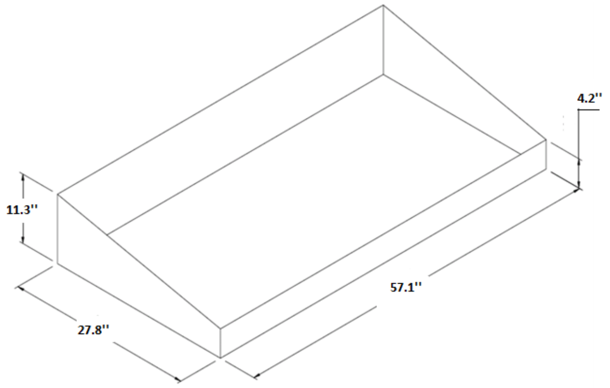


Figure 2.3: CAD model Inner Blackened Tray

Other components include condensate channel, sealing gasket, insulation, supply and delivery system and stand

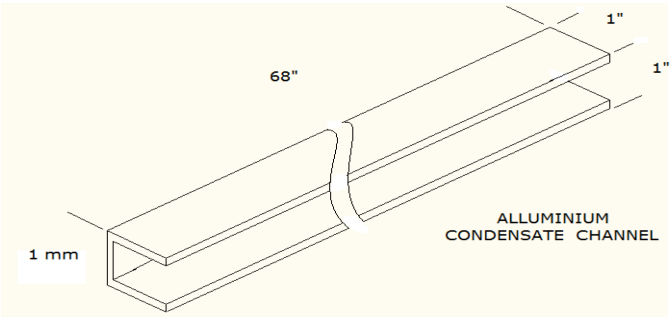


Figure 2.4: Glazing with condensate channel

### 2.2 List of the Solar Still Components

| SR NO. | PARAMETERS | DIMENSIONS |
|---|---|---|
| 1. | Area of Basin | 1.155 $m^2$ |
| 2. | Area of Glass | 1.14 $m^2$ |
| 3. | Thickness of Glass Cover | 5 mm |
| 4. | Angle of Glass | 13.5° |
| 5. | Thickness of Insulation | 5 mm |
| 6. | Height of Still From Ground | 0.71 m |

Table 1: Components of Solar Still

**Principle of Desalination**

Desalination is one of the most important methods of getting potable water from brackish and sea water by using the free energy supply from the sun. In nature, solar desalination produces rain when solar radiation is absorbed by the sea and causes water to evaporate. The evaporated water rises above the earth"s surface and is moved by the wind. Once this vapour cools down to its dew point, condensation occurs, and the fresh water comes down as rain as shown in Figure 1.1.

## III. RESULTS AND DISCUSSION

### Experiments and Calculations

Based on the thermal calculations performed on the still, following result has been obtained.

| SEASON | OUTPUT PER DAY(Litre) | FINAL OUTPUT (Litre) | EFFICIENCY |
|---|---|---|---|
| Winter | 1.59 | 4.80 | 18.5 % |
| Summer | 2.68 | 8.04 | 29.6 % |

Table 2: Result Table

The TDS analysis of the water obtained before and after the distillation for the sea water and the municipal water has been stated in the following table.

| SR. NO. | SAMPLE | TDS |
|---|---|---|
| 1. | MUNICIPALITY WATER | |
| | Before Distillation | 547 ppm |
| | After Distillation | 33 ppm |
| 2. | SEA WATER | |
| | Before Distillation | 3350 ppm |
| | After Distillation | 392 ppm |

Table 3: TDS Analysis of Water Sample

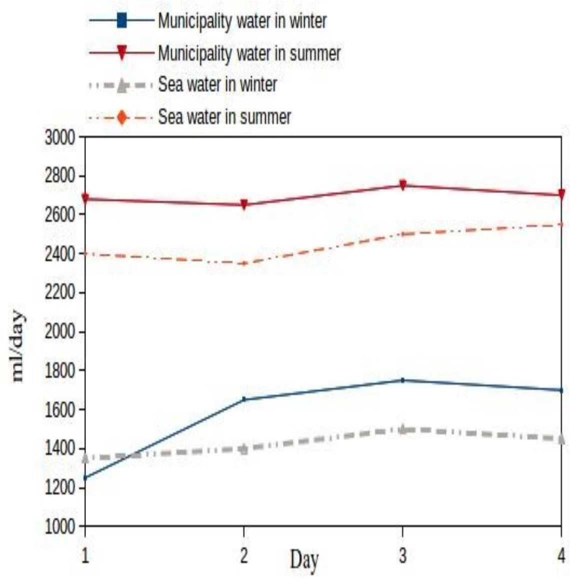


Figure 3.1: Productivity of sea and municipal water in summer and winter season

## IV. CONCLUSION

From reading we conclude that this single effect solar distiller gives 1.56 litres and 2.68 litres (municipality water) & 1.42 litres and 2.44 litres (sea water) of distilled water in winter and summer in 1 day sunlight. It is pure with TDS reduction within safe limit. The water collected from the setup is drinkable for human beings. Also some germs are removed due to heating of water.

## V. REFERENCES

[1]. Hitesh N. Panchal et al, A comparative analysis of single slope solar still coupled with flat plate collector and passive solar still, IJRRAS 7 (2) May 2011.
[2]. Khalifa, A.J.N., A.M. Hamood Performance Correlations for Basin-type Solar Stills. Desalination 249(2009) 24-28.
[3]. Omar O. Badran, Mazen M. Abu-khader, Evaluating thermal performance of a single slope solar still , Heat And Mass Transfer, No.43, pp. 985-995, 2007.
[4]. Al Hayek I and Bardan O O, The effect of using different designs of solar stills on water distillation , Desalination, No.150, pp.230-250, 2004.
[5]. M. Koilraj Gnanadason et al, Comparison of Performance Analysis between Single Basin Solar Still made up of Copper and GI, International Journal of Innovative Research in Science, Engineering and Technology Vol. 2, Issue 7, July 2013.
[6]. Al-Kharabsheh S.& Goswami D. Y. Theoretical Analysis of a Water Desalination System Using LowGrade Solar Heat. Journal of Solar Energy Engineering MAY, Vol. 126, 2004.
[7]. Tiwari A.K. & Tiwari G.N. Thermal modeling based on solar fraction and experimental study of the annual and seasonal performance of a single slope passive solar still: The effect of water depths. Desalination 207,pp. 184–204, 2007.
[8]. Kalogirou S. A. Seawater desalination using renewable energy sources. Progress in Energy and Combustion Science 31,pp. 242–281,2005.
[9]. T. Rajaseenivasan, P. Nelson Raja, K. Srithar. An experimental investigation on a solar still with an integrated flat plate collector, Desalination 347 (2014) 131–137.
[10]. Mohamed A. Eltawil , Z.M. Omara. Enhancing the solar still performance using solar photovoltaic, flat plate collector and hot air, Desalination 349 (2014) 1–9.