Desalination of Water Using A Passive Conventional Solar Still

Jalakanuru Ramesh[1], E. Venkata Subbareddy[2], B. Durga Prasad[3]
[1]Research Scholar, JNTUA, Ananthapuramu, AP, India
[2]Professor of Mechanical Engineering, Sanskrithi School of Engineering, Puttaparthi, AP, India
[3]Professor of Mechanical Engineering, JNTUA, Ananthapuramu, AP, India

Abstract- *Many countries in the world are facing the water scarcity. Many people are suffering from more diseases by taking impure water. So there is a need of potable water. Nowadays there are so many distillation techniques are available for treating water but they are energy dependents. Solar still is a pollution free device that uses the solar energy for water purification. It can produce pure water for drinking, cooking and medical applications. It is very cheap and simple in construction and operation and it uses renewable energy source only. There are so many types of solar desalination systems are available but the conventional solar still is most likely used. In the present work, a passive-conventional type double slope solar still of basin area 1 m2 was fabricated. Two samples of bore water and tap water were collected. The purity of output pure water of the solar still was tested in terms of pH values, TDS values, and electrical conductivities.*

Keywords- solar desalination, double slope solar still, potable water, pure water.

I. INTRODUCTION

However, Most of our earth surface is covered by water, less than 1% of total available water is fresh water which is mostly available in lakes, rivers and underground. Again, about one-third of that potential fresh water can only be used for human needs due to mixed factors. Approximately 1.1 billion people in this world have inadequate access to safe drinking water. There are 26 countries do not have enough water to maintain agriculture and economic developments. The population growth - coupled with industrialization and urbanization results in an increasing demand for water. In India, the scarcity of desalinated water is severe in coastal areas, especially in the remote coastal areas.

Distillation is one of many processes that can be used for water purification. Different methods of desalination have been used in several countries to resolve the crisis of drinking water. A variety of desalination technologies has been developed over the years on the basis of thermal distillation, membrane separation, freezing, electro dialysis, etc. Commercially, the two most important technologies are based on the multistage flash distillation (MSF) and reverse osmosis (RO) processes. It is viewed that three processes – MSF, RO, and multiple-effect distillation (MED) – will be dominant and competitive in the future. Most commercial stills and water purification systems require electrical or other fossil-fueled power sources. The use of electricity in distillation apparatus, like in fractional distillation, is energy intensive. Air pollution, acid rain, global warming and climate change are but a few of the consequences that are attributed to use of fossil fuels and have been widely investigated.

Renewable energy based desalination plants can solve this fresh water production problem without causing any fossil energy depletion, hydrocarbon pollution and environmental degradation. In the last decades, many researchers have been conducted to minimize the cost of this process, and several methods have been developed. Among these methods, solar distillation appears as one of the best practical and the most economical, especially for mass production of fresh water from high saline water like seawater. Solar distillation is a process where solar energy is used to produce fresh water from saline or brackish water for drinking, domestic and other purposes.. Solar energy can be used to supply the energy required to heat water by making use of a solar still. A solar still operates on the same principle as that of rain formation: water from the ocean evaporates, then cools, condenses, and returns to earth as rainwater. When the water evaporates, only pure water vapor is formed while contaminants are left behind in the still basin and the distillate flows to the collection gutter by gravity. The advantage of solar energy based small desalination plant is the requirement of small quantities of energy which is mostly collected from the sun. This should be the most economical solution to provide potable water to villagers residing at remote areas where proper infrastructure is lacking. Solar distillation looks very attractive as it utilizes the free source of energy – the heat from the sun. The energy varies depending on the time of the day and also due to seasonal and climatic changes.

From its operational feasibility and associated costs, it can be inferred that solar still technology is quite capable to provide desalinated water to households in rural India. The fresh water crisis is already evident in many parts of India in varied scale and intensity at different times of the year. The demand for fresh water increases with the growth of its population. The conventional desalination technologies are expensive for the production of small amount of fresh water. Also, use of conventional energy sources is costly and not always eco-friendly.

II. SOLAR STILLS

Solar still is possibly the oldest method of desalination of water. Its principle of operation is the greenhouse effect; the radiation from the sun evaporates water inside a closed glass covered chamber at a temperature higher than the ambient. A schematic diagram of typical basin type solar still is shown in figure.

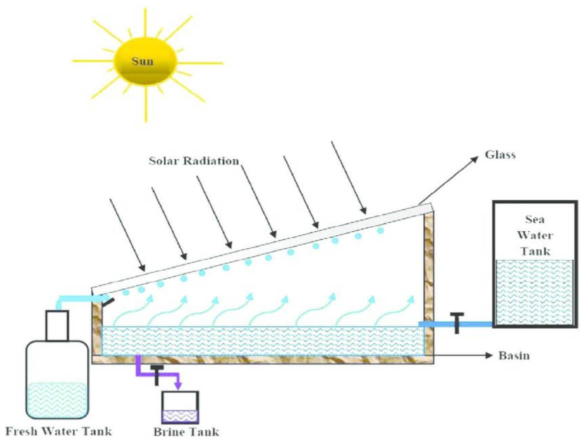


Figure 1. Schematic diagram of a simple solar still

The saline water is fed on a black plate in the lower portion of the solar distiller. The heat of the sun causes the water to evaporate and water vapor condenses to form purely distilled droplets of water when it reaches the cool transparent leaning surface made of glass or plastic. The droplets slide down along the leaning surface and are collected through special channels located under the leaning surface

The classification of solar desalination system, is as follows:

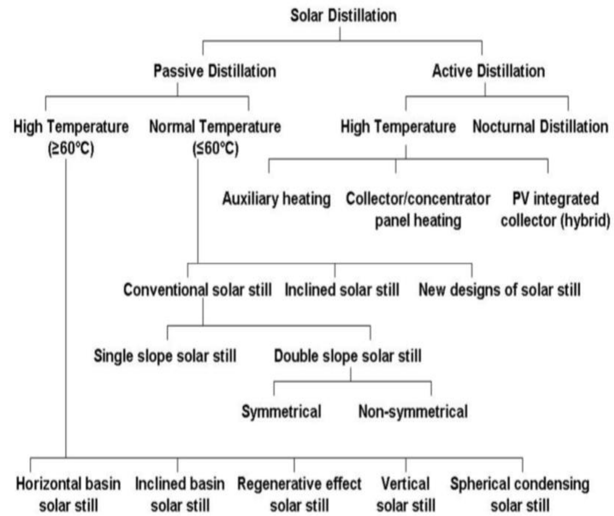


Figure 2. Classification of solar stills

III. PURITY OF WATER

Purity of water measured in terms of pH value, Total dissolved solids (TDS) and Salinity and Electrical conductivity discussed as below

III.I. pH in Drinking-water

The pH of water is a measure of the acid-base equilibrium and, in most natural waters, is controlled by the carbon dioxide–bicarbonate–carbonate equilibrium system. An increased carbon dioxide concentration will, therefore, lower pH, whereas a decrease will cause it to rise.

The pH is of water is of great significance in deciding the corrosivity of water As it can influence the level of corrosion of metals and any impact on health is probably going to be indirect because of absorption of metals from water pipes. The pH of the water has to be maintained to minimize the corrosion of water mains and pipes. Failure to achieve this can bring about the contamination of water and result in unfavorable outcomes on its taste, odor, and appearance. Be that as it may, as a rule, the lower the pH, higher the level of corrosion.

The temperature will have a very slight effect on the pH of water. As water temperature goes up, pH goes down and similarly colder water has a relatively higher pH value.

The pH of most drinking-water lies within the range 6.5–8.5

III.II. TDS in Drinking-water

A total dissolved solid (TDS) is used to describe the inorganic salts and small amounts of organic material present in water. The vital constituents are usually calcium, magnesium, sodium, potassium cations, hydrogen carbonate, potassium carbonate, chloride, sulfate, and nitrate anions. TDS in water supplies originate from natural sources, sewage, and industrial wastewater. Dissolved solids can be introduced via inorganic materials such as rocks and air that may have traces of nitrogen, calcium bicarbonate, iron phosphorous, sulphur, and other minerals.

Different organizations, companies, and government have different regulations for the TDS level. According to World Health Organization, TDS concentration of 1000 mg/ litre is considered acceptable for water consumers but this acceptability factor may change as TDS concentration has a direct impact on the taste of water.

TDS concentration levels and its corresponding taste quality is suggested by the KENT's Mineral RO, following is the preferable level of TDS in water:

Table 1. TDS Concentration levels and its taste quality

Level of TDS (milligrams per litre)	Rating
Less than 300	Excellent
300 - 600	Good
600 - 900	Fair
900 - 1,200	Poor
Above 1,200	Unacceptable

A very low concentration of TDS produces undesirable taste of water, as many people buy mineral water, which has natural levels of dissolved solids. Increased concentrations of dissolved solids can also have technical effects.

III.III. Electrical Conductivity

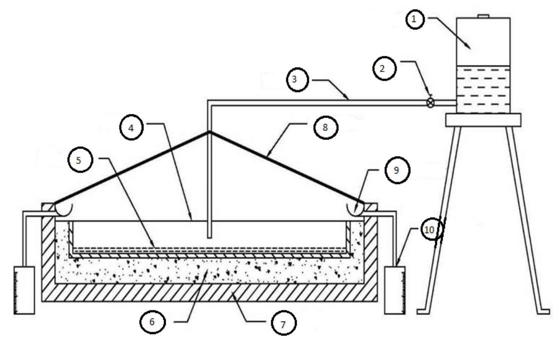
Salinity and conductivity measure the water's ability to conduct electricity, which provides a measure of what is dissolved in water. In the SWMP data, a higher conductivity value indicates that there are more chemicals dissolved in the water.

Conductivity measures the water's ability to conduct electricity, which provides a measure of what is dissolved in water. It is the opposite of resistance. a higher conductivity value indicates that there are more chemicals dissolved in the water. Pure, distilled water is a poor conductor of electricity. When salts and other inorganic chemicals dissolve in water, electrically charged ions increase the water's ability to conduct electricity. Common ions in water that conduct electrical current include sodium, chloride, calcium, and magnesium.

As water temperature increases, the conductivity of water also increases; where TDS in water is directly related to conductivity. For each 1°C increment, conductivity rise by 2–4%. Temperature influences conductivity by increasing ions mobility and additionally the dissolvability of many salts and minerals.

IV. EXPERIMENTAL SETUP

Solar still is a simple device which can convert available water or brackish water into portable water by using solar energy. Experiment layout of solar still is shown in figure below.



1. Storage tank 2. Regulating valve
3. Pipe line 4. Still basin
5. Saline water 6. Insulation
7. Outer shield 8. Glass cover
9. Collection tray 10. Measuring jar

Figure 3. Experimental Layout of Solar still

Main components of solar still are still basin with insulation, transparent glass cover, condensate collection channel, supply and delivery systems.

Basin 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 transmitivity. These are the criteria for selecting the basin materials. Thermocol is used as insulator to provide thermal resistance to the heat transfer that takes place from the system to the surrounding. Three holes are made in the basin, to connect one for supply and two for delivery pipes.

Condensate collection channel 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.

Transparent Glazing glass of 5 mm thickness was used because of its inherent property of producing greenhouse effect inside the still. Glass transmits over 90% of incident radiation in the visible range. Solar radiation transmitted through transparent cover is absorbed in the black lining. Black bodies are good absorbers. Black paint is used as liner.

V. EXPERIMENTAL PROCEDURE

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

All the components of the Solar Still were gathered, cleaned and assembled together. The arrangement was placed at the open place on the clean sky days of summer in the local cell of 78.03°E, 15.82°N at Dr.K.V. Subbareddy Institute of Technology, Kurnool. 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.
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. 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.

The solar still was exposed to the sun, using tracking support, 60 min before start of the experiment. Then the water was made to enter the solar still. Depth of water is maintained at constant level to increase evaporation capacity of solar still. The pure water was collected in the collecting jar. The purity of the collected water was tested at REGIONAL PUBLIC HEALTH LABORATORY at KURNOOL MEDICAL COLLEGE CAMPUS, KURNOOL-AP, India

The same experimental procedure was repeated to purify the tap water in rural areas.

VI. RESULTS AND DISCUSSIONS

Basin is filled with 10 litres of Brackish Water and then working of the Solar Still was tested.

Table 2. Bore water testing Results

S.No	Chemical Characteristics	At Inlet	At outlet
1	pH Value	6.9	7.0
2	Total Dissolved Solids at 105°C	193 mg/L	50 mg/L
3	Electrical Conductivityat 28°C	292 s/m	75 s/m

Table 3. Tap water testing Results

S.No	Chemical Characteristics	At Inlet	At outlet
1	pH Value	7.9	7.8
2	Total Dissolved Solids at 105°C	959 mg/L	55 mg/L
3	Electrical Conductivityat 28°C	1453 s/m	84 s/m

pH of the water was measure using a pH meter of 0-14 range. A Digital TDS meter with 0-2000 mg/L range was used to find the Total dissolved solids of water. Electrical conductivity of water was measured using the Water conductivity meter of rage 0-9999 s/m.

VII. CONCLUSION

pH is one of the most important operational water quality parameters. Careful attention to pH control is necessary to ensure satisfactory water clarification and to avoid the corrosivity of water. The pH values obtained for bore water and tap water are 7.0 and 7.8 respectively. The Ph range of most drinking water is 6.5-8.5. So the water obtained from the solar still is suitable for drinking.

The Total Dissolved solids (TDS) of still output is 50 & 55 at 105°C which are excellent in rating. A very low concentration of TDS has been found to give water a flat taste, which is considered to be unacceptable to many people and same goes the case with increased concentrations of dissolved solids as it produces hard water.

Concentration of TDS has direct impact on electrical conductivity of water. Pure, distilled water is a poor conductor of electricity. The electrical conductivity of still output water at 28°C are 75 and 84.

REFERENCES

[1] J. Ramesh, Dr. EV Subbareddy, Dr. B. Durga Prasad, "Water purification using a fabricated double slope type solar still with external reflecting mirrors", International Journal of Innovative Research in Science, Engineering and Technology, vol. 6, issue 5, **(2017)**, pp. 7484-7490.
[2] J.Ramesh, J.Kanna Kumar, Dr.E.V.Subbareddy, "Design, Fabrication and Performance Analysis of a Parabollic trough Solar Collector Water Heater", International Journal of Innovative Research in Science, Engineering and Technology, Vol. 4, Issue. 7, (2015) , pp. 6038-43
[3] J.Ramesh, J.Kanna Kumar, Dr.E.V.Subbareddy, "Fabrication and Performance Evaluation of a Flat Plate Solar Collector Water Heater", International Journal of

Innovative Research in Science, Engineering and Technology, Vol. 6, Issue. 4, April 2017, pp. 5293-5299.

[4] Yogesh S. Kapnichor, Rasika R. Dahake, Priyanka A. Manmode, Rahul P. Ukey, Alisa A. Sakharkar , "A review on solar still water purification", International Journal for Innovative Research in Science & Technology, Vol 3, Issue 09, (2017), pp 59-63.

[5] C. Tenthani, A. Madhlopa, C.Z. Kimambo, "Improved Solar Still for Water Purification", Journal of Sustainable Energy & Environment 3 (2012), pp 111-113.

[6] Amitava Bhattacharyya, "Solar Stills for Desalination of Water in Rural Households", International Journal of Environment and Sustainability, Vol. 2 No. 1, (2013). pp. 21-30.

[7] Yusef H, Zurigat, Mousa K, Abu Arabi, "Modeling and performance analysis, of a regenerative solar desalination unit", Applied thermal engineering, 24 (2004), pp 1061-1072.

[8] Shannon M.A., Bohn P.W., Elimelech M., Georgiadis J.G., Marinas B.J., Mayes A.M. "Science and technology for water purification in the coming decades", Nature 2008;452:pp. 301–310.

[9] Elimelech M. "The global challenge for adequate and safe water" J. Water Supply Res. Technol. AQUA 55 (2006) 3.

[10] Mink G, Horvath L, Evseev EG and Kudish AI. Design parameters, performance testing and analysis of a doubleglazed, air-blown solar still with thermal energy recycle. Solar Energy 1998;64:265–77.

[11] Mousa Abu-Arabi, YousefZurigat, Hilal Al-Hinai and Saif Al-Hiddabi. Modeling and performance analysis of a solar desalination unit with double glass cover cooling. Desalination 2002;143:173– 82.

[12] Tiwari G, Singh H, Rajesh T, "Present Status of Solar Distillation", Solar Energy 75 (2003) 367-373.