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# REVIEW ON SOLAR DISTILLATION

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**Abstract -** *The lack of safe and clean drinking water sources is one of the problems faced in most rural communities in India. Water in these communities is mostly obtained from shallow wells and rivers. However, this water might be potentially contaminated with harmful substances such as pathogenic bacteria and therefore, unsafe for drinking. Solar water distillation represents an important alternative to problems of fresh water shortages. Solar water stills can be used to eliminate harmful substances from contaminated water by treating it using free solar energy before it can be consumed. Therefore, there is a need to improve solar still performance to produce a greater quantity of safe drinking water.*

***Key Words*: Solar Still, Distillation, Evaporation, Condensation, Purification, Distilled Water, Solar Energy**

## 1.INTRODUCTION

The basic principles of solar water distillation are simple yet effective, as distillation replicates the way nature makes rain. The sun's energy heats water to the point of evaporation. As the water evaporates, water vapor rises, condensing on the glass surface for collection. This process removes impurities such as salts and heavy metals as well as eliminates microbiological organisms. The end result is water cleaner than the purest rainwater. This type still is a passive solar distiller that only needs sunshine to operate. There are no moving parts to wear out.

The distilled water from a still does not acquire the "flat" taste of commercially distilled water since the water is not boiled (which lowers pH). Solar stills use natural evaporation and condensation, which is the rainwater process. This allows for natural pH buffering that produces excellent taste as compared to steam distillation. Solar stills can easily provide enough water for family drinking and cooking needs.

Solar distillers can be used to effectively remove many impurities ranging from salts to microorganisms and are even used to make drinking water from seawater. These stills have been well received by many users, both rural and urban, from around the globe. Solar distillers can be successfully used anywhere the sun shines.

The solar stills are simple and have no moving parts. They are made of quality materials designed to stand-up to the harsh conditions produced by water and sunlight. Operation is simple: water should be added (either manually or automatically) once a day through the still's supply fill port. Excess water will drain out of the overflow port and this will keep salts from building up in the basin. Purified drinking water is collected from the output collection port.

### 1.1 BACKGROUND

Solar distillation is a tried and true technology. The first known use of stills dates back to 1551 when it was used by Arab alchemists. Other scientists and naturalists used stills over the coming centuries including Della Porta (1589), Lavoisier (1862) and Mauchot (1869).

The first "conventional" solar still plant was built in 1872 by the Swedish engineer Charles Wilson in the mining community of Las Salinas in what is now northern Chile (Region II). This still was a large basin-type still used for supplying fresh water using brackish feedwater to a nitrate mining community. The plant used wooden bays which had blackened bottoms using logwood dye and alum. The total area of the distillation plant was 4,700 square meters. On a typical summer day this plant produced 4.9 kg of distilled water per square meter of still surface, or more than 23,000 liters per day. This first stills plant was in operation for 40 years!

Over the past century, literally hundreds of solar still plants and thousands of individual stills have been built around the world.

### 1.2 BASIC OPERATION

A solar still operates on the same principle as rainwater: evaporation and condensation. The water from the oceans evaporates, only to cool, condense, and return to earth as rain. When the water evaporates, it removes only pure water and leaves all contaminants behind. Solar stills mimic this natural process.

A single basin solar still has a top cover made of glass, with an interior surface made of a waterproof membrane. This interior surface uses a blackened material to improve absorption of the sun's rays. Water to be cleaned is poured into the still to partially fill the basin. The glass cover allows the solar radiation (short-wave) to pass into the still, which is mostly absorbed by the blackened base. The water begins to heat up and the moisture content of the air trapped between the water surface and the glass cover increases. The base also radiates energy in the infra-red region (long-wave) which is reflected back into the still by the glass cover, trapping the solar energy inside the still (the "greenhouse" effect). The heated water vapor evaporates from the basin and condenses on the inside of the glass cover. In this process, the salts and microbes that were in the original water are left behind. Condensed water trickles down the inclined glass cover to an interior collection trough and out to a storage bottle.

The still is filled each morning or evening, and the total water production for the day is collected at that time. The still will continue to produce distillate after sundown until the water temperature cools down. Feedwater should be added each day that roughly exceeds the distillate production to provide proper flushing of the basin water and to clean out excess salts left behind during the evaporation process.

## 2. LITERATURE SURVEY

i.The research was done by Prof. Alpesh Mehta, Arjun Vyas, Nitin Bodar and Dharmesh Lathiya on design of solar distillation system[1]. They recorded maximum evaporation in the period of 11:15 am to 1:30 pm. the maximum temperature they achieved was 530◦ C at 1:30 pm and then the temperature decreases. They purified 1.5 liters of water by adding 14 liters of brackish water to their solar distiller. The TDS level of purified water obtained by them was 81 PPM.

ii. A research was done by Pankaj Kalita, Anupam Dewan and Sangeeta Borah at center for energy, Indian institute of technology, Guwahati[2]. They reviewed recent developments in solar distillation unit. They emphasised to present a comprehensive review of the effects of various operating parameters, such as solar intensity, wind velocity, ambient temperature, water-glass temperature difference, free surface area of water, absorber plate area, temperature of inlet water, glass angle and depth of water, on the performance of solar distillation units. They reported 3.5l per m2 in the passive solar still.

iii. The research was done on Designing, fabrication and performance analysis of solar still for purification of water by S.L.Jadhav, B. L. Chavan and S.S Patil at Dr. Babasaheb Ambedkar Marathwada University, Aurangabad[3]. They fabricated four solar stills of different capacities. They analyzed rate of distilled water production. The highest was recorded between 11:30 am to 12:30 noon. The recorded pH was 7 of distilled water. The TS, TDS, TSS, sulfates, phosphates and chlorides were reduced to zero after the solar distillation in all the four solar stills.

iv. The research was done by Amitava Bhattacharyya on solar stills for distillation of water in rural households at Nanotech Research Facility, PSG Institute of Advanced Studies, Coimbatore[4]. He upgraded the solar still version by capillarity skills, which gives high output. The heart of capillarity still is fabric which facilitates high evaporation of water at minimum heating and cost effective manner.

v. The research was done by Jaime E. Wood on the effect of a fresnel Lens upon solar still productivity at California State science Fair[5]. They experimented the affect on water output using fresnel lens. Their average test produced 47.1 grams of water, compared to the 32.6 grams produced by the control still during 120 minutes trial. The fresnel glass has increased almost 44% of water production.

vi. The research was done on solar powered desalination system using Fresnel lens at chemical engineering department, University of St.La Salle, Bacolod city[6]. Their fresnel lens was made of acrylic plastic which was effective solar concentrator. Their still was made of dark colored glass bottles which were effective in absorbing the solar energy. their condenser system was made of polybutylene and polystyrene which was effective in condensing vapor at ambient temperature. They recorded 293 sec for vaporization of salt water at the optimum angle of 36.42◦ C. The amount of condensate was directly proportional to amount of salt water in solar still. The highest mean efficiency of the designed set up was 34.82%.

vii. The research was done by Ravindra kumar Jain, Hari Singh, Amar Varshney, Sagar Bajpai, and Deepak Sharma on water distillation by solar energy in India at mechanical engineering department, Suresh Gyan Vihar University, Jaipur[7]. They estimated the most effective geometries of the distiller and trough concentration system, that maximizes evaporation and condensation and recapture waste heat to minimize thermal losses. They designed a system incorporating parabolic solar trough coupled with a custom designed distillation device. The incoming solar radiation from the sun is focused and concentrated onto a receiver pipe using a parabolic trough, heating the impure water, at which it is sprayed into designed distillation device where it evaporates and is re-condensed into pure portable water. Their results showed that efficiency increases with increase in solar radiation. The efficiency of solar still was 99.64% as compared to the theoretical analysis.

viii. A review was done on solar water distillation using sensible and latent heat by Ravi Gugulothu, Naga Sarada Somanchi, K. Vijaya Kumar Reddy, Davender Gantha at department of mechanical engineering, JNTUH college of engineering, Kukapally, Hyderabad[8]. They used thermal energy storage to increase their efficiency and output of solar power. They experimented combination of sun tracking system coupled with PCM, dyes, sponges and nano materials. They proved that latent heat storage (LHS) one of the effective ways of storing thermal energy. It provides higher storage density with a smaller temperature difference between storing and releasing energy.

ix. A research was done on water distillation method using solar power by Anwarul Islam Sifat, Md. Milon Uddin at institute of energy, university of Dhaka, Bangladesh[9]. They investigated the optimization of different parameters of distillation process. They fabricated a solar still focusing the cost and effectiveness towards water purification. They also did theoretical analysis of an asymmetrical solar distiller is presented. They estimated maximum output in the month of March and April.

x. The experiment study was done on various solar still design by T. Arunkumar, K. Vinothkumar, Amimul Ahsan, R.Jayaprakash and Sanjay Kumar at department of physics, Sri Ramakrishnan mission vidyalaya, college of arts and science, Coimbatore[10]. In this paper they evaluated designs of seven types of solar stills (spherical, pyramidal, hemispherical, double basin, concentric couples CPC tubular, CPC coupled with pyramid solar still). The maximum yeild was observed in tubular solar still coupled with pyramid solar still due to concentrator effect. The concentrator effect played a vital role to increase the water temperature upto 95◦C.

xi. An experimental investigation on thermal model for a basin solar still with an external reflector was done by Masoud Afrand, Rasool Kalbasi, Arash Karimipour and Somchai Wongwises at department of mechanical engineering, Najafabad branch, Islamic azad university, Najafabad, Iran[11]. They introduced external reflector to the basin still using the energy balance equation of different parts of solar still. They calculated the hourly temperature values different places of the still and amount of distilled water. They concluded that thermal model can be used reliably to estimate the amount of distilled water and efficiency of the basin solar still with an external reflector. They revealed that the efficiency of the solar still is low in the early hours , while it was enhanced 44% in the afternoon. They accumulated 4600/day and 4300/day distilled water for theoretical and experimental examinations.

xii. The research was done on design and performance evaluation of solar water distillation plant by Md. Zargistalukder, Avizitbasak Foisal, Ahmed Siddique and Dr. Mohd. Rfiqulalambeg at Bangladesh University of Engineering and Technology (BUET)[12]. They designed solar distiller consisting of two parts. Upper part consist of glass and copper plate which absorbs heat inside it. The lower part is made up of cellulite. The cellulite box is made up of wick. This wick absorbs the ground water and conveys it up to glass box where this is evaporated in presence of solar energy. Effectiveness of this system is 2.289 per m2per day and efficiency is 17.38%. The efficiency was obtained under the average solar intensity 1115 W/m2.

xiii. The research was done on a numerical simulation of solar distillation for installation in Chabahar Iran by Masoud Afrand, Amin Behzadmehr and Arash Karimipour[13]. They presented a theoretical study of solar distillation in a single basin under open environment of Iran. They inclined glass cover at 25 degree. They computed the temperature of glass cover, seawater interface, moist air and bottom using numerical method. They calculate still productivity in July was higher than December.

xiv. The research was done on comparative energy and exergy analysis of various passive solar distillation system by Ragh Vendra Singh, Rahul Dev, M. M Hasan and G.N Tiwari[14]. They included passive solar distillation system such single and double slope solar still. Considering 15, 30 and 45 degree inclined slope. They found that energy, exergy and embodied energy of single slope solar still are found higher than the double slope solar still. They concluded that lower thermal conductivity and low embodied energy than that of FRP such as concrete, PVC, wood can replace the FRP to save the embodied energy for similar performance.

xv. A theoretical analysis of water distillation using solar still was researched by D.W Medugu and L.G Ndatuwong at department of physics, Adamawa state University, Mubi – Nigeria[15]. They did theoretical analysis of heat and mass transfer mechanisms inside the still. They experimented on distillation performance of the solar still. Their system had distillation efficiency of 99.67% as compared to the theoretical analysis.

xvi. The research was done on performance and analysis of advanced solar distillation by Sagar S Shinde and Prof Govind S Dhange at Shreeyash College of Engineering and Technology, Aurangabad[16]. They performed experiment on solar distillation from morning 9:00 am to 5:00 pm within 8 hours. The estimated efficiency was of 65.79%. The maximum pure water was observed between 12:00 noon to 1:00 pm.

## 3. CONCLUSIONS

Solar stills have proven to be highly effective in cleaning up water supplies to provide safe drinking water. The effectiveness of distillation for producing safe drinking water is well established and recognized. Most commercial stills and water purification systems require electrical or other fossil-fueled power sources. Solar distillation technology produces the same safe quality drinking water as other distillation technologies; only the energy source is different: the sun. Various advances can be made in solar distiller to enhance its efficiency depending upon the requirement.

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