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Recent Developments in Solar Water Distillation Designs

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Abstract— Solar energy is one of the cheapest and easily available sources of energy and we can use it in many ways. One of its applications is water purification. The basic idea of solar water distillation came from Aristotle in the 4th century BC. There are many types of solar stills designed for this purpose. Solar still is a device which is used to purify water, it operates on the same process as water cycle i.e., evaporation and condensation. Many researchers in this field give mathematical relations, accomplish different research and show positive results. An extensive review of different types of solar stills has been carried out in this paper. This review will also help us in gathering further practical approach in this field.

Keywords: Solar energy, distillation, solar still

I. INTRODUCTION

The renewable energy is very important in today's world as well as in the near future, the non-renewable energy that we are using is going to get exhausted. Solar energy is one of the most important renewable resources. It has a great feature of no fuel cost.

Clean drinking water is the basic essential need for every human being, and many people don't have a single drop to drink. Solar energy has experienced a vast and impressive technological experience. In many coastal areas, where there is no supply of pure water, people use solar still. Distillation is one of the processes through which we can get purified water. This requires an energy input, as heat, solar radiation can be used. The basic principle behind this technique is evaporation followed by the condensation. This is a perfect alternate source of clean water. This is one of the best solutions for remote areas too. Solar stills are mainly of two types: Active and Passive solar stills. Without the consumption of electrical energy, potable water is derived from the passive solar still. The advantages of using this process are:

- Distillation produces high quality of water.
- Maintenance is not required.
- There is negligible wastage of water.
- pH level is maintained during the process.
- This process uses less energy as compared to other techniques.

As every coin has two sides, this easiest process also has advantages as well as drawbacks. Some of its major drawbacks are:

- Large floor area
- Time consuming

Scientists are working hard to find the solutions to the above-mentioned limitations.The purpose of this introduction about the solar water distiller is to provide a sufficient knowledge and direct the reader to know more about the solar still.

II. LITERATURE REVIEW

Solar water distillation is an antiquated way of converting impure water into potable water. The first time, this technique was used by Arab alchemists in 1551.In 1872, the first modern solar still was built in Chile, which consists of 64 basins and supplied up to 20,000 liters of water per day. US navy during the World War II created 20,000 stills for the navy.

In 2012, Ozuomba J.U. et al discovered a Roof- type solar water distillation which was tested. The system contains four major components: rectangular wooden basin, absorbing surface a glass roof and a condensed channel. The system has a capability to produce 2.3m^3 water in six days, which is not sufficient to fulfill the requirements of human needs [1]. In 2011, Prof. Alpesh Mehta produces potable water in the winter season. The TDS level of water obtained was 81 PPM and the efficiency of the system was 6% [2]. In 2010, Aayush Kaushal et al, in their paper described different types of solar stills [3]. K. Sampathkumar in 2010 gave us a brief study on active solar water distillation systems to beat the low efficiency of passive solar water distillation systems. Basically, in active solar still, extra thermal energy is supplied to the basin to increase the evaporation rate and hence productivity [4]. Kabul et al on their research to discover the most inexpensive solar still and concluded that pyramid type solar still is most efficient still [5]. Velmurugan expands a setup with additional surface and found that the efficiency is increased by 53% as compared to single slope still [6]. Shankar and Kumar studied the effect of design, operational and climatic parameters on the efficiencies of passive solar stills [7]. Akash et al reviewed the effect of absorbing materials on the function of double slope single basin and increased the efficiency by using black rubber by 38%, black ink by 45% and black dye by 60% as absorbing material [8]. Mario et al use tubes to design a solar still to purify sea water [9]. A review of different distillation process is approved by E. Delyannis [10]. A solar still which is capable of maintaining a vacuum in the chamber is designed by Ganeshan et al [11]. By changing the depth of water, Suleiman et al evaluated double solar still and concluded that water productivity is depending upon solar radiation intensity [12].

III. WATER PURIFICATION

The process of removing unwanted chemicals from unhygienic water is known as water purification. Water can be purified by many ways, few are given below:

i. Distillation: In distillation, with the help of solar energy impure water is evaporated, steam is collected resulting in pure water.

ii. Reverse osmosis: In this process, a semi-permeable membrane is used, which pass water but prevent contaminated molecules from passing.

IV. WORKING OF SOLAR STILL

Solar stills are designed according to the requirements of water, i.e., for family, society or for a whole village. A simple solar still can be made with the help of few stones, transparent plastic sheet or glass and a container for condensate. Solar energy heats water till the evaporation takes place. As water evaporates, water vapor collects on the inner surface of the glass and resultant water is obtained which is cleaner than the rain water. Solar stills can be used to remove any type of impurities. The diagram of simple solar still is shown in figure1.

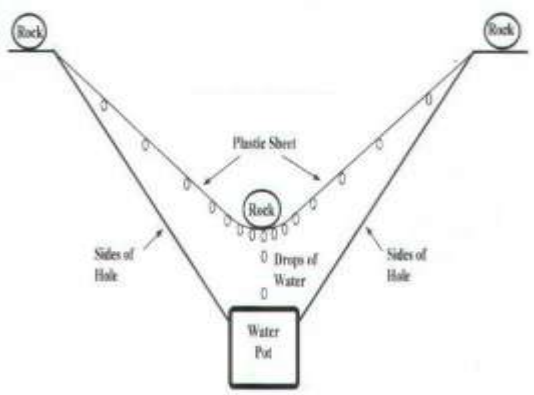

Fig.1. Simple Solar Still [13]

A solar still is based on two scientific principles named evaporation & condensation. Firstly, the water which is to be purified is collected outside the collector. The solar still is then allowed to expose to the sun which allows the still to absorb the sun's short wave energy. As the sunlight falls on it, the water absorbs the solar energy and start to heat. As the temperature rises with time the liquid water is converted into steam and evaporates towards glass ceiling and leaves all other impurities in the trough below. After evaporation, condensation is the second scientific principle on which a solar still works. As the evaporated water hits the glass ceiling, the water slowly condenses on the glass resulting in pure water droplets. Since the glass is angled down toward the second trough, the water droplets roll down and the clean water comes towards the second trough. In most of the other methods of water purification, water is boiled and the pH level drops resulting in flat tasting water. With a solar still, the water is purified naturally, allowing the pH levels to stay balanced.

V. TYPES OF SOLAR STILLS

There are many types of solar stills, the major types are:

1. Active solar stills
2. Passive solar stills.

Passive solar still is one in which no external energy source is required to produce potable water while in active solar still, an external source of thermal energy is required.

Other classifications are:

TYPES OF SOLAR STILLS	FIGURE
Simple Solar Still	Figure 1
Single Sloped Basin Solar Still	Figure 2
Double Sloped Basin Solar Still	Figure 3
Spherical Solar Still	Figure 4
Hemispherical Solar Still	Figure 5
Pyramidal Solar Still	Figure 6
Tubular Solar Still	Figure 7
Spherical Basin Solar Still	Figure 8

Table 1: classification of solar stills

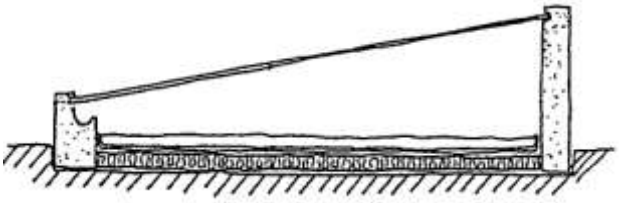

Fig. 2. Single Sloped Basin Solar Still [14]

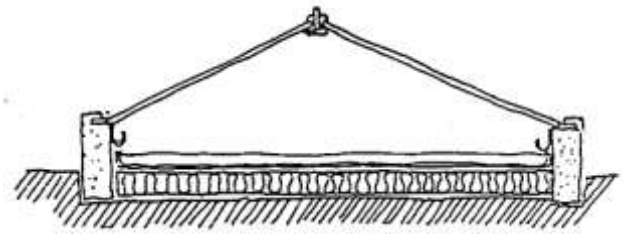

Fig. 3. Double Sloped Basin Solar Still [15].

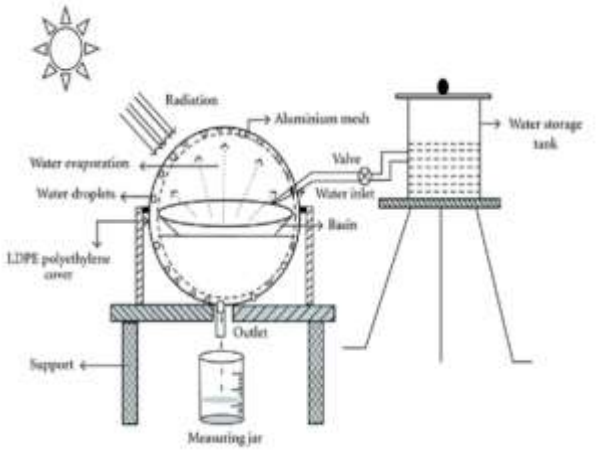

Fig. 4. Spherical Solar Still [16]

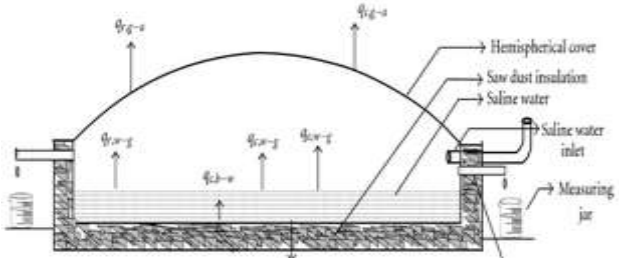

Fig. 5. Hemispherical Solar Still [16]

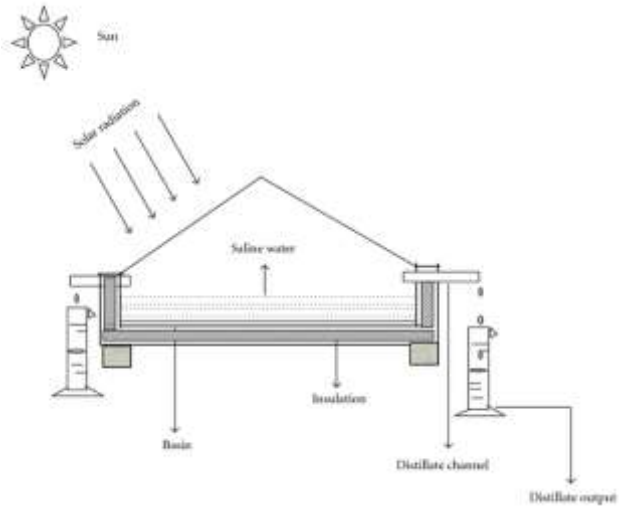

Fig. 6. Pyramidal Solar Still [16]

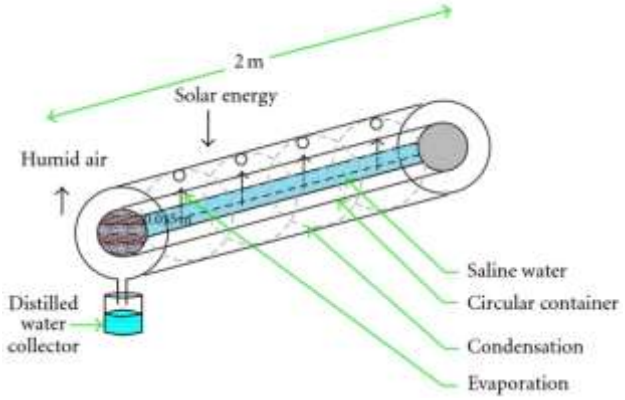

Fig. 7. Tubular solar still [16]

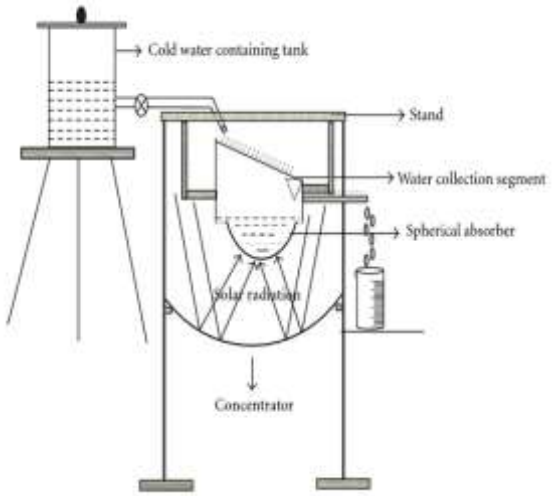

Fig. 8. Spherical Basin Solar Still [16]

FUTURE ASPECTS

1. Solar paint can be applied on stills so that system remains heated for several hours.
2. Copper sheets can be used as heat absorbers.

CONCLUSION

Water is a basic necessity for all human beings. Solar water distillation is the simplest and the easiest way to purify water, especially in rural areas as it is the cheapest source. It can be concluded that solar water distillation promises to enhance the quality of people living in rural areas. The main drawback of this process is low productivity, which can be improved. The other challenges for researchers are to reduce the time and to continue this process in the rainy season.

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