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Pyramid solar still: A comprehensive review

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ABSTRACT

Adequate quality and reliability of drinking water is vital for all inhabitants and for agriculture and industrial applications. Solar desalination is impactful method for getting potable water from brackish/wastewater in hot climatic condition and/or remote area where the scarcity of water as well as for electricity. In recent years, attention has been focused on development of various designs of solar still in order to overcome limitations possesses by conventional single basin single slope solar still. Pyramid solar still is one of the outcomes of such a development. The present paper reviews the development in the field of pyramid solar still as well as the various techniques to improve the performance of still. From the review on research carried out by the various researchers, it has been found that pyramid solar still is more efficient and economical in compare to conventional single slope single basin still. Thus, the review paper will assist the researchers to understand the fundamentals of pyramid solar still with the need, developments and challenges in pyramid solar still to improve its thermal performance and to make it more and more economic.

1. Introduction

Clean drinking water is crucial for human being and all other animals. Fresh and pure water is also required for agriculture and industrial applications [1]. The earth contains about 1.4 billion km^3 of water i.e. around 70% of surface area; in which 97.5% is salty. From the remaining fresh water, only 0.5% is available and accessible to support all life on earth [2].

As per the report published by UNICEF and WHO on “Progress on sanitation and drinking water – 2015 update and MDG assessment” [3], 54% of global population (≈ 7.3 billion) lived in urban area. As per the report, 91% of the population uses improved drinking water sources whereas 159 million people use surface water and 663 million people lack in improved drinking water sources. The average per capita consumption of the low salinity drinking water (150 ppm) is limited to 2 l/day but it takes 2000–5000 l of water to produce one person's daily food [4]. Further, the per capita consumption rate for other household purposes is 200–400 l/day [2]. In the year 2010, 2769 km^3/year water was withdrawn by agriculture area which was 69% of total global water withdrawals whereas 768 km^3/year (19%) and 464 km^3/year (12%) water was withdrawn by industrial and municipal sector respectively [5]. Hence, agriculture sector withdraw maximum amount of water globally.

For the year 2010 in India, total water withdrawal was 761 km^3/year out of which 688 km^3/year (≈ 91%) are for irrigation and per inhabitant it was 630 m^3/year. The per capita availability of water resource for India is expected to reduce to 1335 m^3/year by 2025. Agriculture in India will face tough competition for water from other sectors. By 2025, the withdrawal of water by agricultural sector is anticipated to fall to 70% of total withdrawal, against 90% at present. [6]

Tremendous growth in world population and industrialization increases the demand of clean and pure water [7]. At the same time, deforestation leads to reduced rainfall. Thus, the mismatching between demand and supply of pure water occurs and accessibility of water for today and future being major concern for the researchers. Desalination is one of the important process to convert saline or/and impure water in to potable water. The comprehensive classification of desalination process is shown in Fig. 1. Most of desalination technologies in Fig. 1 are based on conventional fuel which has adverse impacts on environment, nature and health [8].

1.1. Solar desalination

Solar desalination is the best alternative technology which is simple in operation and eco-friendly [9]. In a solar desalination process, solar energy is utilized to separate salts from brackish water to get pure drinking water. The device, called solar still is used to execute the solar desalination process. The use of solar stills was recorded by Arab Al Chemists in 1551 and then by Della Porta in 1589, by Lavoisier in 1862 and by Mauchot in 1869 [1,10]. The first ever conventional single basin solar still plant on large scale was built by Charles Wilson, a Swedish

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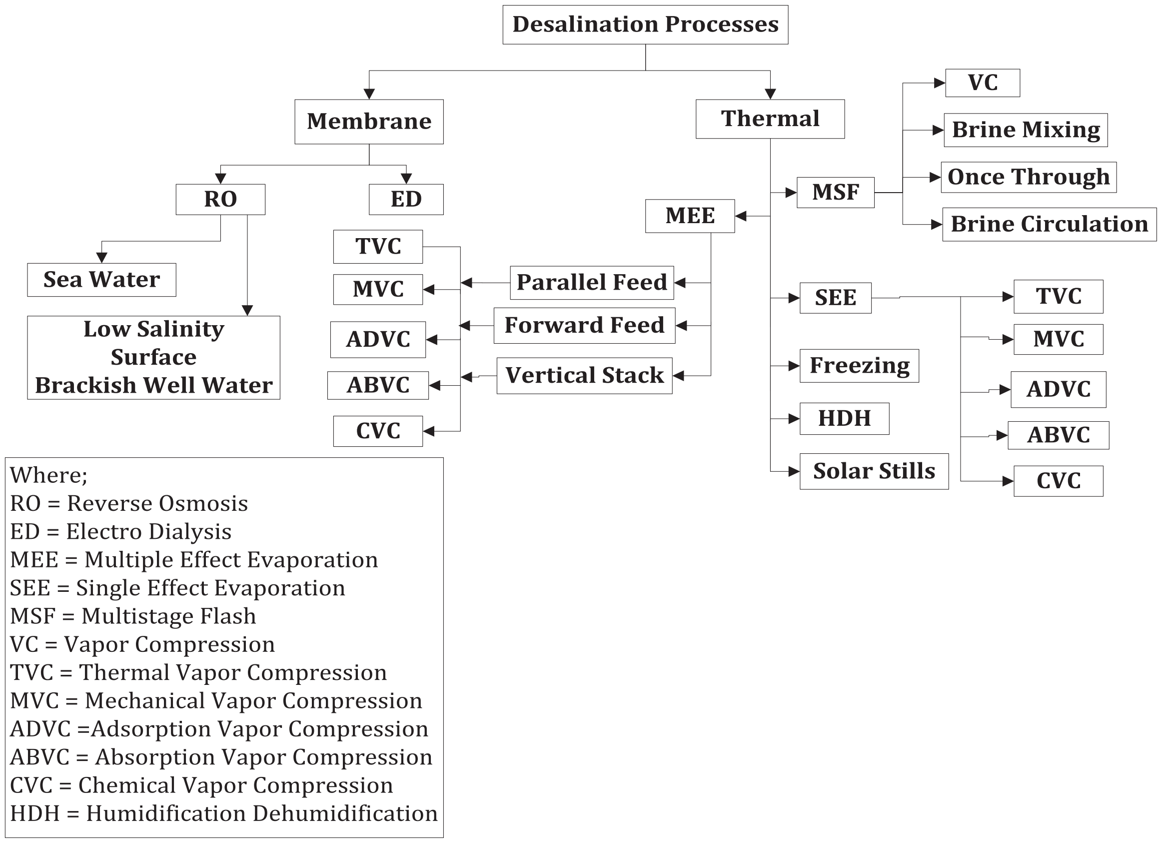

Fig. 1. Comprehensive classification of desalination processes [2].

engineer in 1872 for providing fresh potable water to the workers of mine and nearby peoples at northern Chile [11].

The working principle of solar still is the same as that of raining. The basic structure of conventional solar still is shown in Fig. 2. Conventional solar still is one in which single basin filled with saline water, which is covered by single inclined glass cover. The universally acceptable materials for basin are copper, aluminium or galvanized iron (GI) Sheet. The inner surface of basin is black painted to increase the absorption of solar radiation. The basin is insulated by wood, thermocole [12] or Glass wool from sides and bottom to reduce the heat transfer loss from basin to atmosphere. Top of basin is covered by highly transparent glass or plastic so that the maximum solar radiation reaches to the basin as well as generated water vapor cannot escape from the still. Generally, the cover is inclined at an angle equals to local latitude so that maximum solar radiation can entered in device.

The solar radiation penetrates through the cover and absorbed by

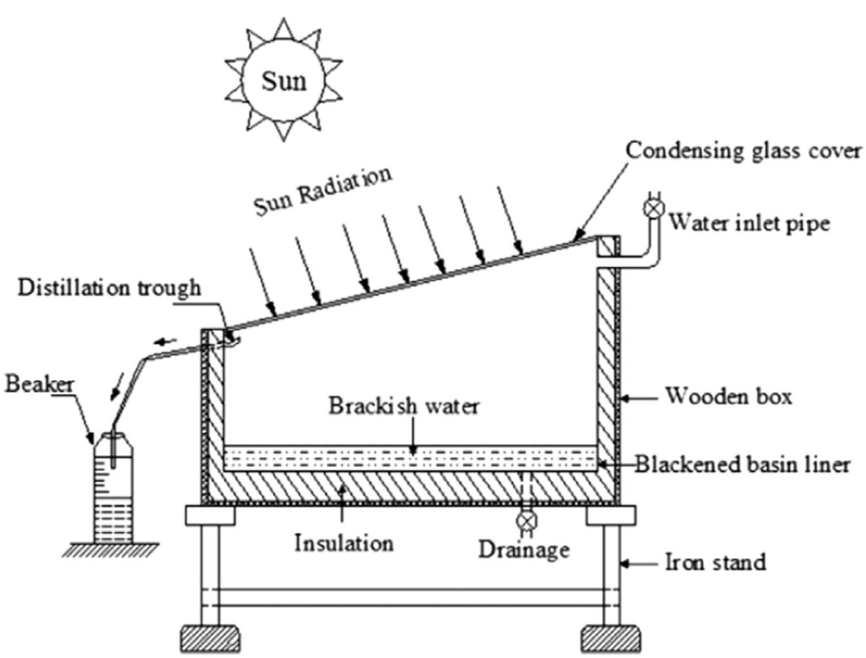

Fig. 2. Schematic of conventional solar still [2].