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Recent Advancement in Solar distillation System :A Review

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ABSTRACT:
There is only 1% of pure water left on the earth that are safe to use for our primary requirements especially for drinking and cooking. Pure water requirements are increasing day by day as the populations are increasing. Pure water is also required in industries like pharmaceuticals, food processing etc. After two or three decade it was estimated that, there is no pure water left on earth that are directly we can use. This is bold but unfortunately very true statement. So we have to find alternative for it and purification of water is the best amongst it. Desalination is the most promising method to solve this problem. In this review paper we discuss the different desalination methods and improvements that are needed for commercialize this method. Also we discuss the different parameters that affect the performance of distillation system. Solar distillation system is very feasible and easily implementable technique as it does not require any means of non-renewable energy. We also list out the characteristics of most effective solar still design in terms of different parameters. A lot of investigations and researches has been carried out and much more are ongoing. The main disadvantage of solar distillation system is that it has lower productivity, so we have to optimize the parameters to enhance the productivity of it. The latest researches are based on the concept of nano technology. So many researchers has studied the effect of nanofluid on the productivity and they found that, it shows marginal effects on the output of the distilled water.

KEYWORDS: Solar distillation, productivity, passive solar still, renewable energy, solar radiation, nano fluid

INTRODUCTION

Water is the basic requirement for the all living entities in the world. Major resources for fresh water are ponds, lakes, river and underground water. Availability of fresh water on the earth is limited. But therequirement of fresh water increases, due to over population and esteemedindustrialization. Industrial contaminated water and sewage discharge are mostlymixed in the rivers and ponds, so the available fresh water is further reduced. Theavailability of fresh water is gradually becoming an important issuein many areas of the universe. The ocean is the only available source forhigh amount of water. But the ocean water have highsaline fraction, so it needs to desaline the water[1]. The desalination process is very much similar to natural rain cycle. In which the solar radiation evaporates the water and it goes above the earth's surface by means of wind speed, when they are reached to the dew point temperature it condensed and then we get the fresh water in terms of rain. But now-a-days rain water is also contaminated due to the pollutions and presence of other harmful particles that are present in the atmosphere. Due to that the rain water is also not useful because of the term 'acid rain'.

To purifying the dirty water, many methods are used, but all ofthose methods require a significant amount of energy. The energyresources to be used in purification process such as oil, natural gas,and

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electricity have both high costs and lead to environmental pollution.The studies carried out in recent years aimed to increase theuse of renewable energy resources as energy source [2].

Desalination systems can be classified according to the source of energy like; thermal, mechanical, electrical andchemical energy. Another classification depends on the distillation process: evaporation-condensation,crystallization and filtration techniques. Some of the desalination technologies are still under development like;solar chimney, greenhouse, membrane distillation, membrane bioreactor(MBR), forward osmosis (FO), and ion exchange resin (IXR). The reverse osmosis (RO) followed by multistageflashing (MSF) and multi effects desalination (MED) systems are the mostly implemented distillationtechnologies. It is important to know the amount of the conventional energy required by the desalination processes to understandwhy we need to move toward the renewable and sustainable energy resources. The contribution of the conventionaldesalination systems to the global warming phenomenon can be assessed by estimating the amount of the fossil fuelneeded to be burned to produce a certain amount of fresh water. In the average, producing 1000 cubic meters of freshwater by desalination technology consumes about 5 tons of crude oil which produces about 10 tons of carbon dioxideor about 5000 cubic meters of greenhouse gases. The total global desalination capacity has witnessed a severeincrease within the last few years, from 66.48 million cubic meters per day in 2011 to 86.6 million cubic meters per day in 2015. Therefore, serious forward steps toward integrating the desalination systems with the renewableand sustainable energy technologies will be required to mitigate the negative effects of the desalination systems [3].

We can say that from different desalination techniques, desalination method integrate with renewable sources i.e. solar desalination is most effective technique as it does not require external power or any other conventional energy sources (Figure 1). Due to that solar desalination is also effective in remote area where energy and water are not easily available or very costly to meet the requirements of it. Now we review the different techniques and design of solar desalination that are investigated by different researchers. They have also optimize some parameters to enhance productivity and efficiency of the system (Table 1).

Nanofluid has such an improved properties like, high thermal conductivity, high solar intensity absorptivity as compare to base fluid. This properties help to improve the yield of solar still by handsome amount. Different researchers have used different nanofluid at different volumetric fraction and try to improve productivity and thermal efficiency. They have shown great result by using nanofluid (Table 2).

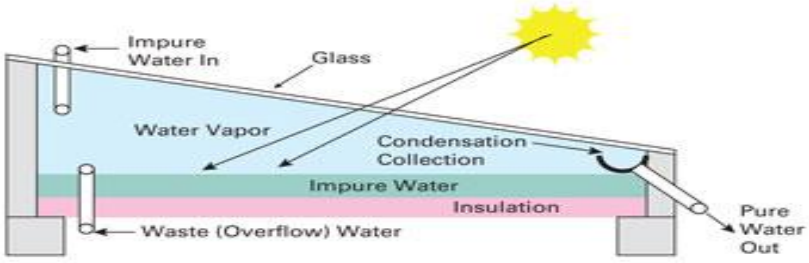

Fig 1: Simple Solar distillation system

Extensive reviews of different researchers with conventional fluid

El-maghlany, El-samadony & Kabeel[4] have investigated single slope solar still to find out the effect of shape factor on the productivity. They observed that productivity of still ncreased by 9 to 12.6%. They have concluded that the shape factor have more impact where solar radiation is low and altitude is high. Metha et al. [5] investigate the single basin single slope solar still, they observe the optimum angle is 30° which is near to the latitude of the site. Hashim & Alramdhan[6] experimented different types of stills i.e. single slope, double slope, pyramid type etc are investigated by varying different parameters like inclination angle of glass cover and different basin area, they concluded that double slope solar still has highest productivity. They also found that as we increase the inclination angle produtivity increases and while increasing area, productivity

will decrease. Al-Garni et al. [7] suggest that as depth of water in basin increases the productivity will decrease.

Khalifa[8] shows that the cover tilt angle should be more in winter as compare to summer season. He also concluded that increasing cover tilt angle gives rise in productivity.Al-Hayeka et al. [9] have done the experiment using two different types of still, ASGHT & SGHT and observe the productivity and efficiency of stills. They have found that by using mirror on side wall in both the stills increases the productivity and comparing both the still they concluded that ASGHT has higher productivity and efficiency than SGHT. Optimum cover tilt angle is 35° for both the still. El, Çakmak, & Yıldız[2] recorded the cooling effect by free and force convection on the glass cover and found that, the distilled water output in free convection is 1820 ml/day.For forced convection output is 1686 ml/day at flow rate of 30 kg/hr and 1568 ml/day at flow rate of 50 kg/hr.Okibe[10] has done the experiment with different cover tilt angles 4°,7°,10°,13°, 15°. He partially concluded that the best tilt angle for particular region is about 15°, but it may be more than 15°. So the research should be carried out to optimize it.Medugu & Ndatuwong[11] have investigated the single slope solar still to find the effect of wind velocity on the productivity of the still.Increasing the velocity shows the increment in productivity as it cools down the glass cover rapidly. Arunkumar et al. [12] investigated different four model of single slope solar still i.e. Single slope solar still (SSSS), CCC(compound conical concentrator) SSSS coupled with crescent absorber, CCC SSSS coupled with crescent absorber with cooling coil, CCC SSSS coupled with crescent absorber with shadow on top cover tested.The highest productivity is obtained in CCC SSSS coupled with crescent absorber with cooling coil.Natural circulation mode is useful in coupled system which avoids the electricity used to operate the pump.

Nanda kumar & Shantharaman[13] investigated single slope solar still and found that it shows that the performance of blackened surface of still is more efficient than having normal surface still.Rizwan[14] investigatedtabular type solar still with and without parabolic solar collector. During case- II, the temperature obtained is insufficient to generate steam as there is not sufficient pressure. In case- I, the temperature is high so it completely converts the water into steam as sufficient pressure is generated. But the efficiency is lower in case I as compare to case II.Kumar, Tiwari& Singh[15] have done the experiment using active type solar still with solar collector at angle 20° and glass cover angle of 15°. Experiment shows that, inclination of the glass cover has marginal effects on yield/productivity.Shinde[16] investigated single slope solar collector with external heating system. The available energy is not sufficient to get higher productivity, so we can establish an external heating system so the temperature of water is increased and hence productivity increased. Manchanda & Kumar[17] has investigated the single slope solar collector attached with drying unit and also coupled with parabolic collector. The amount of heat energy loss from the bottom surface of the basin is utilized for drying of ginger.Effect of water depth also measured, and conclude that at low water depth the productivity is higher.Also efficiency is 15 % more in 4 cm water depth as compare to 6 cm water depth.

Yadav et al.[18] measured the effect of solar tracking system on productivity of the system.By using solar tracking system production can be increased up to 22%. We can use phase change material for working of still up to 18 hrs, because this type of material store energy during day time and release in night.We can also adopt hybrid (solar + wind) system for 24 hrs working.Panchal & Mohan[19] has done the experiment on different types of solar still by using fin.Attachment of fin enhance the distillate output due to increment in surface area of water inside the basin.Due to fin, it is found that it reduces the heat loss from bottom and side wall.By using multi basin still, it enhance the output by using the latent heat of condensation.H. N. Panchal[20] has done investigation on single slope double basin solar still with vacuum tubes and with black granite gravel. He observed that the overall productivity of double basin solar still with vacuum tube and vacuum tube with black granite gravel is increased to 56% and 65% as compare to alone double basin solar still.Black granite gravel not only worked as an energy absorbing material but it also release this energy in no-sun shine conditions.H. Panchal, Patel, Patel, & Thakkar[21] nvestigatedsingle slope single basin solar still with the use of sand stones and marble pieces and concluded that energy absorbing material have high impact on productivity even in sun shine hours. High productivity we can get by using sand stones as compare to marble pieces. Also the marble pieces have high productivity as compare to solar still with no energy absorbing material used in it.Same trend follows for efficiency of solar still also.

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Some other researcher have investigated solar still by using nanofluid and it is summerised as follow.

Table1.Extensive reviews of different researchers with Nanofluid

Author	Nano particles	Volume fraction (%)	Particle size (nm)	% Increment in Yield	Results and discussion
Madhu, Bala Subramanian, Nagarajan, Sathyamurthy, & Mageshbabu, 2017 [22]	Al_2O_3 TiO_2 CuO	0.05, 0.1, 0.2	25	74.19 50.23 53.54	As the volume fraction increased the yield is increased. Result shows that the highest yield is obtained in 0.2% volume fraction.
Sharshir et al., 2017 [23]	Copper oxide Graphite micro flakes	0.125 - 2	1000 1250	47.80 57.60	It is found that the productivity increases as volume fraction of nano fluid increases. Cooling water flow over glass increases yield. While using cooling water as make up water, the productivity we get is maximum. Optimum volume fraction of the nano fluid is 1% and depth of water in the basin is 0.5 cm.
Kabeel, Omara, & Essa, 2014 [24]	Cu_2O Al_2O_3	0.02 – 2.0 (step of 0.02)	10-14	133.64 125.0	By providing vacuum in the basin the productivity we get is more than without vacuum. Optimum volume fraction of the nano fluid for CuO and Al_2O_3 are0.08% and 0.1% respectively.
Sahota, Shyam, & Tiwari, 2017 [25]	Al_2O_3 TiO_2 CuO	0.143 – 0.272 0.059 – 0.187 0.044 – 0.153	___	19.10 10.38 5.25	Maximum productivity achieved by using Al_2O_3 nano-particles. Climatic conditions affects the required volume fraction of the nano fluid.
Kabeel, Omara, & Essa, 2013 [26]	Al_2O_3	0.2	___	116	By operating a fan or providing vacuum we can get high productivity.

CONCLUSION:

From above research articles we can say that solar desalination is most effective modes of purification of water. The distillate water match the standards of drinkable water. By optimizing different parameters we can get high productivity of system. So this parameters are listed out which should be kept in mind while designing the solar distillation system.

- Types of solar still (Single basin, multi basin, active type, passive type, single slope, double slope, pyramid type etc.)
- Area of the basin
- Angle of inclination of top cover
- Shape factor between basin water and top cover
- Water depth inside the basin
- Temperature difference between glass cover and water inside basin
- Pressure generated inside the still
- Solar tracking system
- Glass cover thickness
- Minimum heat loss from the basin
- External heating system (Active solar still)
- Climatic conditions like ambient temperature, wind speed, solar radiation etc.
- Use of energy absorbing material
- Use of Floating absorber
- Convective and evaporative heat transfer co-efficient
- Latitude and longitude of the site
- Amount of TDS
- Volumetric fraction of nanofluid
- Size of nano-particles
- Methods of preparing nanofluid

Above factors are keep in mind while designing solar still. The experiments suggest that the inclination angle should be close to the latitude of the site. Although the angle should be more in winter than in the summer. Heat loss from the basin can be minimized by providing insulation to the bottom and side wall of the solar still. Mirrors can be placed to the side wall to maximize the use of radiation that are imparted on solar still. Solar tracking system is also plays an important role to use the maximum solar radiation. Energy absorbing material increases the productivity and efficiency of the system by providing energy in the non-sun shining hours. High wind speed reduces the temperature of glass cover which increase the temperature difference between glass cover and water. Also it increases the condensation rate of evaporation. This effect is greatly achieved by use of nanofluid. It shows the high impact on the yield of the still. Nanofluid has provide the opportunity to enhance the productivity and efficiency by taking the advantages of the properties of nanofluid and so many researchers have shown that.

Experiment shows that, still we can't get high output of distilled water which increases the cost and time duration. So, lot of researches required in this field to enhance the productivity and make it to commercial. Use of nanotechnology is one of the great advancement in this field of study.

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