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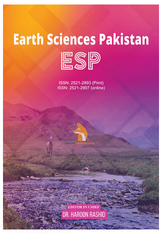

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RESEARCH ARTICLE

PRODUCTIVITY COMPARISON OF CONVENTIONAL AND SINGLE SLOPE SOLAR STILL WITH INTERNAL REFLECTORS: AN OVERVIEW

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ABSTRACT

Nearly two-third part of earth cover by water and this water is not for drinking from this only one percent is only for human use and which is not of sufficient to fulfill the human needs as water is the base of life so to overcome this water shortage problems there are different techniques which are helpful for the treatment of water like Desalination, phytoremediation, reverse osmosis, filtration, chlorination, coagulation and flocculation. As above-described processes solar water distillation is one of the most economic and renewable technique which is easily available everywhere. Many varieties of solar still are now developed regarding design like symmetric solar still, Asymmetric solar still, inclined single slope still, double slope still Steeped solar still and vacuum tube solar still etc. There are different natural factors which effect the yield of water purification like solar radiation, water depth in the basin, ambient temperature, and wind speed. These solar still are successful in arid atmosphere like in continent Africa and some parts of Asia where there is water shortage and irradiance values are higher there. Solar still working principle is to evaporate water in the basin and condense it on glass inner surface and then collect it in the collector. Conventional solar stills are less productive as compared to stills with vacuum tubes and steeped solar still in which internal reflectors were used.

KEYWORDS

Conventional solar still, steeped solar still, vacuum tube still, internal reflectors, Evaporation, Desalination.

1. INTRODUCTION

Earth surface is covered by water more than two-third of its total surface area (Hikmet, 2006; El-Sebaii, 2004; Omara et al., 2013). The water that is covering two-third part of earth occur in different location and different form like sea water, glaciers, and in polar regions from this of total water about 97% is saline water while remaining is fresh water of which less than 1% is in human access. This small percent is still sufficient to support existence of life on earth and this is restocked through the large solar distillation process which is also well known as hydrological cycle (Hikmet, 2006). Besides increasing population and industrial revolution consequently increase the need of fresh water (Omara et al., 2013). In Developing countries one third part of their population are facing a problem of continuous supply of drinking water and also bearing water shortage every day (Kevin et al., 1999; Omara et al., 2017). There are three basic needs of every living thing on planet earth which are energy, air, and water.

Water is continuously necessary for every human and living thing and will remains till the life exist. Solar water still is a kind of apparatus with is renowned for the purification of water by evaporation and condensation process (Sarda et al., 2014). It is most viable application of solar energy and considers as a great source of water (Omara et al., 2013). This method had also proved as cheap source of fresh water back in 16th century (Bassam, 1996). Water is more importantly required along with food, air and energy for the socioeconomic development of a community, nation and a country (Ravi et al., 2014; Abdallaha and Badranb, 2008). Pure water resources are not abundant and continuously lacking day by day due to ingression of large amount of pollutants to water bodies like rivers, lakes, well and sea (Sarda et al., 2014). Industrial growth is directly in collaborate with the contamination of water resources as well as land and air (Rajendra et al., 2011). This world is suffering lack of potable and clean water resources (Sarda et al., 2014).

Different techniques are using by different developing and developed countries for treatment of water like reverse osmosis, membrane distillation, multiple stage and multiple effect desalination by using fossil fuels as a source of energy to increase fresh water yield sea water exist in large amount with the vast amount of solar energy it is a kind of blessing or whatever can said that in time of high water demand the solar energy is also intense due to global warming (Manokar et al., 2018). So where solar radiation intensity is high there solar still present friendly solution of water shortage in that particular area. Solar still assist due to easy operation, simple design and friendly to environment (Omara et al., 2017). It is a very special approach to take advantage of solar energy directly by installing solar stills. The major output of using solar still are the clean, free

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of costs and friendly water resources.

To use renewable energy finding different ways has become interest in these days (Sarda et al., 2014). Desalination by solar Energy is hot development in gulf region due to high solar intensities there (Al-Hinai et al., 2002). Solar water distillation is a process in which solar energy or solar radiations are used to separate clean and pure water from salt and other contaminants. By achieving the thermal energy required for phase change process solar energy can be utilized for sea water desalination (Sarda et al., 2014). The desalination phenomena that occur in the solar still is like a natural phenomenon on earth (Hikmet et al., 2005). Solar energy heats the earth's water that is in the seas, rivers, and lakes and as a result of this heat evaporation takes place and water that evaporate condense in the atmosphere and return to earth in form of rain similarly this is the working procedure take place in solar still (Hikmet, 2006; Husham et al., 2010). Swedish engineer Charles Wilson was the man who built the first conventional solar still in 1872. In construction of this plant wooden bays which had blackened bottoms using logwood dye and alum were used. There are different design variations exists and wide variety of raw and construction material used (Al-Hayeka and Badran, 2004).

2. Methodology and Experimental Set up

One single slope Solar still were designed from locally available material the structure of solar still was made of wood. The base of solar still was made of iron sheets and painted with black color which act as absorber. The interior surface of solar still was blackened for maximum absorption of solar radiation that fall on it. The base and sides of Solar still was insulated with white foam plastic material (expanded polystyrene) and then enclosed in the wooden structure to minimize the heat loss. The solar still was covered with glass through which radiations pass and fall on water inside the basin (Manokar et al., 2018; Hikmet, 2006). First heating process take place on absorber plate after it as a result of this heating the evaporation process take place on absorber plate also and then condense water start condensing on the inclined glass cover this is the condensation process (Hikmet et al., 2005). The entire solar still made airtight by rubber gaskets and clamps (Shashikanth et al., 2015). An inlet valve is also set through which water enters the basin. When the distillation process starts, and water starts condensing on inclined glass and runs along the lower edge due gravity and collected in the bottle and measured by the gradual glass beaker in the laboratory.

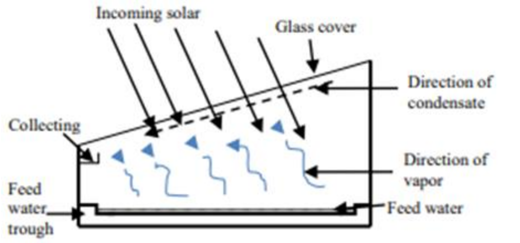

Figure 1: Single slope still

2.1 Equipment's used in experiment

Gradual glass beaker, pyranometer, thermometer, thermocouple, and anemometer. Through Pyranometer device diffused and direct solar radiations are measured. Gradual glass beaker is a laboratory apparatus used to measure the water that distilled out from solar still. Thermocouples are the devices which measure the temperature of water that is in the basin and the temperature of inclined glass from inside and outside. Thermometer measure the atmospheric temperature. Anemometer shows wind speed hourly readings of wind speed was taken (Shashikanth et al., 2015).

2.2 Factors affecting the Productivity of solar still

- Wind velocity
- Temperature
- Solar radiations
- Water level in still

2.2.1 Wind velocity

Wind velocity is the factor which directly affect the productivity of solar still. Efficiency of solar still increases as the temperature of cover decreasing due to temperature difference and this effect consequently increase the air mass circulation within solar still. Like water film cooling of glass cover enhanced the efficiency by 6% (Bassam, 1996). El sebaii concluded through investigation, effect of active and multi-effect passive skills and concluded that the efficiency of solar still increases as the wind velocity increases (El-Sebaii, 2004). El sebaii [13] also monitored the effect of wind speed for different air masses and it concluded that the efficiency increases with increasing velocity and it also shown in these experiments when wind speed increase from 1-9m/s then the yield of system fall (El-Sebaii, 2011; Nafey et al., 2000). Wind speed is the matter of discussion because some scientist are in favor of wind speed as increasing productivity factor and some are against it like EL-Sebaii confirmed that the effect of wind increase productivity up to a typical speed above that limit that speed effect become insignificant (Karthikeyan and Alagumurthi, 2018). The typical velocity for summer and winter is 10m/s and 8m/s respectively (Rajvanshi, 1981). Rajvanshi and Abdenacer also stated that wind speed increase productivity (Abdenacer and Nafila, 2007). A group researcher also proved through experimentation that wind speed is a factor which can increase productivity up to 50% when its value changes from 0-10m/s where as some are against this fact that wind speed increase productivity Holland are against this like others Yeh and Chan, Morse and Read are have opinion that wind speed does not have much effect on the productivity of solar still (Algarni, 2012; Hollands, 1963; El-Sebaii, 2004). Nafey clearly stated that the value of wind speed when changes from 1 to 9m/s the productivity of solar still decrease by 13% (Nafeya et al., 2000).

2.2.2 Temperature

Effect of temperature would be main factor which surely enhance the productivity of solar still which states efficiency of solar still increase by increasing temperature. This statement proved by work of Hinai which states that the output of solar still increases by 8.2% with the rise of 10 °C temperature (Al-Hinai et al., 2002). Abdenacer elaborate that with increasing temperature difference between glass and brine more productivity can be achieved and this temperature difference can be increase by increasing wind speed outside the surface of glass lid (AD. Nafey proposed that with increasing the solar radiations incident on the still its productivity can be increased (Nafeya et al., 2000). Muftah in his research state from work of Hinai et al that with increase in ambient temperature by 100C the value of solar still productivity increased by 8.2% (Nafey et al., 2000). Hinai concluded that the effect of increasing the wind speed is more important factor than the ambient Temperature of solar still (Al-Hinai et al., 2002). Another factor that lower the efficiency of still is salt concentration. Mahdi concluded that when salt concentration increases from 0 to 10% then the efficiency of solar still decrease from 38% to 28% under 420W/m2 incident solar radiations (Mahdi et al., 2011). The inner temperature of lid and water can be increased by using the inner reflectors which help to increase productivity up to 20-30% (Hiroshi and Yasuhito, 2006).

2.2.3 Solar radiation

The optimum angle of tilt is 230 in literature (Al-Hinai et al., 2002). Solar radiation is the main factor which highly effect the output of solar still there are different research work on this factor which are highly appreciate able the results shows that efficiency of solar still increases with increase in solar radiation incident. Solar radiations were in range of 0 to 1.2kW/m2 and maximum yield is during noon because solar radiations are maximum at that noon (Badran, 2007). Solar still productivity can be increased when solar radiations incident on glass lid increased (Adenacer and Nafila, 2007). A group researchers investigation reported that the radiations that incident on water heats up liquid and because of this heat water starts evaporating and then initiate heat losses as shown in fig 2 (Okeke et al., 1990).

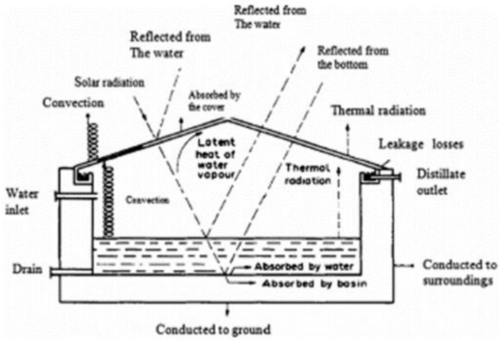

Figure 2: Diagram of solar still

2.2.4 Water Level in Still

Water depth or water level in the solar still basin is a productivity factor. When the water depth increases then the productivity decreases and vice versa. It is also proved by some experiments done by some researchers like Nafey stated that when the water level in basin increases from 2 to 7 cm the output decreases by 14% (Nafeya et al., 2000).

3. Results and Discussion

Solar productivity that got after the experimentation of this conventional solar still was 900ml/day on December 3,2019 and basin area was nearly 5 ft2.on day 2, 5th of December the productivity was 835ml due to slight cloudy weather and on day 3, 6th of December the solar productivity the 915ml.Wind speed on an average was 5.85m/s and solar radiations on an average was in range of 300-400W/m2. But when these results compared with another experimentation results done in which internal reflectors were used to reflect solar radiations and fall these reflected radiations on water in the basin (Omara et al., 2013). The condition during the experimentation was this experiment was conducted during winter in the month of December the conditions was here was not good nearly these days were foggy days but nearly at 9am skies were clear and solar radiations were falling on the ground at 10am experimentation was started and values were noted till 5pm.

The solar radiations were not good initially on day 2 but at 11:30 am the conditions got better, and maximum temperature achieved during noon 12-3 pm. The wind velocity was also a factor it gradually starts increasing from 10am to 2pm and then start decreasing throughout these days. When this experimentation results were compared with another experiment results it shows a huge difference because in our case basin area was small as compared to another conventional still which has area of 1m2 and this still reaches the maximum yield of 3720 ml/m2/day and stepped solar still were having productivity of 5840 ml/m2/day. After that, when the internal reflectors were used in the conventional still then its productivity reaches 3630 ml/m2/day and for stepped still by using internal reflectors the enhanced up to 6350 ml/m2/day and it give a productivity boost of 75% to steeped solar over the conventional still this give us clear conclusion that using internal reflectors in the still the productivity of still can be increased and if the arrangement made like steeped still then it can a extra factor to more enhance the solar productivity of still because when we install mirrors inside the wall of conventional and stepper still the radiation loss become decreased and all radiations nearly fall on the water surface and it also enhance the greenhouse effect inside the still due to this factor the productivity increased.

The design and material parameters also effect the efficiency of the still. Here is an example of design factor that how design factor affect the efficiency of solar still. This experiment was conducted by MOKHTAR et al. in which vacuum tubes were used and experiment was conducted during month of September 2005 the experiment was conducted for 5 days first experiment was conducted on 1st of September on that day the solar radiation was nearly gone up to 500 W/m2 and productivity was boosted up to 6000ml and next experiment was conducted on the 8th of September and here irradiance value touched 500W/m2 and solar still productivity jumped to nearly 7500ml. when next experiment was done then the productivity not increase like the solar radiations increase on 9th of September the irradiance goes up to 550 W/m2 but still productivity was same as previous day experimentation. On 10th of September the irradiance falls more but the productivity did not decrease in which manner the irradiance decreases the productivity was nearly 7000ml along with solar radiations of 450W/m2. On 5th experiment day 13th of September, the solar radiations fall, and productivity also falls in similar fashion and value of productivity drops to 5800ml and solar radiations were 475W/m2[Ould Dah Mohamed El Mokhtar et al. 2006]. hence it proves that design parameters also effect the efficiency of a solar Distillator. So, design is also very important.

4. Conclusion

The conclusions that are made after this whole experimentation are following:

- Conventional solar still has lower efficiency as compared to other modified solar stills.
- Solar still with internal reflectors also increase the efficiency of solar still but it is not as good as steeped solar still
- In steeped solar still without using internal reflectors the productivity of solar still with steeped is 57% more than the conventional. If the internal reflectors used in steeped solar still, then the productivity can enhance up to 75% as compared to conventional solar still.
- It is also concluded that the design parameters are also important factors like vacuum tube still has more productivity than the steeped still in which internal reflectors also used so design and material parameters should be considered before the preparation of still.

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