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EXPERIMENTAL STUDY OF DIFFERENT SOLAR STILL WITH EFFECT OF PCM AND REFLECTOR MECHANISM

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Abstract - *Clean potable water is a basic necessity for man along with food and air. Fresh water is also required for agricultural and industrial purposes. The main sources of water are rivers, lakes and underground water reservoirs. However, direct uses of water from such sources are not always advisable, because of the presence of higher amount of salt and harmful organisms. The higher growth rate in world population and industries resulted in a large escalation of demand for fresh water. The natural source can meet a limited demand and this leads to acute shortage of fresh water. Hence, there is an issue to essentially treat the salt and contaminated water into purified water. In this work we can improve the performance of solar still by using PCM and use of Reflector mechanism. Also we study the single and double slope solar still.*

Key Words: ***Clean Water, PCM, Solar Energy***

1. INTRODUCTION

India's huge and growing population is putting a severe strain on all of the country's natural resources. Most water sources are contaminated by industrial waste, sewage and agricultural runoff. India has made progress in the supply of safe water to its people, but gross disparity in coverage exists across the country. The World Bank estimates that 21% of communicable diseases in India are related to unsafe water. In India, diarrhea alone causes more than 1600 deaths each day (John Briscoe 2005). The average annual rain fall for whole India varies from 96 cm to 146 cm (Parthasarathy and Dhar 1975). According to the report by Metrological Depart of India, Most parts of Andaman and Nicobar Islands, Arunachal Pradesh, Assam, Meghalaya, Nagaland, Manipur, Mizoram, Tripura, West Bengal, Sikkim, Orissa, Bihar, Uttar Pradesh, Goa, Kankan Goa, Coastal Andra and Karnataka, Kerala and Lakshadweep receives an annual rain fall more than 150 cm. Himachala Pradesh, Jammu and Kashmir, Gujarat, Maharashtra, Andhra, Tamil Nadu, Pondicherry and Karnataka receives an annual rain fall around 100 cm. For remaining states the annual rain fall is around 50 cm. The average annual precipitation is estimated to be 4000 billion m^3/year. Only 1000 billion m^3/year is available as usable surface water and ground water. This quantity is about 10-20% of per capita consumption in industrialized countries. At present, the water consumption in India is about 750 billion m^3/year for all the applications, viz. agricultural, industrial, domestic and commercial. Assuming a per capita water consumption of 1000 m^3/year, the water availability in the country is likely to get fully stretched by the year 2010 unless, augmentation is planned right now. Moreover, the geographical distribution and seasonal variation of rainfall are not uniform. There are pockets like Saurashtra and Kutch, the coastal areas of Tamil Nadu and land locked areas of Western Rajasthan, Andra Predesh and Marathwada in Maharashtra with scanty rainfall and perennial water scarcity. In addition, a large number of villages in various parts of the country are known to be suffering from excess salinity, fluoride, nitrate, iron, arsenic and microbial contaminations of ground water.

Clean potable water is a basic necessity for man along with food and air. Fresh water is also required for agricultural and industrial purposes. The main sources of water are rivers, lakes and underground water reservoirs. However, direct uses of water from such sources are not always advisable, because of the presence of higher amount of salt and harmful organisms. The higher growth rate in world population and industries resulted in a large escalation of demand for fresh water. The natural source can meet a limited demand and this leads to acute shortage of fresh water. Hence, there is an issue to essentially treat the salt and contaminated water into purified water.

2. LITERATURE REVIEW

1. **Selva kumar et al., (2008)** [1] studied the thermal performance of "V" type basin solar still with charcoal absorber. The internal heat transfer and external heat transfer modes are studied. Performance ratio of the still, variation of Nusselt number (Nu), Grashof number (Gr) and heat transfer rates were also calculated.

2. **Bharat Kumar Patil, Sanjay Dambal (2016)** [2] the maximum productivity of a double slop single basin solar still is effective when paraffin wax is used. As the productivity of water is obtained in the month of April for paraffin wax is 1100ml. When compared to PCM the productivity is a bit low when black pebble was 954ml. But the productivity of water did not obtain without Paraffin wax nor is Black pebble found to be 795ml. This is comparatively low. The productivity of the still can be enhanced by varying the Declination angle and it is observed that as the solar radiation increases the temperature in the still also increases and as a result the productivity increases remarkably.

B. N. Subramanian (2016) [3] solar desalination is one of the most sustainable and attractive method employed to meet the supply of drinking water for remote areas at very reasonable cost. Heat loss is one of the major parameter affecting the productivity of the solar still. The objective of this study is to enhance the thermal performance and productivity of single basin solar still with integrated phase change material. The important parameters affecting the performance of the still are analyzed theoretically. Effect of water depth in galvanized iron, aluminum and copper basin still and effect of mass of PCM in solar still were investigated. It was found that the productivity of still decreases with increase in water depth. The highest daily productivity of 1.39 kg/m2wasobtainedwhen the depth of water was maintained at 10 mm. The use of stearic acid and paraffin wax as PCM beneath the basin liner improved the daily productivity of still by 164% and 180% respectively compared to still without PCM.

El-Swify and Metias (2002) [4] induced the concept of planer reflector in a double exposure solar still. Still was theoretically analyzed and experimentally tested. It is found theoretically that the double exposure still gained much more daily energy than that of the ordinary one.

Singh et al., (1995) [5] have been analyzed the orientation of the glass cover inclination for higher yield in a solar still. The effects of water depth on the hourly instantaneous cumulative and overall thermal efficiency and internal heat transfer coefficient have also been investigated.

El-Sebaii et al., (2000) [6] designed and fabricated a single slope single basin solar still with baffle suspended absorber (SBSSBA) as an alternate to external pre heater. Results concluded that the daily productivity of the SBSSBA is about 20% higher than that of the conventional still (SBSS).

A single-basin solar still have been designed and analyzed by **Mohammed Farid and Faik Hamad (1993)** [7] Efficiency of the still was found to be independent of solar radiation, however, an increased diffused radiation lead to slight decrease in its efficiency. Still productivity increases with the increase in ambient temperature and decrease in wind velocity.

Hiroshi Tanaka and Yasuhito Nakatake (2007) [8] investigated outdoor experiments for vertical single-effect diffusion solar still and the proposed multiple-effect still has a very high rate of productivity in spite of its simple structure.

Avesahemad Husainy (2017) [9] Hygienic drinkable water is a basic necessity for man along with food and air. Fresh water is also required for agricultural and industrial purposes. Most water sources are contaminated by industrial waste, sewage and agricultural runoff. The higher growth rate in world population and industries resulted water in a large acceleration of demand for fresh water. The natural source can meet a limited demand and this leads to acute shortage of fresh water. Hence, there is an issue to essentially treat the salt and contaminated into purified water. There are several methods to convert impure water into potable water for drinking, but out of them thermal method is economically viable. In this paper experimentation were carried out on two different setups of double slope single basin solar still with and without thermal energy storage by phase change material.

3. METHODOLOGY AND EXPERIMENTATION

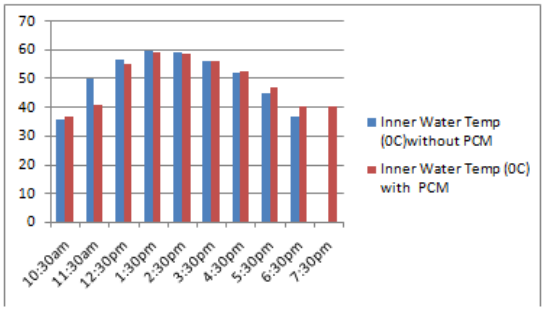
Two double slope single basin type solar still units are fabricated with same design parameters, and tested under field conditions. The experiments were conducted at the open terrace in Miraj (Maharashtra) area March 2018. Total 8 Lit waste water (Soap Water) can be used for experimentation. Total water depth for both set up is 2 cm. The glass and cover of solar still for both set up is sealed by cello tape to avoid loss of heat due to convection and radiation. The output of distilled water is collected in two plastic bottles. Inner surface of both the stills are coated with black colour to improve the thermal performance. The observations: were taken for 9 hours starting from 10 am to 6 pm. The global and diffused irradiances on horizontal and irradiances on inclined planes, the temperatures of the atmosphere, glass surface temp, basin water temp, and the masses of distilled water supplied and condensate collected were recorded every 1 hr. Temperature and solar intensity was measured in every 1 hr with the help of digital temp meter and flux meter. And output of water in ml is measured by digital weight pan. Experiment was conducted on two different setup with and without TES and readings are recorded accordingly. Also effect of Reflector with TES is studied.

1. Comparison of experimental set up of solar still with and without PCM:

Table shows comparison of temp of soap water with and without thermal energy storage. After conducting experiment on two different set up it is observed that temp of impure/soap water is more in case of thermal energy storage set up.

Time(hr)	Inner Water Temp (0C)without PCM	Inner Water Temp (0C) with PCM
10:30am	35.7	36.8
11:30am	50.2	40.8
12:30pm	56.6	55.3
1:30pm	59.8	59.1
2:30pm	59.3	59
3:30pm	56.2	56.3
4:30pm	52.1	52.7
5:30pm	44.9	47.2
6:30pm	36.9	40.5
7:30pm	34	40.2

Table No 1: Comparison of water temp with and without PCM



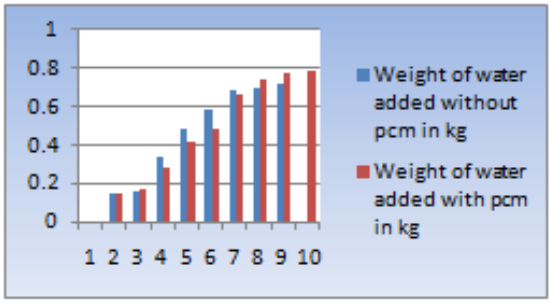
Graph No 1: Comparison of water temp with and without PCM

2. Comparison of Weight of water added in per hr with and without thermal energy storage

Time(hr)	Weight of water added without pcm in kg	Weight of water added with pcm in kg
10:30am	0	0
11:30am	0.152	0.156
12:30pm	0.164	0.176
1:30pm	0.34	0.288
2:30pm	0.484	0.42
3:30pm	0.588	0.484
4:30pm	0.684	0.67
5:30pm	0.704	0.745
6:30pm	0.724	0.778
7:30pm		0.79

Table No 2: Comparison of Weight of water collected with and without PCM

Also it is observed that with the help of PCM we get more water output and we can use PCM integrated set up even in evening time



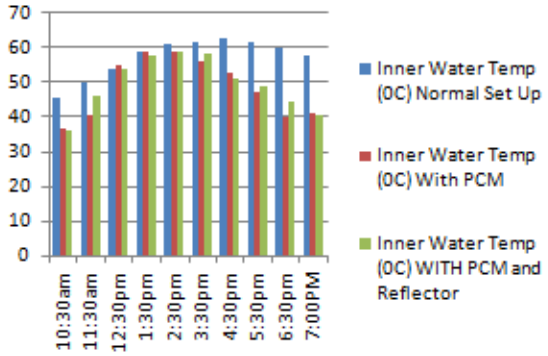
Graph 2: Comparison of Weight of water collected with and without PCM

3. COMPARISON OF 3 DIFFERENT SOLAR STILL

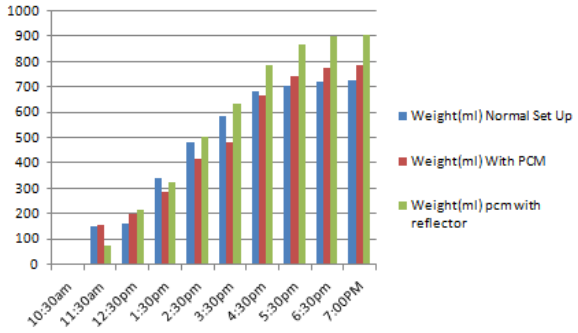
In this experimentation we are comparing solar still with effect of PCM and Reflector. After conducting experimentation we can observed that Solar still with PCM along with reflector mechanism gives more power output than normal solar still. Also we can use PCM integrated solar still during evening time when sunshine radiation are less or no more. PCM along with reflector solar still gives more efficiency.

Time	Inner Water Temp (0C) Normal Set Up	Inner Water Temp (0C) With PCM	Inner Water Temp (0C) WITH PCM and Reflector	Weight(ml) Normal Set Up	Weight(ml) With PCM	Weight(ml) pcm with reflector
10:30am	46	36.8	36.6	0	0	0
11:30am	50	40.8	46.5	152	156	76
12:30pm	54	55.3	54.1	164	200	220
1:30pm	59	59.1	58	340	288	324
2:30pm	61	59	59.1	484	420	504
3:30pm	62	56.3	58.6	588	484	636
4:30pm	63	52.7	51.4	684	670	788
5:30pm	62	47.2	49.1	704	745	868
6:30pm	60	40.5	44.4	724	778	900
7:00PM	58	41.1	40.6	727	790	910

Table No 3: Comparison of three different solar still



Graph No 3: Comparison of three different solar still



Graph No 4: Comparison of three different solar still

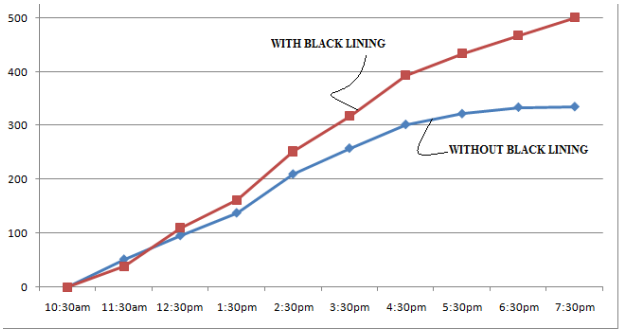
4. EXPERIMENTATION ON SINGLE SLOPE SINGLE BASIN SOLAR STILL

The experiment were conducted on single slope single basin solar still at the open terrace of the in Miraj area March 2018. Total 6 Lit waste water (soap water) can be used for experimentation. The observations were taken for 9 hours starting from 10 am. The global and diffused irradiances on horizontal and irradiances on inclined planes, the temperatures of the atmosphere, condensate and basin

water, and the masses of raw water supplied and condensate collected were recorded every 1 hr. The experiments were conducted between the time periods of 10:00am to 7:30pm. Temperature and solar intensity was measured in every 1 hr with the help of digital temp meter and flux meter resp. Experiment was conducted on two different setup with and without black coating and readings are taken

Time	Weight(ml) Without Black Coating	Weight(ml) With Black Coating
10:30am	0	0
11:30am	52	38
12:30pm	96	110
1:30pm	138	162
2:30pm	210	252
3:30pm	258	318
4:30pm	302	394
5:30pm	322	434
6:30pm	334	468
7:30pm	335	501

Table No 4: Comparison of Single slope single basin solar still with and without black coating



Graph No 5: Comparison of Single slope single basin solar still with and without black coating

CONCLUSION AND FUTURE SCOPE

1. The still continues to produce the fresh water by converting soap water. The distillate production is said to be increased to 10-25% with PCM

2. Tests proved that the water is as pure as rain water and there are no harmful salts at all. It is suggested that for higher masses of PCM, the still will be more effective. The energy storage materials which are used in this investigation system are economically suitable for solar still to improve the output and efficiency.

3. As compared to single basin single slope solar still single basin double slope are more effective.

4. Black Coated solar still gives more power output than without black coated still.

5. Reflector integrated solar still gives more water power output than normal still.

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