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Recent Trends in Solar Distillation

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Abstract-Water is the main source for sustaining the man on earth. Groundwater and reservoirs are the largest available sources of freshwater to fullfill needs of mankind. However, these sources do not always proved to be useful due to the excessive salinity in the water. Solar still is one of the process by which we can purify the water with the help of solar radiations. This device can be fabricated easily with lower cost. This paper takes review of latest development in solar distillation system.

KEYWORDS-Solar radiations, Solar still, Salinity, Phase changing material (PCM)

I. INTRODUCTION

A Solar Still is a device that produces clean, drinkable water from dirty water using the energy from the sun as shown in fig.1.This inexpensive device can easily be built using local materials. Presently, basin type solar still is the only device that is being used for water distillation applications. Solar distillation is very old technology. It is simple treatment for water purification. The basic principles of solar distillation areyet effective, the heat of the sun evaporates the water and the vapour condenses on inner surface of the cover. The condensate runs into trough from which it can be collected in storage containers.The solar still is Non-conventional, cheap, simple, easy to construct and is of low thermal capacity. The two main categories of basin stills are single and double sloped. The double sloped basin still has two sloped pieces of glass rather than one. The main parts of still arebasin, frame, glass cover and support structure. Solar distillation has advantage of cost saving over other types of distillation such as reverse osmosis.

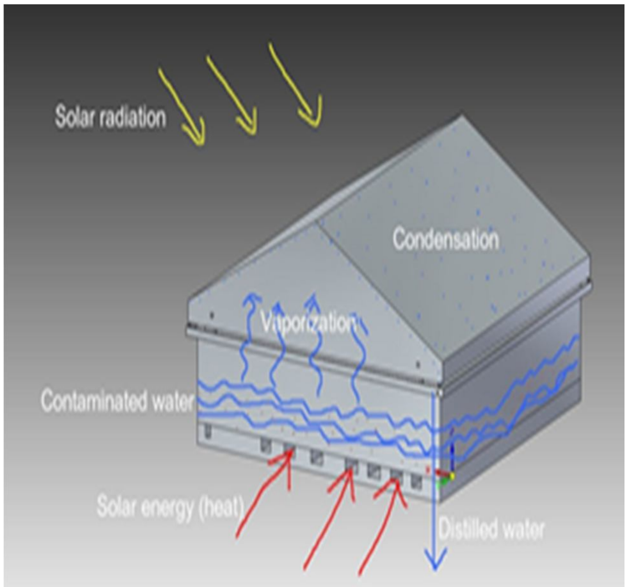

Fig.1 Solar still

II. LITERATURE REVIEW

A. Chendake A.D., Pawar R.S., Thorat P.V. and Pol A.D.

Chendake A.D., PawarR.S., Thorat P.V. and Pol A.D. told about the basics of design and development of the double slope solar still as shown in fig.2. The design of the components of stillare cover plate,insolation,basin,collector plate**.**Thermocol material was used for insulation between basin and plywood to reduce heat loss due to conduction.

They also did chemical analysis and economic evaluation of solar still which were used for the study of pH, TDS.

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Fig.2 Double slope solar still

The result found by them was the daily average insolation about 20.81×106 Jm−2. The ambient temperature during the project duration ranged from 19°C to 34°C with the highest temperatures always observed around 11:00-13:00 hrs. Amount of brackish water poured initially was 12 litres. Amount of pure water obtained after the process was 1.6 litres.TDS of pure water was reduced from 300 ppm to 30 ppm.

B. Sagar Suresh Agrawal

In this paper, Mr.SagarAgrawaldidthe experiment on the solar still in which heused the phase changing material (PCM). Experimental setup of solar still with PCM is shown in fig 3.

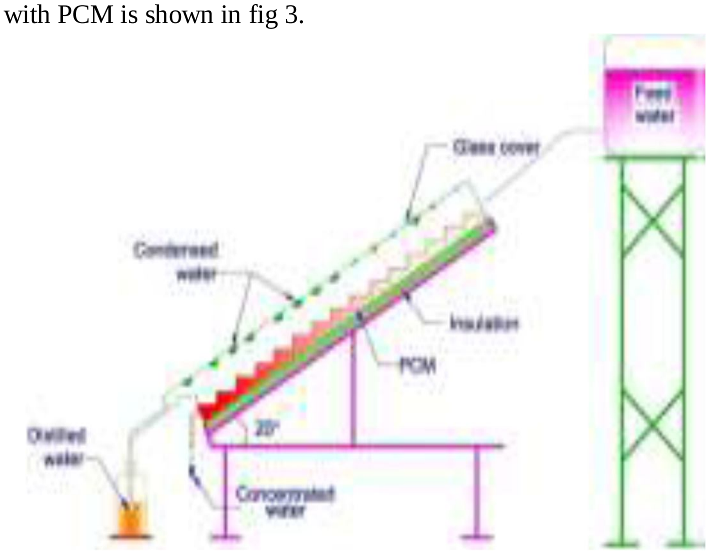

Fig.3Schematic diagram of experimental setup of solar still with PCM

In this experiment he made the solar still using PCM. PCM used in this experiment was Paraffin wax. Phase Change Material (PCM) in Solar still is found to be a best option to increase the efficiency of solar still not only at a day time but also during night. At locations where there is plenty of solar energy and brackish water available small amount of fresh water can be produced at reasonable cost by using solar still with PCM. These devices are relatively inexpensive to build and easy to maintain. Hence, it can be used at any place without much difficulty Two single slope stepped solar still were constructed with and without phase change materials in order to compared the productivity of stills at day as well as night during sunny days. Paraffin wax was selected as Phase Change Material (PCM). It is found that the higher mass of latent heat thermal energy storage system with lower mass of water in solar still basin significantly increases the daily productivity and the efficiency.Experimental results of daily productivity is shown in table no.1

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1) Daily Distillate Output

Sr.no.	Time (hour)	Distillate in ml	
		With PCM	Without PCM
1	9.00	0	0
2	10.00	100	130
3	11.00	145	185
4	12.00	200	225
5	13.00	300	280
6	14.00	255	350
7	15.00	300	290
8	16.00	390	245
9	17.00	255	205
10	18.00	255	1940
11	19.00	70	0
12	20.00	40	0

Table No. 1

Table no.1 shows that the potential of integration of phase change material with solar still system for producing potable water in rural, semi urban and urban areas throughout the day and night increases the productivity by 35-40%.

C. T. Arunkumar and V. Joevivek

A double basin solar still is fabricated as show in the fig.4. In the experimental setup K-type thermometer, digital thermometer, absorber plate, analog thermometer.

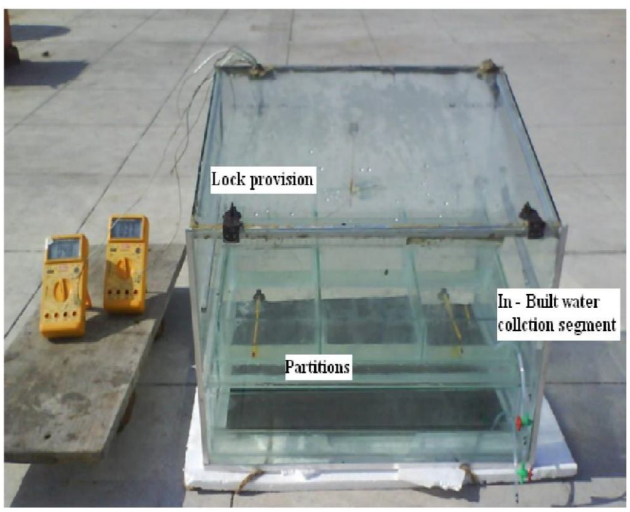

Fig.4 Photographic view of the double basin glass solar still

The performance of a double basin glass solar still is generally expressed as the quantity of water evaporated per unit basin area per day. The experimental water temperature was maximum 59°C. Similarly, the maximum cover temperature was observed at 43.5 °C. Variation of the performance ratio depends on the irradiation intensity. The performance ratio increases with the solar radiation intensity. The performance ratio observed during the study ranged between 14% to 34% in the upper basin and 24% to40% in the lower basin of the solar still. When the temperature reached the maximum value, it did not affect the performance ratio of the still, which remained constant. The warm-up period caused a change in the performance ratio as the temperature rose. This effect could be due to the differences in the solar energy radiation It was observed from the measured data that the upper basin (1.64 l/0.27 m2/day) gives a higher yield compared to the lower one (0.630 l/0.27m2/day). The water evaporation in the lower basin is caused

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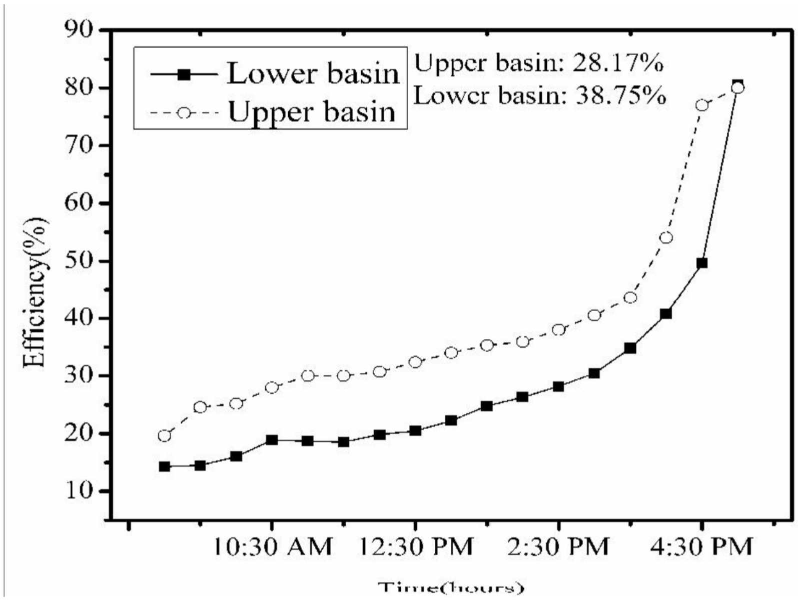
mainly by heat. As a result the upper basin continues to produce an appreciable amount of condensate during night. This clearlyproves that the performance of the double basin glass solar still is much better as compared to the single slope solar still as shown in graph no. 1. The maximum efficiency is found to be in experiment is 66.9%.



Graph No.1 Efficiency of upper and lower basin on summer climate

D. S. Kalaivani, S. RugminiRadhakrishnan

In this set up,S. Kalaivani, S. Rugmini Radhakrishnan used wax as PCM to improve the efficiency and performance of pyramid type solar still. The still was filled with the water to a height of 0.05m. Top of the system was covered by a 3 mm transparent glass pyramid cover with a height upto 0.30m at the middle. It was air tightened using the cushion supports at the interface between the top cover and the sides of sliding support for uniform landing. Bottom of the still was insulated using sawdust.

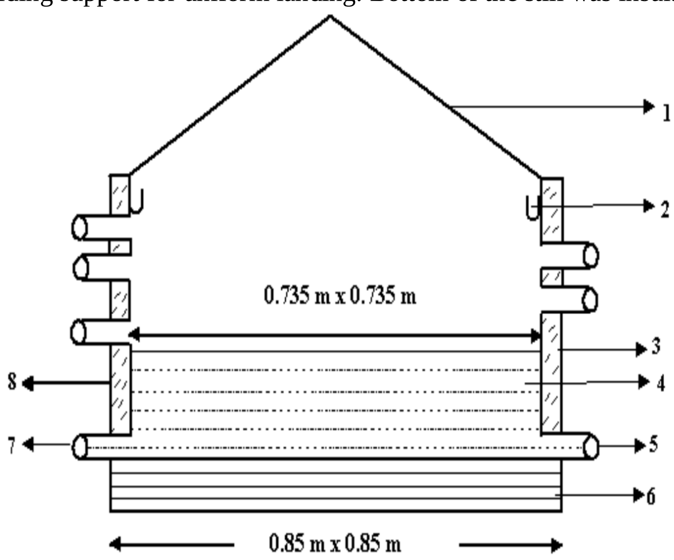


Fig.5 Cross sectional view of pyramid solar still

They analysed the performance of single solar still and pyramid type solar still. Analysis was done with the help of PCM storage material wax . The water collection from pyramid cover solar still as shown in fig.5 and single slope solar still was 1876ml and 1726ml respectively. The pyramid cover solar still performance was reasonably good compared to single slope solar still in daily output with nocturnal output as shown in graph no. 2 The addition of sensible heat absorbing materials was capable of enhancing the

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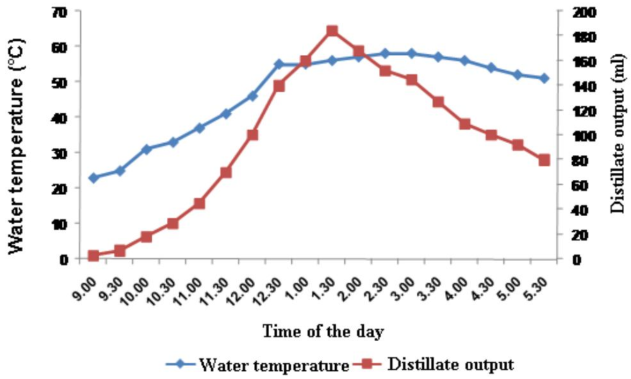
productivity with heat retention causing continued evaporation.



Graph No.2 Water Temperature / Distillate Output Vs. Time for single slope solar still

E. Sureshbabu.k, Prof.S.Chinnathambi , CT.Muthiah

The aim of the work was increase the basin water temperature economically. By utilizing the solar water heater, the basin water temperature was increased. The passive solar distillation system is a slow process for purification of saline/brackish water in solar desalination. To enhance the daily yield many options such as use of various materials for condensing covers, hybrid solar still with parabolic concentrator and evacuated tube and flat plate collector wastried by researchers. Due to low maintenance cost and simple design flat plat collector is still widely used. When flat platecollector solar water heater were integrate with solar still, extra thermal energy was supplied to the basin water from the storage tank and hence rise in water temperature was more when compared to passive solar still. Their experimental setup shown in fig. 6 included- Thermal modelling of double slope active solar still under natural circulation mode without considering the heat capacity of condensing cover and thermal insulation. Study of the flat plate solar water heater integrated with the double slope solar still.

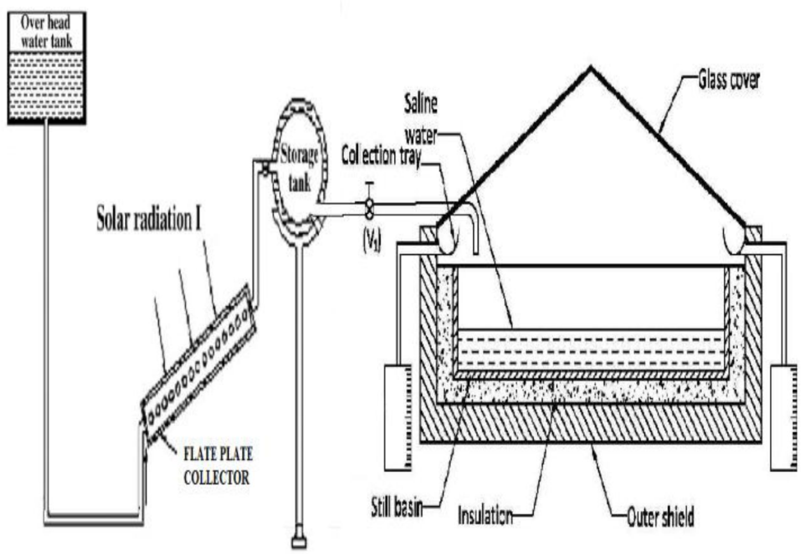


Fig.6The double slope active solar still under natural modes gives higher yield when compared to the double slope passive solar still.

F. Al-Hamadani, S. K. Shukla

These Authors used lauric acid as storage medium. The experimental setup with PCM and without PCM is shown in fig.7 The latent energy stored in the lauric acid keeps the system operational during the night to deliver distillate productivity. The productivity increased during post sunset which occurred due to high temperature difference between water and cover glass at relatively lower ambient temperature. Lauric acid has superior properties like melting congruency, good chemical stability, non-toxicity, good

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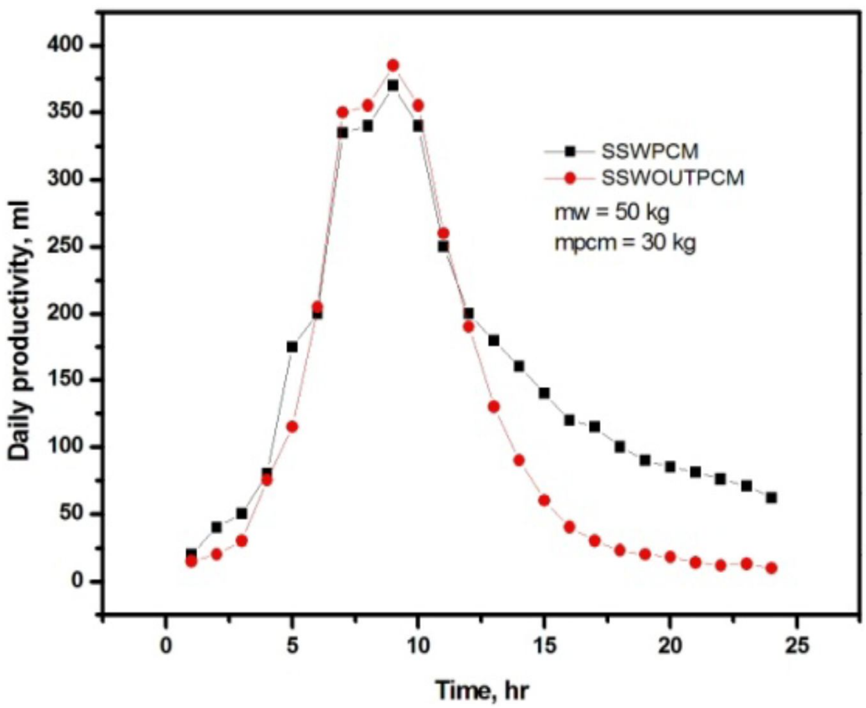
thermal reliability and also it has low cost and easily available.

Fig.7 photograph of the conventional solar still and solar still with (right) and without PCM (left).

It was observed that PCM enhances the productivity by 30% due to PCM being acting as heat source under discharge mode during night. It was interesting to note that lower water mass in solar still with PCM yields more distillate during day time whereas high water mass in basin gives relatively high productivity during night hours as shown in graph no.3



Graph No.3 Variation of daily productivity for solar still with and without PCM for summer day

The instantaneous efficiency keeps increasing due to increase in temperature difference between basin water and ambience. It increased productivity by 30-35% and reduced loss of heat to surrounding. The highest productivity rate is at least water depth.

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Volume 4 Issue XI, November 2016
ISSN: 2321-9653

G. ShristhiShrestha, SaradShrestha, PradipBawari

The authors analysed the performance of solar still integrated with Green house. Green house can be defined as an artificially constructed sophisticated structure that provides near to ideal conditions for plant growth and production round the year. Inside environment of a greenhouse is controlled by controlling the plant growth factors like light, temperature, humidity, air composition, air circulation rate etc. A schematic diagram of a solar still integrated greenhouse, indicating the solar energy absorbed bythe roof and wall is shown in Fig.8 The absorbed solar radiation by the basin liner is partially transferred to water mass and the rest is transferred to the greenhouse through conduction, convection and radiation. The stored energy in the water causes evaporation of the same, which later condenses to form fresh water. The remaining solar energy that is transmitted is absorbed by the plants and the floor. The absorbed energy is finally transferred to the air inside the greenhouse through convection and radiation from the plants and thus the greenhouse air gets heated. A part of the energy absorbed by the floor is also conducted to the ground.

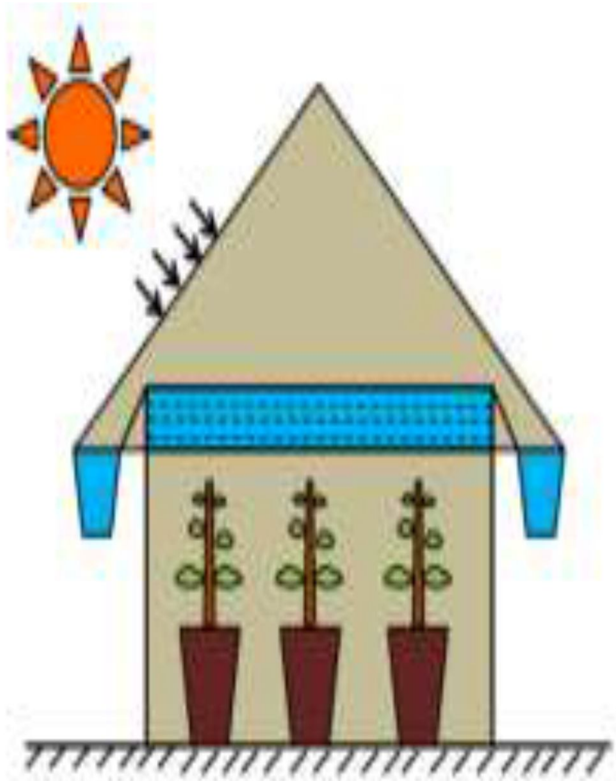

Fig.8: Schematic diagram of a solar still integrated with greenhouse

It was observed that for various seasons of a climatic cycle, the variation in greenhouse inside air and plant temperature is much less compared to temperature of water in solar still. This helps to maintain favourable climate in greenhouse for cultivation and at the same time maximize the yield of fresh water through distillation.

H. N. Suresh, S.Dhanabagyam& R. Jayaprakash

The solar still consists of steel type of basin. It has a thickness of 0.7mm to 1.2mm. Also have top cover with tilted glass angle of 150. It is coated with black paint for absorbing heat energy from solar radiation. The thermocouples were fitted at different places of a solar still to know the various stages of heat energy. The readings are noted at the top of a glass cover, inside the glass cover, basin water temperature, Air temperature. The solar still use K2S.H2O as a PCM as energy storage materials which also improves efficiency of solar water distillation. Most important design parameters influencing the productivity are optimization of glass inclination, absorber plate area, and free surface area of water and depth of water. The main difficulty with conventional still is maintaining minimum depth and large surface area of water. Inclined solar still is alternative to increase the surface area of water and maintain minimum depth. Researchers have put efforts to develop various designs of inclined solar stills to maintain the minimum depth of water using wicks, steps in the stills to increase the productivity.

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1) Basic Principle Of Membrane Distillation

Fig.9 polytetrafluoroethylene membrane

A Membrane distillation (MD) is a hybrid of thermal distillation and membrane processes and the membrane used in this experiment is PTFE is shown in fig .9. MD is a relatively new process that is being investigated worldwide as a low cost and energy saving alternative to conventional separation processes such as distillation and reverse osmosis. Membrane distillation (MD) process is not commercialized yet for large scale industry. The reason behind this is that MD process flux is lower than the commercialized separation processes. The principle of membrane distillation is illustrated in Figure.10Conventionally, membrane distillation (MD) is a thermally driven process in which a micro-porous membrane acts as a physical support separating a warm solution from a cooler chamber, which contains either a liquid or a gas. As the process is non-isothermal, vapour molecules (water vapour in the case of concentrating non-volatile solutes) migrate through the membrane pores from the high to the low vapour pressure side; that is, from the warmer to the cooler compartment.

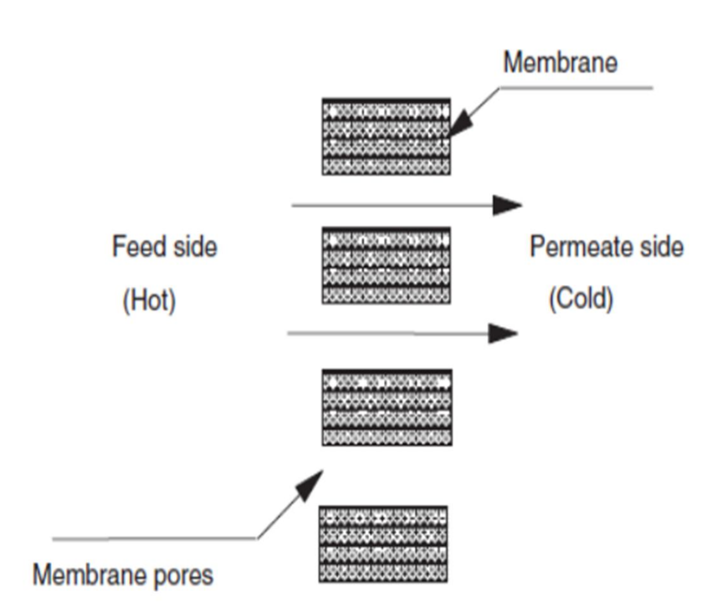

Fig.10 Transport mechanism of MD

Generally, the transport mechanism of MD can be summarized in the following steps:

a) Evaporation of water at the warm feed side of the membrane.

b) Migration of water vapour through the non-wetted pores.

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c) Condensation of water vapour transported at the permeate side of the membrane.

This study shows the potential of integration of phase change material with solar still system for producing potable water in rural, semi urban and urban areas throughout the day and night. The preliminary results show that the system dramatically increases the productivity by 35-40% as compared to conventional solar stills.

III. CONCLUSION

Solar distillation processes is evaluated with the various mentioned processes. From the literature review following conclusions can be drawn:

A. The TDS level of purified waterobtained is 30 PPM. So the water obtained is potable.
B. The potential of integration of phase change material with solar still system for producing potable water throughout the day and night.
C. Double basin glass cover solar still had maximum efficiency 66.9%.
D. The double slope active solar still under natural modes gives higher yield when compared to the double slope passive solar still.
E. The productivity on night increased significantly with increased PCM.
F. Energy storage materials K2S.H2O improve the efficiency of solar water distillation.

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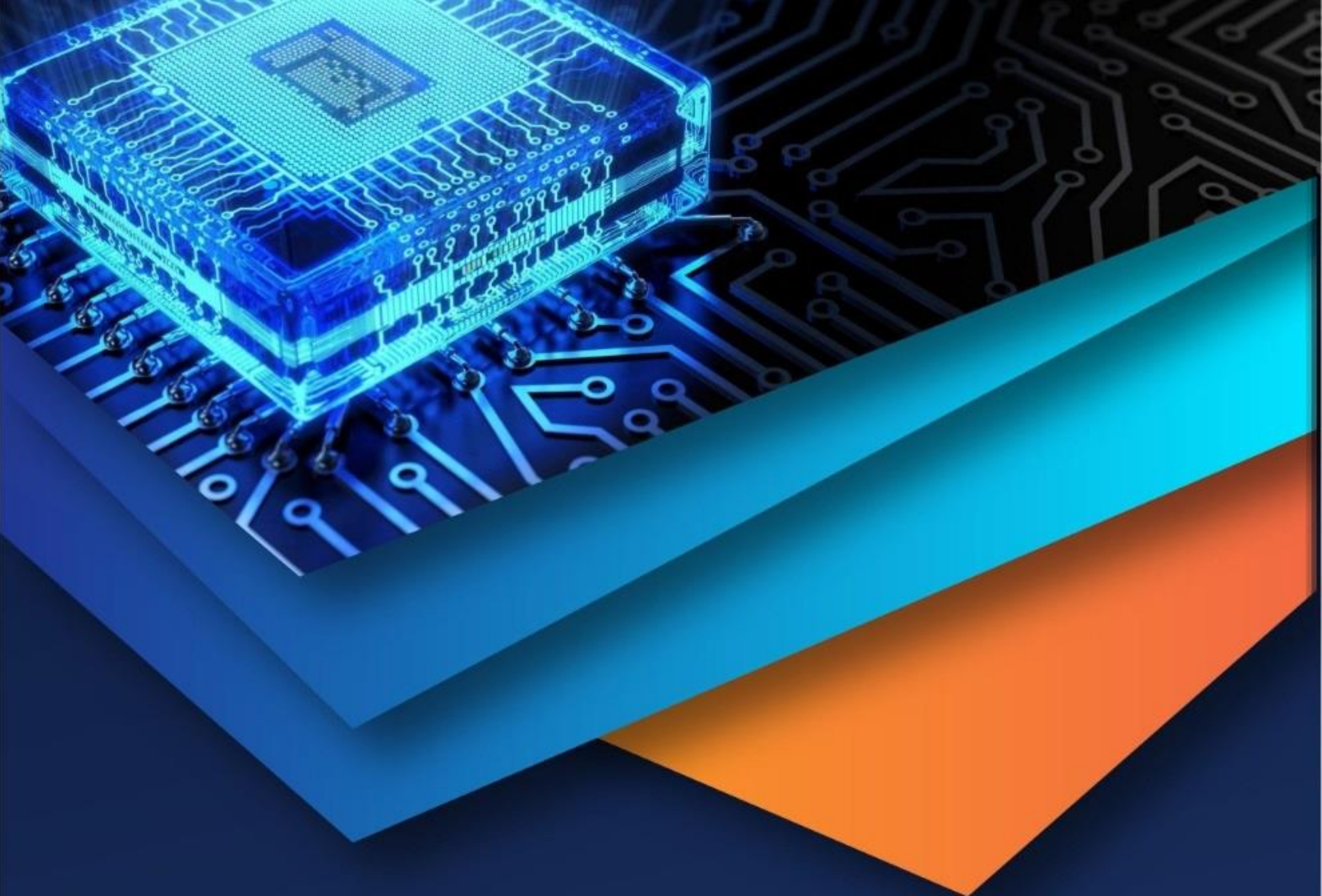

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