Solar Distillation Using Nanoparticle Integrated Phase Change Material

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***Abstract*— The test examination has been done in the period of April, 2019 for the climatic states of Kharghar, Maharashtra, India with scope of 19.047321 N and longitude of 73.069908 E. The reason for this undertaking is to explore the impact of Nano-composite material on the activity of a conventional sun oriented still. The sunlight based still utilized in this examination is of single incline type because of its simplicity of creation and cost amicability. In this venture the customary sun based refining process is improved by the utilization of Nanoparticle incorporated Phase Change Material as inert warmth stockpiling medium. For the experimentation reason, CuO nanoparticles of 10nm size are implanted in Paraffin Wax as Phase Change Material by ultra-sonication process for even scattering of nanoparticles. Paraffin Wax can discharge its inactive warmth amid stage change process which improved not just the time term of the refining procedure yet in addition the efficiency on every hour premise. While the conventional refining procedure could yield greatest yield for a time of 2-3 hours, the work on Nano-composite expanded this period by 2 hours for example 4-5 hours roughly. The timeframe of experimentation was of 12 hours (from 8am to 8pm). In spite of the fact that a further water quality examination should be played out, the investigation uncovers promising outcomes for cutting edge sun powered refining process.**

Keywords- Solar Distillation, Nano-composite, Ultra-sonication.

I. INTRODUCTION

Water is the most copious asset on Earth. Majority of the our planet's surface is secured by water sources. Anyway this squanderer is profoundly unpotable because of its salt content. Likewise the consumable water levels are falling exponentially because of populace burst. Therefore it has turned into a commitment for scientists around the globe to find ways for consumable water generation. Solar desalting is the broadly accepted and the most crude technique for desalting of salt water. Solar desalting is a way to desalinate water using solar power. There exists two methods of carrying out desalting using this method; direct and indirect. Sunlight may provide heat for evaporative desalting processes. Within the direct way, solar panel is used with distillating mechanism. In the indirect solar desalting, a solar plate array and a distinct desalting plant is employed. A sunlight powered still essentially utilizes the standard of dissipation and build up utilizing the sun's radiations. Though being a shoddy medium and available in different varieties, it is less effective and gainful and is valuable just amid the sunlight hours. Various works in the branch of solar distillation are explained further. D.Dsilva Winfred Rufuss, S. Iniyan, L. Suganthi Davies PA[1] utilised CuO impregnated paraffin for productivity boost in individual solar stills 35% improvement in productivity was obtained. C.L. Saw, H.H.Al-Kayiem, A.l. Owolabi[2]. Experimented on nanocomposite with 1% by weight of 20nm CuO nanoparticles to boost the latent heat storage capacity. Effeciency and productivity were the factors accounted for. Saw C. Lin and H.H. Al-Kayiem prepared four different nanocomposite mixtures and employed them in the solar still. The efficiency was boosted by 1.7%[3].Bhupendra gupta , Anil Kumar and Prashant V. Baredar mixed 0.12% Cuo nanoparticles with PCM along with sprinkler attachment. They concluded with an yield of 4000mL/sq.m/day as compared to 2900mL/sq.m/day.P. Sundaram,D.Mohan and S. Madhan Kumar used pyramidal slope solar still using PCM alone and found an increase in efficiency by 9.908%[4].G. Rajashekhar and Easwarmoorthy experimented with three distinct solar stills by applying Al2O3 nanocomposite and found an increase in efficiency by 45%. To enhance these downsides, vitality holds as paraffins are utilized. Still the profitability improvement is minimal. Consequently to additionally enhance this, composites are shaped by utilizing nanomaterials (Copper oxide) inside the Paraffin by ultrasonication process. Past examinations uncovered that nanocomposites altogether improved the still efficiency.

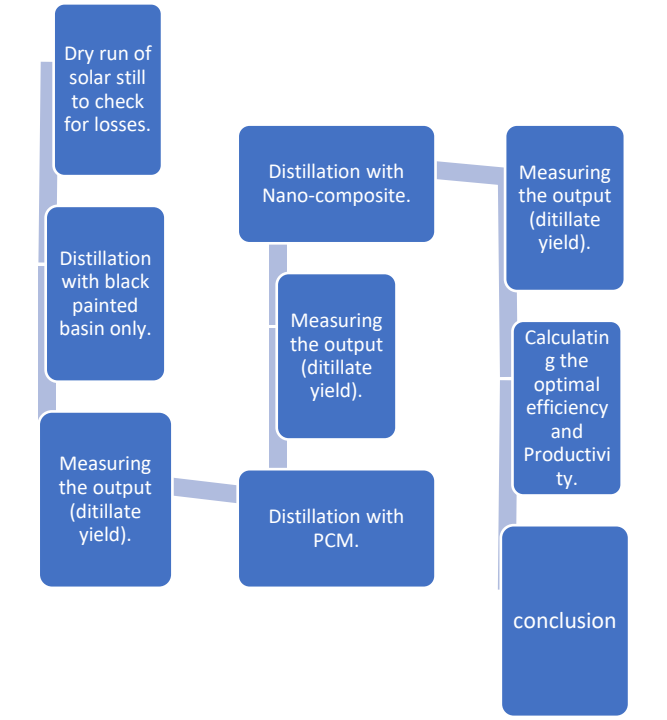


Fig. 1. Overall methodology

II. Experimental Details and Measurement

Single slope solar distillator is used for the experiment. The base dimensions are 50 x 50 cm. The high and low sides of the walls are 36 cm & 15 cm respectively. Glass cover used to cover the top of the set-up is of 3mm thickness and inclined at an angle of 23º (approximate optimum value selected according to location in which the experimentation to be done). The basin material used is aluminium sheet of 2mm thickness. Base surface is coated black to improve the absorption inside the distillator. The side walls are painted white to increase reflectivity in the still. The outside of basin is supported by wooden cover of 3cm thickness. A reservoir is provided beneath the basin surface to accommodate the storage material. The water condensate accumulated on surface of the glass is collected in a channel at the lower end and further collected in a storage reservoir connected to the channel with plastic tube. A sealant is provided at the edges of the wood and glass to prevent slipping of the glass and also for reducing any heat losses from the still. Phase change material integrated with nanoparticles is used as solar storage medium. The PCM used is Paraffin Wax, purchased from Premium Wax. CuO nanoparticles were used, purchased from Amnium Technologies, Pune. The properties of paraffin wax are given in the table

III. Experimental Method

Investigation is completed utilizing following system:

• First a perception table is set up for taking note of down the readings. The table comprises of following sections: Time (in hr), Atmospheric Temp. (in °C), Basin Water Temp.(BWT) (in °C), PCM Temp. (in °C) and Productivity (in ml).

• The test hours are from 8 am to 8 pm.
• The sun based still is set where the daylight is brilliant appropriately ensuring that no piece of the still is under shadow of outer articles amid the test hours.
• All the sealings are checked to ensure that glass plate is laying legitimately on still with no holes.
• The glass plate is cleaned with a dry material to expel any earth or residue aggregated.
• The saline water is made to stream into the bowl at normal interims.
• Now at an interim of an hour the readings are taken as needs be.
• The temperatures are estimated utilizing the computerized thermometers introduced in the still and profitability is estimated as far as refined water gathered in ml.
• The abundance water is expelled from the still through flood port.
• The above methodology is rehashed for somewhere around a month. The counts are done to get productivity of still.
• Following charts are plotted from the readings: Atm. Temp. Versus Time, BWT Vs. Time, PCM Temp. Versus Time and Productivity Vs. Time.
• Final outcomes and ends are drawn from the above computations and diagrams.

The test was directed in three phases as referenced before. In each stage the saline water upto 5 cm tallness of the bowl was filled.

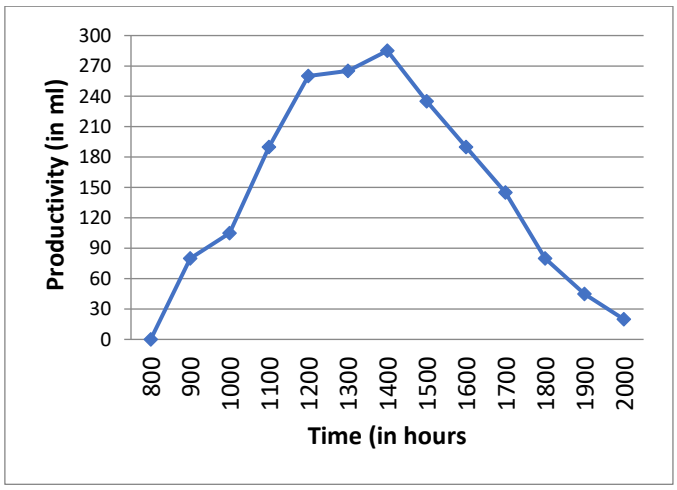
IV. RESULTS

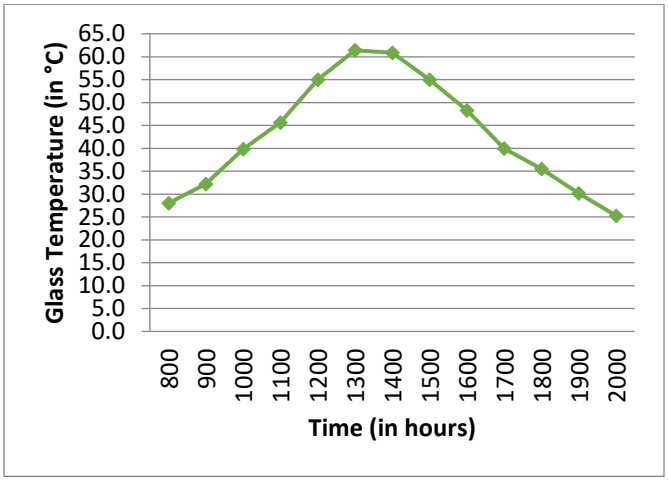
The observations in case of conventional solar distillation process are as follows:

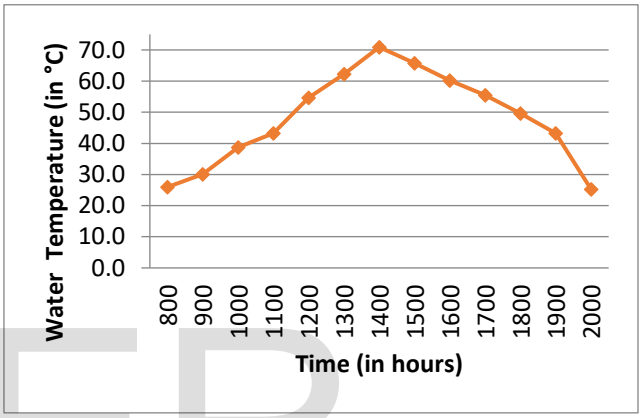
Table No. 2: Observations for conventional distillation

Sr. No.	Time	Productivity (in ml)	Glass Temperature (in °C)	Water Temperature (in °C)
1	8:00 am	0	28.0	26.0
2	9:00 am	80	32.2	30.1
3	10:00 am	105	39.8	38.7
4	11:00 am	190	45.6	43.2
5	12:00 pm	260	55.0	54.6
6	01:00 pm	265	61.4	62.3
7	02:00 pm	285	60.9	70.9
8	03:00 pm	235	55.0	65.8
9	04:00 pm	190	48.3	60.2
10	05:00 pm	145	40.0	55.5
11	06:00 pm	80	35.5	49.6
12	07:00 pm	45	30.2	43.2
13	08:00 pm	20	25.3	35.8

From the above observations we can see that the maximum total distillate yield obtained was 1880 ml/day.





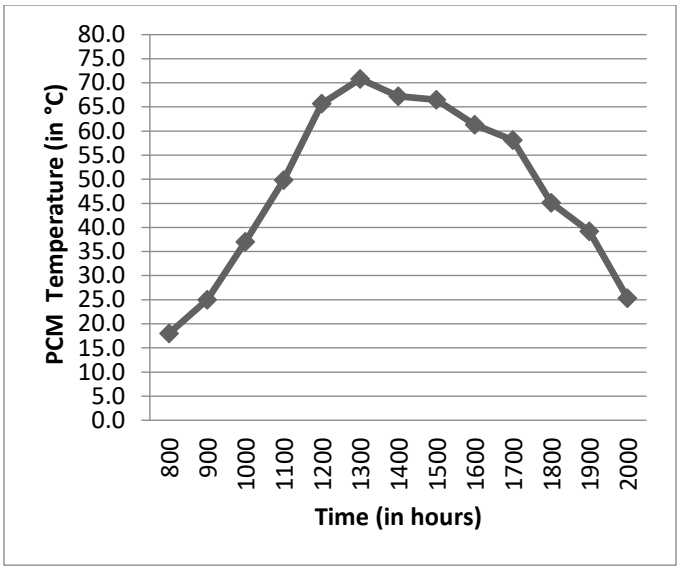


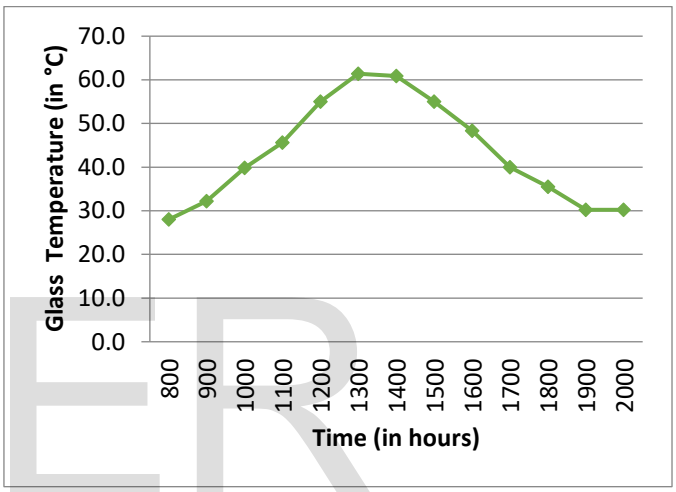
In the second stage of the experiment, distillation with Paraffin Wax as PCM below the still basin was carried out. The observations recorded in this stage were as below:

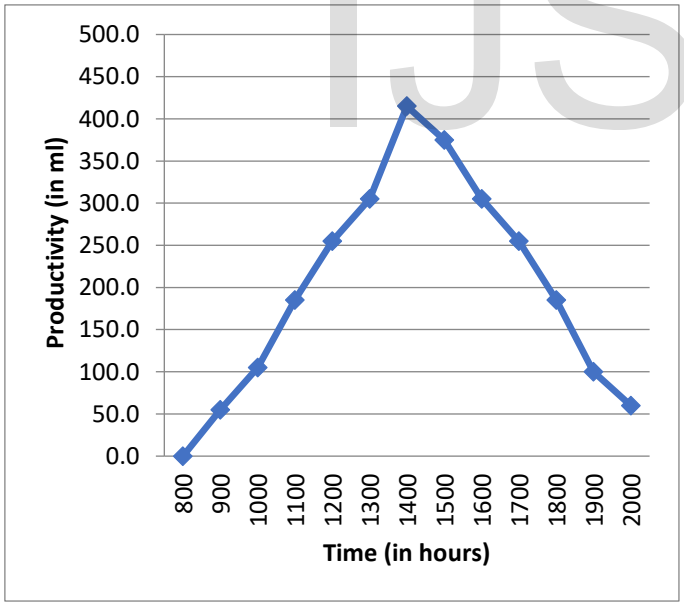
Table No. 3: Observations for solar distillation with PCM

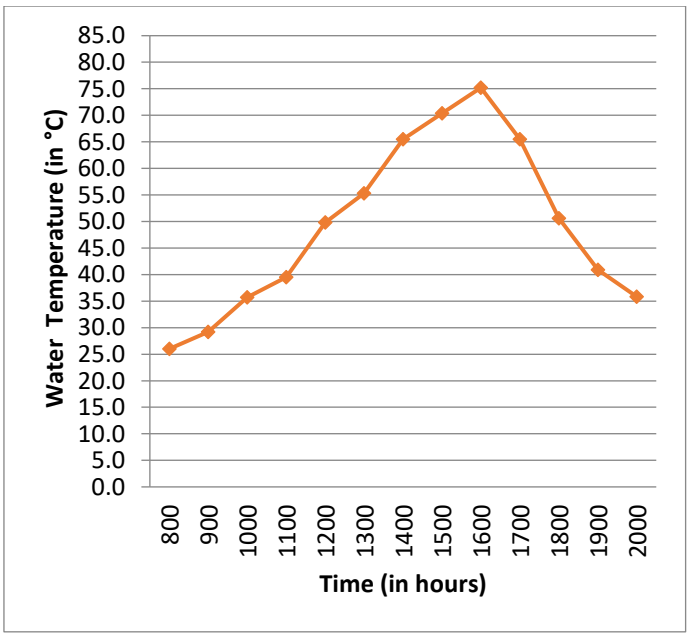
Sr. No.	Time	Productivity (in ml)	PCM Temperature (in °C)	Glass Temperature (in °C)	Water Temperature (in °C)
1	8:00 am	0	18.0	28.0	26.0
2	9:00 am	55	25.0	32.2	29.2
3	10:00 am	105	37.0	39.8	35.7
4	11:00 am	185	49.8	45.6	39.5

5	12:00 pm	255	65.7	55.0	49.8
6	01:00 pm	305	70.8	61.4	55.3
7	02:00 pm	415	67.2	60.9	65.5
8	03:00 pm	375	66.5	55.0	70.4
9	04:00 pm	305	61.3	48.3	75.2
10	05:00 pm	255	58.1	40.0	65.5
11	06:00 pm	185	45.1	35.5	50.6
12	07:00 pm	100	39.2	30.2	40.9
13	08:00 pm	60	29.2	25.3	30.2







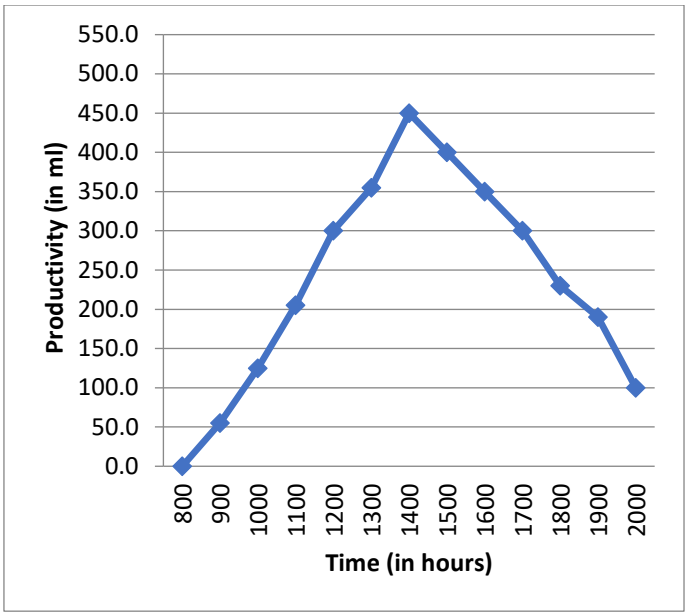


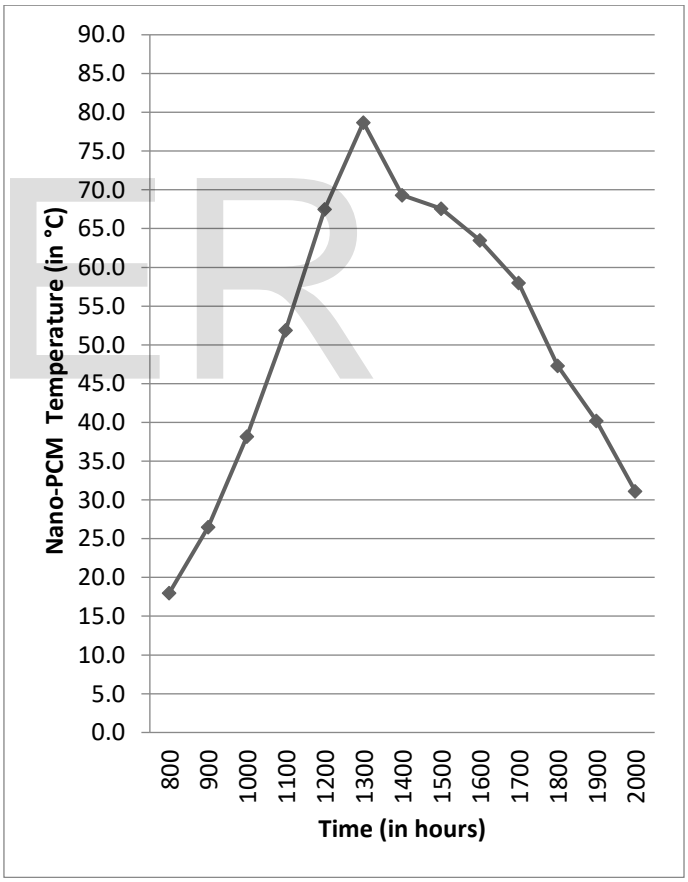
These observations indicate that in case of solar still with PCM as energy storage medium the basin water temperature is initially lower than that in conventional still because initially the heat energy absorbed by the basin water is transferred to the PCM so that phase change occurs and later on as the solar radiations become weaker the same heat is passed by the PCM to the basin water wherein it acts as a heat sink. The overall distillate yield in this case comes out to be 2600 ml/day.

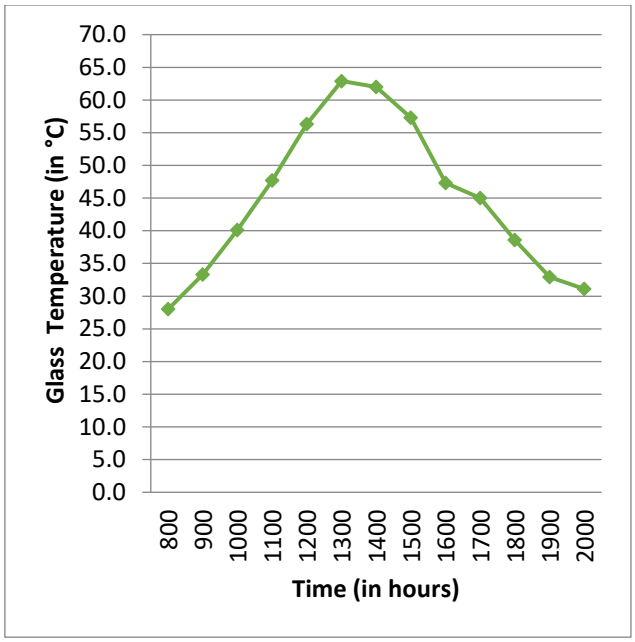
In the last stage of the experiment, the distillation process was carried out using nanocomposite material below the solar still basin. The observations made in this stage are as follows :

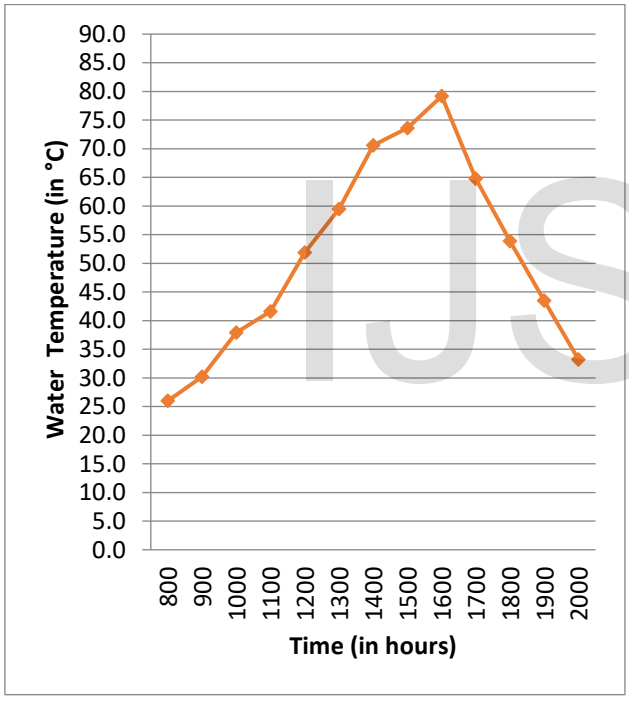
Table No. 4: Observations for solar distillation with Nano-PCM

Sr. No.	Time	Productivity (in ml)	Nano-PCM Temperature (in °C)	Glass Temperature (in °C)	Water Temperature (in °C)
1	8:00 am	0	18.0	28.0	26.0
2	9:00 am	55	26.5	33.3	30.2
3	10:00 am	115	38.2	40.1	37.9
4	11:00 am	195	51.9	47.7	41.6
5	12:00 pm	285	67.5	56.3	51.9
6	01:00 pm	325	78.7	62.9	59.5
7	02:00 pm	425	69.3	62.0	70.6
8	03:00 pm	400	67.6	57.3	73.6
9	04:00 pm	325	63.5	47.3	79.2
10	05:00 pm	290	58.0	45.0	64.8
11	06:00 pm	215	47.3	38.6	53.9
12	07:00 pm	175	40.2	32.9	43.5
13	08:00 pm	90	31.1	28.3	33.2









From above table we can see that the distillate yield is the highest in case of solar distillation with Nano-PCM and it is 3085 ml/day.

V. CONCLUSIONS

The following conclusions were incurred upon after the three stage experimental process:

- The overall distillate yield of the conventional solar still has been found out to be increased using the introduction of PCM and nanocomposite material below the solar still basin.
- Computed daily distillate output for the solar still with PCM alone was 2600 ml/day as against 1880 ml/day. The productivity was found to be increased by 38.29%.
- In case of the solar still with Nano-PCM below the solar still basin the distillate yield came out to be 3085 ml/ day. The productivity was found to be increased by 64%.
- Above results indicate that the solar still with Nano-PCM shows better performance than the conventional solar still.

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