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Enhancing Solar Still Performance Using Phase Change Material and Ultrasonic Mist Generators

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ABSTRACT

Using solar energy to provide potable water is an effective way to protect the environment and supply drinking water to remote areas. One of the simplest types of solar stills is the single-basin solar still (SBSS), which is easy to manufacture, operate, and maintain. However, it suffers from limited production per square meter. This study is one attempt to increase the productivity of the basic still by adding phase-change materials at various positions within the still, in addition to using ultrasonic steam generators. Two basic stills, each measuring 0.4 m² (1.0 m × 0.4 m), were manufactured. The first remained unmodified, whereas the second was enhanced by adding phase change material (PCM) in three configurations: material immersed in the basin throughout the day, referred to as horizontal phase change material (HPCM); material placed vertically during the daytime and then submerged in water after sunset, referred to as vertical–horizontal phase change material (VHPCM); and material maintained in a vertical configuration, referred to as vertical phase change material (VPCM). The second improvement: ultrasonic mist generators (UMGs) with VPCM. The study used 1 UMG (VPCM+1UMG), 2 UMGs (VPCM+2UMG), or 3 UMGs (VPCM+3UMG). All UMGs were operated intermittently using a cycle of 15 min ON followed by 60 min OFF, with 12 ON cycles per UMG during the experimental day, corresponding to 180 min/day of operation for each UMG. The experiments were conducted in Diyala, Iraq (33.77° N, 45.15° E). The results showed that the use of PCMs can either improve or negatively affect productivity, and the method of use affects this. If the PCM is used horizontally during the day or part of the day, productivity decreases by 30.5% for horizontal application during the day and by 23% for horizontal application at night. Using PCM vertically, not immersing it in water, increases productivity by 15.6%. The productivity gained by using 1, 2, and 3 UMGs is 27.8%, 38.6% and 55%, respectively, compared with SBSS. The highest productivity was achieved with the VPCM and 3 UMGs, reaching 6975 mL/m²·day. The lowest productivity was 3125 mL/m²·day for HPCM. The highest hourly productivity was approximately 900 mL m^{-2} h^{-1} for VPCM and 3 UMGs, and the lowest was 175 mL m^{-2} h^{-1} for HPCM. The highest moisture content was recorded at 15:00, at 0.7 kg_w/kg_{da} 9 for VPCM and 3 UMGs, and the lowest at 0.27 kg_w/kg_{da} for the HPCM.

1. INTRODUCTION

Water is vital for human life, making up two-thirds of the human body and sustaining all life forms. While 70% of the Earth is covered with water, only 2.5% is fresh, and only 1% is available for human consumption [1, 2]. Growing population, industrialization, and changing consumption patterns have led to rising water demand, while contamination and overuse have diminished water resources. This has resulted in water scarcity, with regions receiving less than 100 L/day per capita, and in extreme cases, less than 50 L/day, causing health and social problems, as illustrated in Figure 1 [3-5]. Solar distillation is a simple method for converting seawater into vapor using solar energy. It involves a black basin and a sloping glass cover for evaporation and condensation. It is simple but has low productivity (5 L/m²·day) [6-8].

Numerous studies have been conducted to improve the efficiency of single-basin solar stills (SBSS) by implementing thermal and structural modifications to enhance evaporation, condensation, and freshwater production. The performance enhancement techniques can be broadly grouped into three categories: latent heat storage, vapor-generation enhancement, and hybrid multi-component systems. Phase change material (PCM) has been extensively used as a latent heat storage to maintain basin temperature and provide heat during non-sunshine hours. Sharshir et al. [9] reported that the addition of 0.5% graphite nanoparticles to a paraffin-based PCM, along with membrane-based glass cooling, led to a substantial improvement in system performance, with a 73.8% increase in freshwater productivity compared to a conventional still. Likewise, Kateshia and Lakhera [10] observed productivity gains of 24% and 30% with PCM alone and PCM combined with pin fins, respectively. On the other hand, vapor-generation enhancement techniques, such as ultrasonic mist generators (UMGs), have shown significantly greater productivity gains due to their capacity to enhance evaporation by producing fine mist. Abed et al. [11] achieved a staggering 415% increase in productivity when UMG was coupled with PCM capsules and an external solar heater, and a 39.3% improvement in thermal efficiency during short-term operation. But a decrease in efficiency with longer operating times suggests the need for better system stability and operating conditions. Similarly, Kandeal et al. [12] and Immanual and Kannan [13] reported productivity improvements of 59.1% and 61.35%, respectively, further validating the role of UMG in improving mass and heat transfer and lowering production costs. Kandeal et al. [14] proposed a holistic modification approach combining nanocomposites, glass cooling, reflectors, and UMG, resulting in a 113.72% increase in productivity and substantial improvements in energy efficiency (96%) and exergy efficiency (167.62%). Alwan et al. [15] integrated thermoelectric cooling with UMG, resulting in a 124% increase in productivity and a thermal efficiency of 95.8%. Abdelaziz et al. [16] also showed that humidification-dehumidification processes combined with UMG and controlled airflow can increase productivity by 115%. Shalaby et al. [17] demonstrated that PCM-based spiral-fin design yielded a relatively low increase in productivity of 4.54%. Moreover, recent research has investigated low-cost, environmentally friendly materials to improve performance. Sathyamurthy et al. [18] showed that using recycled soda cans filled with paraffin wax as a thermal storage medium can be effective, achieving 75.7% thermal efficiency and a 102.3% increase in productivity, demonstrating the effectiveness of low-cost design approaches. Recent studies have also explored innovative vapor management strategies. Ziauddin et al. [19] introduced a new design incorporating UMG with a dehumidification tank, resulting in a productivity of 10.2 L over 6 hours of operation. But issues with airflow and droplet distribution were noted, suggesting the need for design improvements. Similarly, Alwan et al. [20] explored a hybrid conventional solar still (CSS)-SBSS system with UMG, achieving 68% improvement in productivity and 110% enhancement in thermal efficiency at peak operating conditions, further validating the benefits of hybrid system designs.

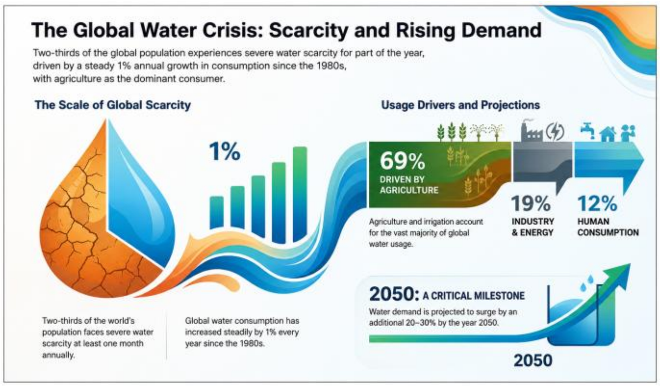


Figure 1. Global water scarcity and consumption distribution with future demand projections [3]

Although PCM and UMGs have been separately investigated as enhancement techniques for solar stills, the combined influence of PCM orientation and the number of UMGs has not been sufficiently clarified. Specifically, there has been little research on the impact of vertical and horizontal PCM layouts on the heat storage, water temperature, moisture production, and productivity when combined with intermittent ultrasonic mist production. Thus, in the present study, the performance of the modified single basin solar still integrated with PCM, which is installed at different positions with one, two, and three UMGs, is assessed in the climatic conditions at Diyala, Iraq experimentally. The aim is to separate the thermal storage effect of the PCM from the vapour generation effect of the UMGs and to determine the optimal configuration to increase freshwater productivity.

2. EXPERIMENTAL METHODS

The experimental work was conducted using both the conventional SBSS and the modified single-basin solar still (MSBSS) under the climatic conditions in Diyala, Iraq (33.7733° N, 45.1495° E). Both stills were fabricated from 1.5 mm thick galvanized steel sheets with basin dimensions of 1000 × 400 mm². The front face height was 60 mm, whereas the rear face height was 250 mm, providing a glass cover inclination angle of 25°, as shown in Figure 2. The inner surface of the still was painted matte black to enhance absorption of solar radiation. To reduce heat losses, the stills were insulated with 50 mm-thick foam insulation (density 30–34 kg/m³) and enclosed in a wooden casing. The MSBSS was integrated with a movable PCM container fabricated from aluminum measuring 960 × 180 × 25 mm. The container was filled with 1 kg of paraffin wax (RT62HC) as the PCM, as shown in Figure 3. Two positions of the PCM container were investigated: horizontal and vertical, as illustrated in Figure 4, to evaluate their effects on thermal storage and distilled water productivity. The same figure also illustrates the locations of the UMG inside the modified solar still. Three UMGs with a power of 1.5 W, powered by 5 V DC source, were installed inside the MSBSS to enhance evaporation by generating fine water droplets, as shown in Figures 3 and 4. The UMGs were arranged in a straight line parallel to the front wall of the still with a spacing of 250 mm between adjacent units. An off-grid PV solar system powered the UMGs, which consists of two 20 W PV panels. The Open-circuit voltage is 21.7 V, and the Short-circuit current is 1.23 A. The two panels are connected in parallel: two 18650 Li-ion batteries, with a total capacity of 4.4 Ah. Figure 5 illustrates the electrical wiring diagram of the UMGs, solar panel, charge controller, 12 V battery, main controller, and a mechanical timer switch to control the ON/OFF operating periods of the UMGs. Each UMG was operated intermittently using a cycle of 15 min ON followed by 60 min OFF. During the experimental day, 12 ON cycles were applied for each UMG, corresponding to a total operating duration of 180 min/day per UMG. For the three-UMG case, this is equivalent to 540 UMG-min/day. K-type thermocouples over the range of 0 to 1000 °C, with an accuracy of ±0.4 °C or less, were installed to measure temperatures at various locations in the solar still systems. In the case of the DBSS, four thermocouples were used to measure the glass cover, the water basin, and the dry- and wet-bulb temperatures of the surrounding environment, as shown in Figure 2. For the modified MSBSS, five thermocouples were used to measure the temperatures of the aluminum plate filled with PCM, the glass cover, the water basin, ambient conditions, and the dry- and wet-bulb temperatures of the surrounding environment, as shown in Figure 4. Figure 6 shows the installation of the conventional and modified SBSS systems at the experimental site. The experimental measurements were recorded using a data logger under the climatic conditions of Diyala, Iraq (33.77° N, 45.15° E).

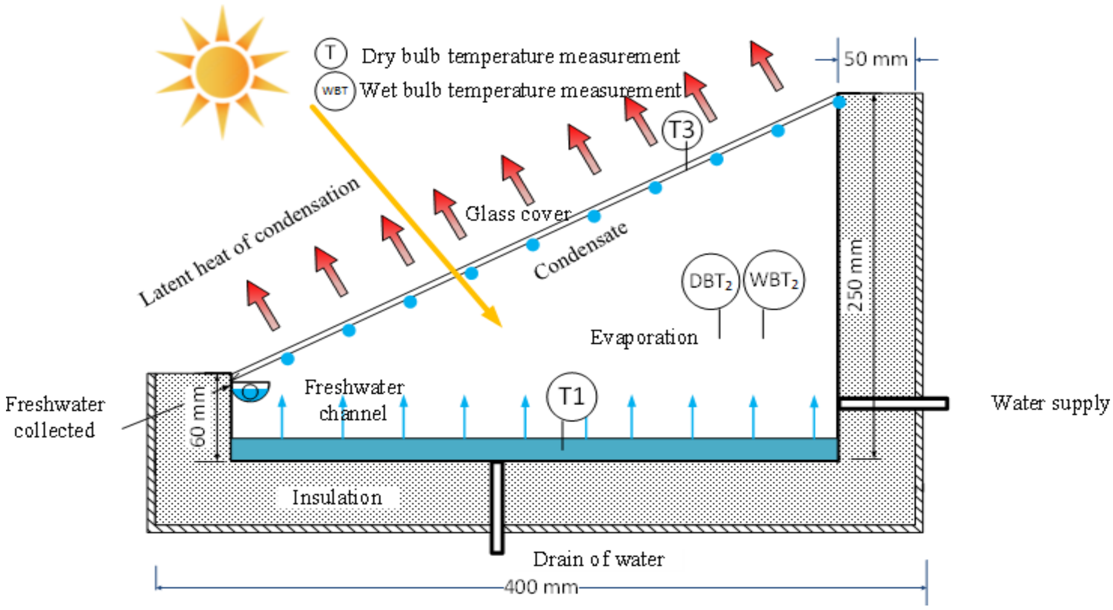


Figure 2. Schematic diagram of a single-basin solar still (SBSS)

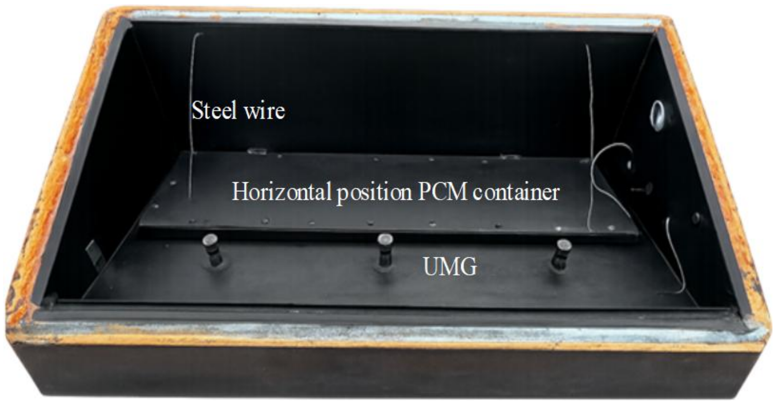


Figure 3. Installation of the phase change material (PCM) container and ultrasonic mist generator (UMG)

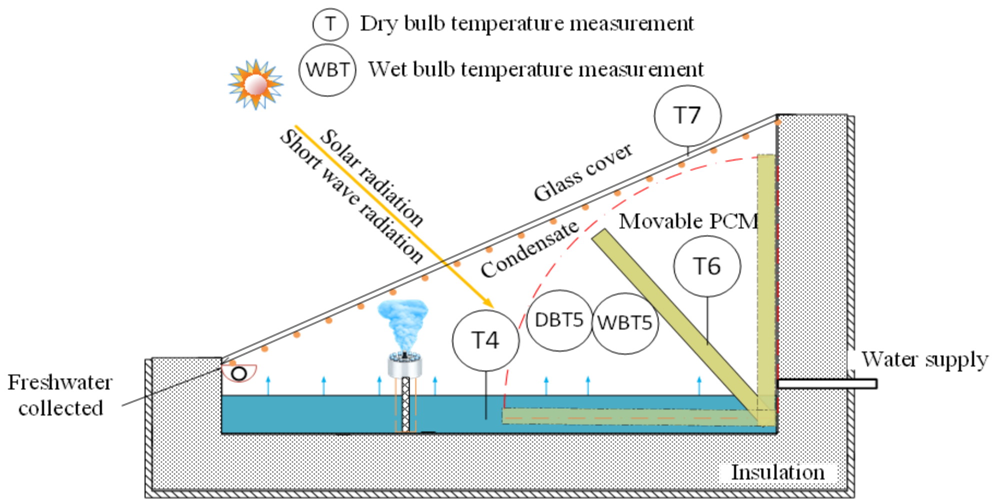


Figure 4. Side view of modified single-basin solar still (MSBSS) integrated with ultrasonic mist generators (UMGs) and phase change material (PCM)

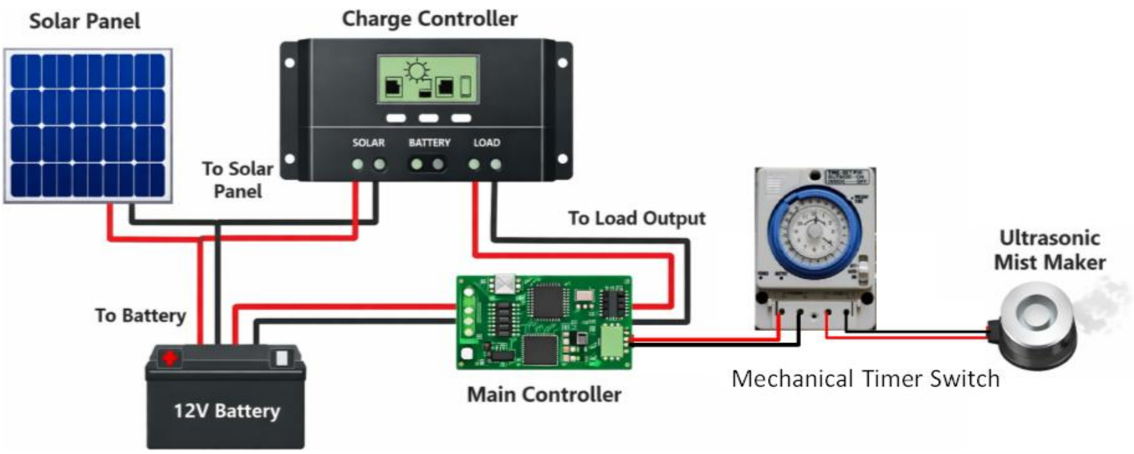


Figure 5. Wiring diagram of the ultrasonic mist generator (UMG) system used in the single-basin solar still (SBSS)

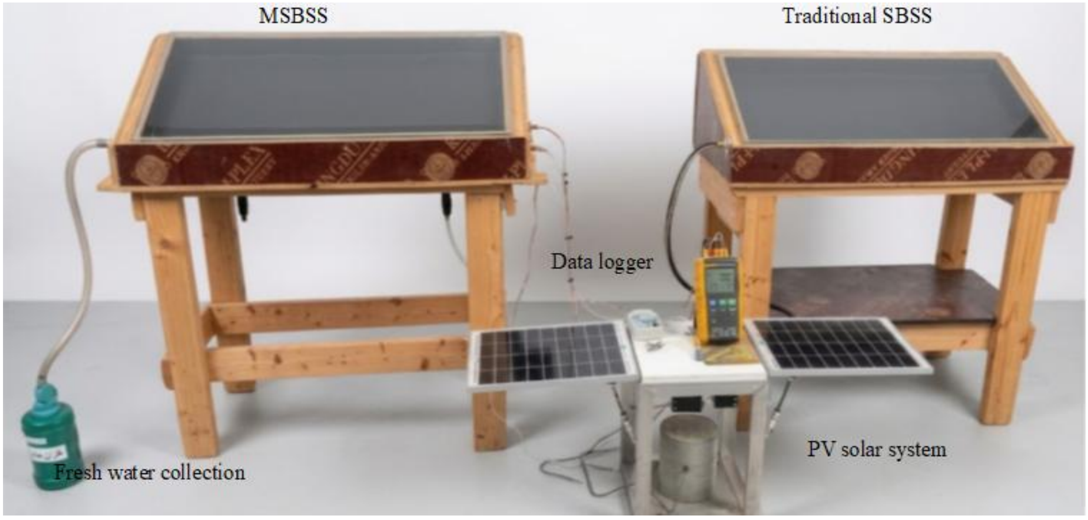


Figure 6. The installation of the modified single-basin solar stills (MSBSS) and the traditional single-basin solar stills (SBSS)

Table 1. Experimental parameters and corresponding measuring instruments

No	Measuring Parameter	Measuring Instrument	Range	Accuracy	Standard Uncertainty
1	Productivity	Beaker	0–100 mL 0–250 mL	±1 mL ±2.5 mL	0.577 mL 1.555 mL
2	Temperature	Type K thermocouples connected to a data logger	-270 to 1260 ℃	±2.2 ℃	1.1 ℃

The daily productivity of SBSS is as follows [21]:

$$m_{\text{pure}} = \sum_{24\text{h}} \text{m}_h \tag{1}$$

The latent heat of evaporation can be either extracted from the steam table at a given temperature or using the equation below:

$$\text{h}_{\text{fg}} = 2.4935 \times 10^6 (1 - 9.4779 \times 10^{-4} \text{T}_\text{w} + 1.3132 \times 10^{-7} \text{T}_{\text{w1}}^2 - 4.7974 \times 10^{-9} \text{T}_{\text{w1}}^3) \tag{2}$$

The hourly efficiency of the SBSS is:

$$\eta_h = \frac{m_h . h_{fg} \times 1000}{I . \tau\alpha . A \times 3600} \tag{3}$$

Daily efficiency of the SBSS is:

$$\eta_d = \frac{m_d . h_{fg} \times 1000}{I . \tau\alpha . A \times n . 3600} \tag{4}$$

The hourly efficiency of the MSBSS is:

$$\eta_h = \frac{m_h . h_{fg} \times 1000}{(I . \tau\alpha . A \times 3600) + (N_{UMG} . P . t . 3600)} \tag{5}$$

Daily efficiency modified still:

$$\eta_d = \frac{m_d . h_{fg} \times 1000}{I . \tau\alpha . A \times n . 3600 + (N_{UMG} . P . t \times 3600)} \tag{6}$$

where,

m_{pure}: is the hourly productivity of pure water (kg/h)
m_h: Hourly productivity (kg/h)
m_d: Daily product (kg/d)
T_{w1}: Basin water temperature (℃)
h_{fg}: Latent heat of evaporation kJ/kg

I: Solar intensity W/m^2
$\tau\alpha$: Transmissivity, absorptivity product = 0.96
n: Number of operating hours (hr)
N_{UMG}: Number of UMGs
P: Power of UMG (w)
t: Operating time of UMGs
A: Area of basin solar still (m^2)

3. MEASURING INSTRUMENTS

The experimental uncertainties are shown in Table 1, which lists the measured parameters and the instruments used.

The experimental data were processed according to the measured time-series values recorded during the test day. The hourly productivity for each case investigated was calculated by dividing the distillate collected from each time interval by the number of hours in the interval and dividing the productivity by the area of the basin. The hourly productivity values were summed to get the daily productivity. The temperature shown in the figures is the temperature recorded by the thermocouples at the time of the measurement, and the moisture content was calculated from the measured dry- and wet-bulb temperatures using EES software. Reported daily productivity values are the measured values for the experimental run performed in the given climatic condition. The plotted time-series data was not smoothed post processed.

4. RESULTS AND DISCUSSION

The field experiments were conducted in Diyala, Iraq (33.77° N, 45.15° E) on May 4, 2026. The hourly solar radiation and ambient temperature used in the analysis were obtained from Meteonorm 8 for the same experimental site and test date. Climatic data were used to represent the weather conditions on the experimental day, and the productivity and still-component temperatures were measured on site. The hourly solar radiation and ambient temperature are retrieved from the Meteonorm 8 site for Diyala, Iraq, on May 4, 2026, as shown in Figure 7.

As previously mentioned, a container containing 1 kg of PCM was used in three positions. The first position was vertical, attached to the back of the still throughout the day, and was noted as (VPCM). The second position was always submerged in water and designated (HPCM). The third position was vertical during the day, then submerged in the still after sunset, and designated (VHPCM). The thermal performance of the three positions was compared to that of a simple still.

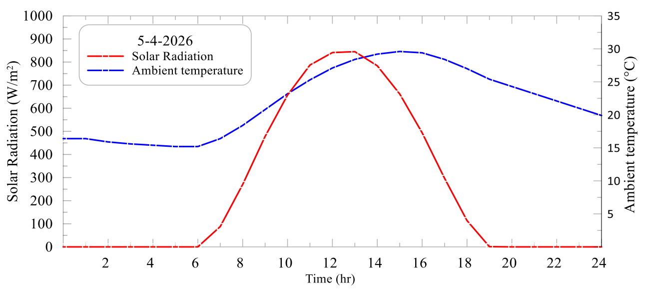


Figure 7. Solar radiation and ambient temperature

As shown in Figure 7, the hourly solar radiation and ambient temperature were obtained from Meteonorm 8 for Diyala, Iraq, on May 4, 2026.

Figure 8 shows that the lowest productivity is for the HPCM configuration. This is because the immersed PCM stores heat without raising the water temperature, significantly reducing evaporation. On the other hand, productivity continues into the night due to the stored heat in the PCM. The second scenario, VHPCM, is better than HPCM but produces less water than the simple still. Using the PCM in a vertical configuration can be beneficial, allowing for longer production periods, as illustrated in the figure. The highest hourly productivity at noon was observed for the VPCM, reaching 675 mL/m²h, while the lowest was for the HPCM at 175 mL/m²h. The moisture content shown in Figure 9 reflects the productivity at different PCM positions. The figure shows that the highest moisture content in the still space was for the VPCM, reaching approximately 0.64 kgw/kga at noon. This is due to the storage of incident solar radiation in the PCM and its subsequent release as convective heat, which aids water evaporation. The moisture content of the simple distiller was of the second order, and the lowest was for the HPCM at 0.27 kgw/kga at midday.

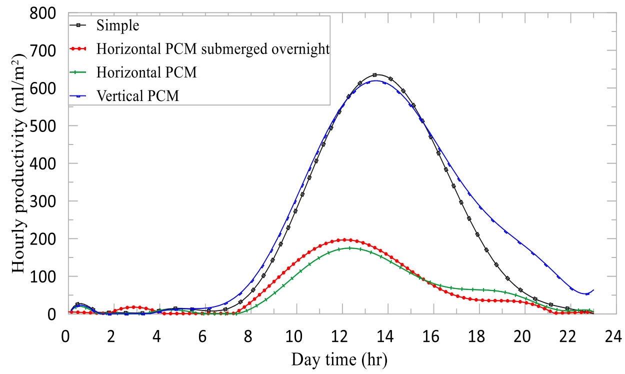


Figure 8. The variation of hourly productivity for different phase change material (PCM) container positions

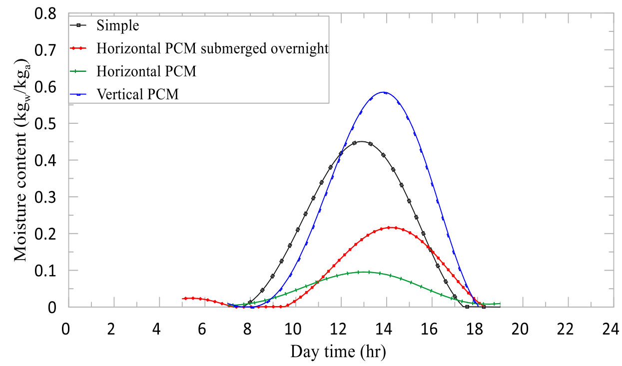


Figure 9. The variation of still space moisture content for different phase change material (PCM) container moisture content positions

Figure 10 shows the accumulated productivity of the still under different PCM container positions, as well as for the simple still. The figure shows that the VPCM achieves the maximum productivity of 5200 mL/m^2·day, an improvement of 15.6%. The minimum is 3125 mL/m^2·day for the HPCM, while the simple still productivity was 4500 mL/m^2·day.

Thermal efficiency for the various still configurations studied, both hourly and daily, are given in Figure 11. The line curves show the change in thermal efficiency throughout the day during the experiment, and the labelled bars show the resulting thermal efficiency for each configuration on the day of the experiment. The VPCM configuration recorded the highest hourly efficiency at midday, approximately 66.2%, and the highest daily efficiency of approximately 60.2%. The HPCM configuration, on the other hand, exhibited the lowest efficiency in both hourly (around 42.7%) and daily (around 50%).

From the foregoing, it can be concluded that the horizontal position of the PCM, whether immersed in the still basin all day or only at night, does not yield encouraging results. Therefore, it is excluded from future studies, and the VPCM is adopted for other studies.

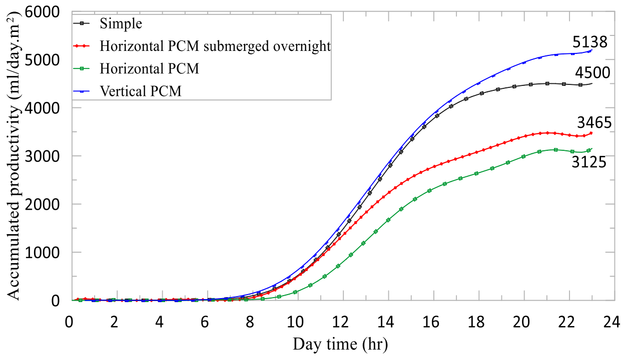


Figure 10. The accumulated productivity of different positions of the stills

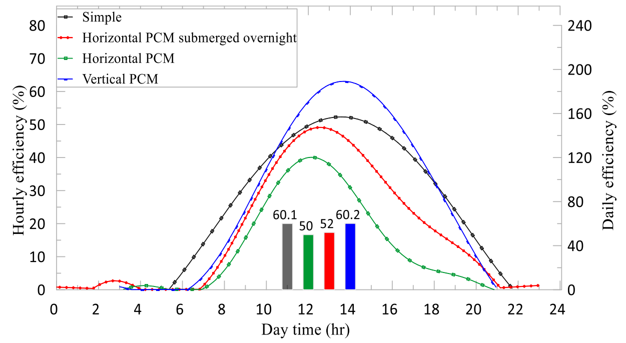


Figure 11. The hourly and daily efficiencies of the still are under different configurations

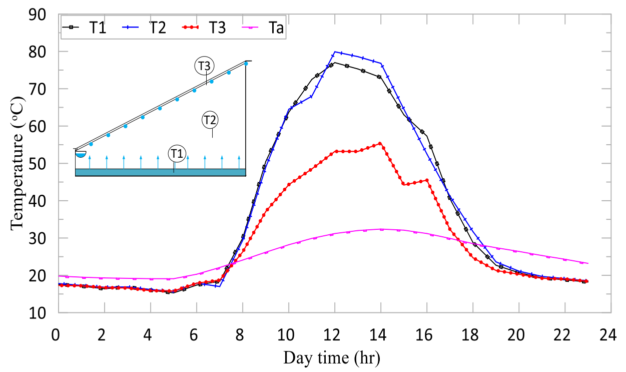


Figure 12. The temperature distribution of the single-basin solar stills (SBSS) components

To clearly identify the temperature measurement locations in Figures 12 and 13, the temperature labels T1–T7 were assigned according to the actual thermocouple positions. The labels show the temperatures at various locations such as the basin water temperature, glass cover, air–vapour space inside the still cavity, modified still container/Aluminium plate surface, and ambient dry- and wet-bulb temperatures. Thus, the plotted temperatures should be taken as indicative of the temperature measured locally by the sensors, not as indicative of the temperature of the whole medium.

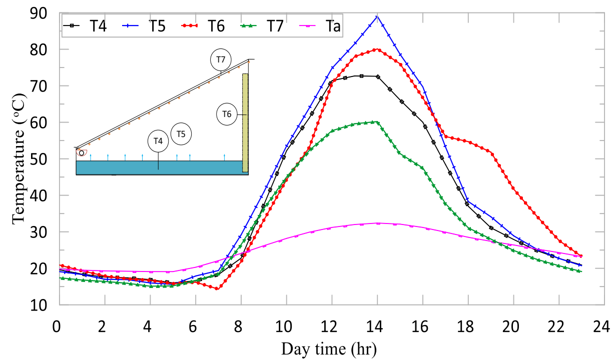


Figure 13. The temperature distribution of the modified single-basin solar still (MSBSS) components

Figure 12 shows the temperature distribution of the SBSS components based on the local sensor positions. The highest local temperature was measured by the sensor located inside the air-vapour space inside the still cavity, and the lowest temperature was measured by the sensor attached to or near the glass cover due to heat exchange with the ambient air. The water temperature in the basin followed the general trend of the internal still temperature, though it is a measure of the water temperature at the particular measurement location in the basin.

Figure 13 shows the temperature distribution of the MSBSS components based on the local sensor positions. The temperature sensor in the cavity was found to be the highest temperature sensor in the air–vapour space. The temperature of the PCM container/aluminum plate surface was measured and recorded as the PCM-related curve, which is not necessarily the same temperature as the bulk temperature of the PCM. This is an increase in temperature, which represents heat storage in the PCM container region, and could relate to the thermal response of the PCM when heated. There is no obvious constant-temperature plateau in Figure 13, however, so the phase-change interpretation is made tentatively, rather than as a certain melting interval. The water temperature in the basin and the glass-cover temperature are as expected based on where they are measured in the basin and how they exchange heat with the environment.

The second improvement to the SBSS was the use of UMGs alongside the VPCM. A maximum of three UMGs were used, and experiments were conducted using the VPCM with one, two, or three UMGs. The operation of the steam generators was controlled by a mechanical timer switch that operated them for 15 minutes, followed by 1 h off.

Figure 14 shows the hourly productivity of the stills under study. It can be observed that using UMGs improves hourly productivity. Using a single UMG operating for 15 minutes with an hourly shut-off increases maximum productivity compared to a simple distiller or a VPCM still, while using three UMGs results in a maximum hourly productivity exceeding 900 mL/m^2, decreasing to 800 mL/m^2 with two UMGs, and to approximately 700 mL/m^2 with a single UMG. This contrasts with the simple distiller, whose maximum hourly productivity is around 600 mL/m^2.

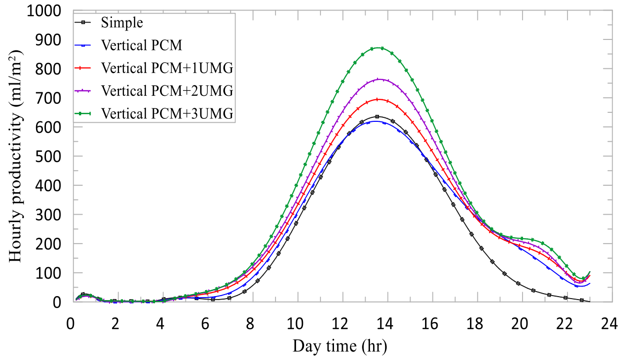


Figure 14. Variation in hourly productivity for the vertical phase change material (VPCM) configuration integrated with ultrasonic mist generators (UMGs)

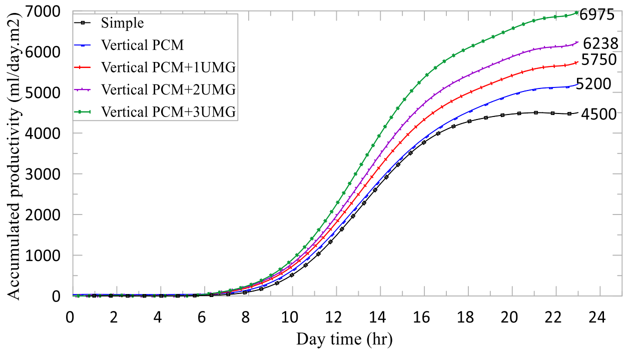


Figure 15. The accumulated productivity of different numbers of ultrasonic mist generators (UMGs) used

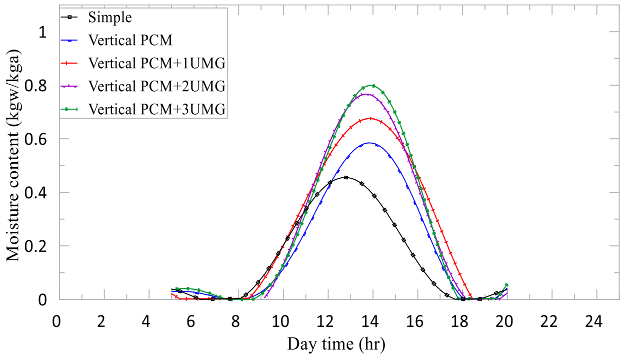
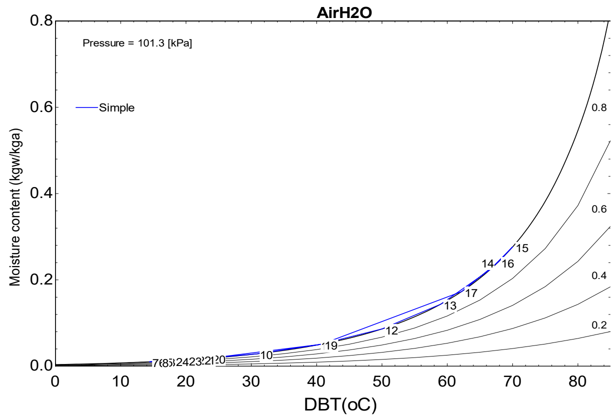


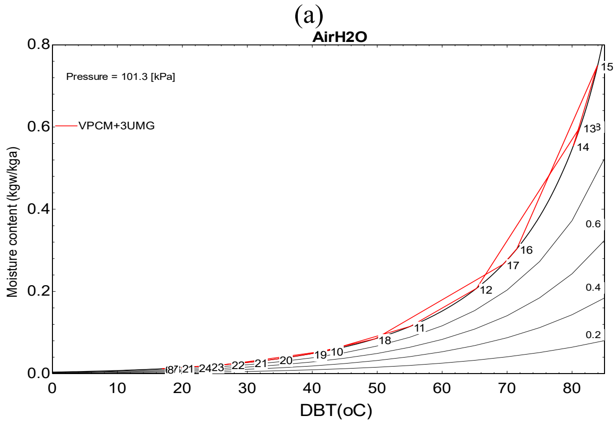
Figure 16. The effect of the number of ultrasonic mist generators (UMGs) on the still space moisture content

The cumulative productivity of the distillers is shown in Figure 15. The VPCM case achieved a daily productivity of 5200 mL/m²·day, corresponding to an improvement of approximately 15.6% compared with the SBSS. Incorporation of one UMG into the VPCM case led to an improvement in the productivity to 5750 mL/m^2·day, which is around 27.8%. When two and three UMGs were employed, the productivity further increased to 6238 and 6975 mL/m^2·day, representing 38.6% and 55% improvement, respectively, compared to the SBSS. Using generators 1, 2, and 3 increases productivity by 27.8%, 38.6%, and 55%, respectively.

Figure 16 shows that using 1, 2, and 3 UMGs increased the moisture content in the still space to 0.618, 0.76, and 0.79 kg_w/kg_{da}, respectively. These values correspond to increases of 25.3%, 54.2%, and 60.0% compared with the simple still.



(a)



(b)

Figure 17. Psychrometric process for (a) the single-basin solar still (SBSS) and (b) the vertical phase change material integrated with three ultrasonic mist generators (VPCM+3UMG).

Note: VPCM = Vertical Phase Change Material; UMG = Ultrasonic Mist Generator.

By measuring the dry and wet temperatures of the air-vapour mixture in the still space, and using the Engineering Equation Solver (EES) software, the moisture content of the air inside the still was calculated and plotted on a psychrometric chart. Figure 17(a) shows the air-moistening process inside the single-basin solar still (SBSS), whereas Figure 17(b) shows the corresponding process for the vertical phase change material integrated with three ultrasonic mist generators (VPCM+3UMG). In both figures, it can be observed that the air inside the still has the lowest humidity at the beginning and end of the day, due to the inability to generate steam. During the day, vapour generation is observed due to solar radiation received by both stills and by the UMGs in the enhanced still. As solar radiation increases, vapour generation peaks around 15 hr, not at noon, due to thermal storage of water on the one hand and the PCM and UMGs in the enhanced still on the other. The accumulation of steam at noon reflects the glass's reduced ability to condense large amounts of steam. This provides insights for future studies investigating improvements to the condensation process during midday. After 15 hr, the moisture content of the air gradually decreases, reaching its lowest the following morning due to the condensation of all water vapour in the distiller, and there is nothing to stimulate evaporation during that period.

Some points in Figure 17(a) and Figure 17(b) appear close to or slightly beyond the saturation line. These points are not taken as a definitive arrival at a psychrometric condition but are viewed with caution as possible measurement uncertainty at saturation conditions. Uncertainty in the measurement of the wet-bulb temperature, local condensation on the wick of the wet-bulb, or small deviations during moisture content calculation from the measured dry-bulb and wet-bulb temperature can be responsible for this behaviour.

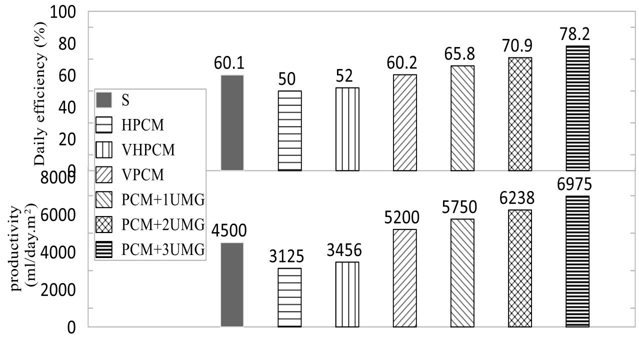


Figure 18. The summary of the results of the stills under study

Table 2. Summary of daily productivity, daily efficiency, and percentage change for the investigated configurations

Configuration	Daily Productivity (mL/m²·day)	Daily Efficiency (%)	Change Relative to SBSS (%)
SBSS	4500	60.1	0
HPCM	3125	50.0	-30.5
VHPCM	3456	52.0	-23.0
VPCM	5200	60.2	+15.6
VPCM+1UMG	5750	65.8	+27.8
VPCM+2UMGs	6238	70.9	+38.6
VPCM+3UMGs	6975	78.2	+55

Note: SBSS = Single-Basin Solar Still; HPCM = Horizontal Phase Change Material; VHPCM = Vertical-Horizontal Phase Change Material; VPCM = Vertical Phase Change Material; UMG = Ultrasonic Mist Generator.

Figure 18 summarizes the final results for daily productivity, daily efficiency, and the change in distillate production resulting from the different modifications. The individual contributions of the VPCM and UMGs can be distinguished from the results. The VPCM alone increased the daily productivity by approximately 15.6% in comparison with the SBSS, mainly due to its role in improving heat-storage behavior and extending evaporation during the later operating hours. The greater productivity achieved with the addition of the UMGs, on the other hand, is primarily due to the direct increase in moisture content inside the still cavity and short-term evaporation intensity inside the still cavity. Hence, the primary contribution of the PCM was towards the thermal storage and extended evaporation while the primary contribution of the UMGs was towards the increased production of vapour and moisture accumulation. The figure shows that the HPCM and VHPCM experienced decreases in productivity of 30.5% and 23%, respectively, due to the negative effect of the PCM thermal storage on water temperature and, consequently, steam generation. In both cases, this is due to the PCM's immersion in water. Using the VPCM, the improvement is approximately 15.6%. Using generators 1, 2, and 3 increases productivity by 27.8%, 38.6%, and 55%, respectively, compared with the SBSS.

To ensure consistency among the text, Figures 15 and 18, abstract, and conclusion, the verified daily productivity, daily efficiency, and percentage change values are summarized in Table 2.

5. CONCLUSION

Based on the results of the studied cases, the following can be concluded:

1. The use of PCMs can either improve or negatively affect productivity, and the method of use affects this.

•If the PCM is used horizontally during the day or part of the day, productivity decreases by 30.5% for horizontal application during the day and by 23% for horizontal application at night.

•Using PCM vertically, not immersing it in water, increases productivity by 15.6%.

2. Using UMGs with the vertical PCM improves productivity by 27.8%, 38.6%, and 55% when using 1, 2, and 3 UMGs, respectively, compared with the SBSS.

3. The highest productivity was achieved with the VPCM and 3 UMGs, reaching 6975 mL/m²·day. The lowest productivity of 3125 mL/m²·day for HPCM.

4. The highest hourly productivity was approximately 900 mL/m² for VPCM and 3 UMGs, and the lowest was 175 mL/m²h for HPCM.

The highest moisture content was recorded at 15:00, at 0.79 kg_w/kg_{da} for VPCM and 3 UMGs, and the lowest at 0.27 kg_w/kg_{da} for the HPCM.

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NOMENCLATURE

m_h	Hourly productivity, kg
m_d	Daily productivity, kg
h_{fg}	Latent heat of vaporization, J/kg
T_w	Basin water temperature, °C
η_h	Hourly thermal efficiency, %
η_d	Daily thermal efficiency, %
I	Global horizontal irradiation, W/m²
τα	Transmittance–absorptance product
A	Area of basin solar still, m²

Abbreviations

SBSS	Single-Slope Solar Still
MSBSS	Modified single-basin solar still
PCM	Phase Change Material
UMG	Ultrasonic Mist Generation
DBT	Dry Bulb Temperature
WBT	Wet Bulb Temperature