Int. J. Renew. Energy Dev. 2023, 12 (6), 1123-1130

Contents list available at IJRED website

International Journal of Renewable Energy Development

Journal homepage: https://ijred.undip.ac.id

Research Article

Experimental investigation on the performance of a pyramid solar still for varying water depth, contaminated water temperature, and addition of circular fins

Mayilsamy Yuvaperiyasamy[a], Natarajan Senthilkumar[a*], Balakrishnan Deepanraj[b]

[a]*Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences, Chennai, Tamil Nadu, India - 602105*

[b]*Department of Mechanical Engineering, College of Engineering, Prince Mohammad Bin Fahd University, Al Khobar, 31952, Saudi Arabia*

Abstract. The experimental investigation was meant to investigate the effect of water depth in the basin, the water temperature at the inlet of solar still, and adding circular fins to the pyramid solar still on freshwater output. The investigation was divided into three sections. The first area of research is to study effect of increasing water depth in the solar still, which ranged from 2 to 6 cm, second section concentrated on varying the inflow water temperature from 30 to 50°C, and third section investigated the influence of incorporating circular fins into the solar still basin on the water output and quality. The experimental findings showed that basin depth considerably impacts freshwater flow. The highest significant difference, 38%, was recorded by changing the water level in the basin from 2 to 6 cm. Freshwater yielded the most at a depth of 2 cm, totalling 1250.3 mL, followed by 1046 mL at a depth of 3 cm. A water depth of 4 cm produced 999 mL, whereas a water depth of 5 cm made 911 mL. The lowest production occurred at a water depth of 6 cm, producing 732 mL; furthermore, including fins at the bottom increased productivity by 8.2%. Elevating the temperature from 30 to 50°C of the inlet water led to a water output increase of 15.3% to 22.2%. These findings underscore the profound potential of harnessing solar energy to address global water challenges and pave the way for further advancements in efficient freshwater production.

Keywords: Solar still, Desalination, Water purification, Solar energy, Circular fins, Pyramid solar still

Received: 11th August 2023; Revised: 8t Oct 2023; Accepted: 21st Oct 2023; Available online: 26th Oct 2023

1. Introduction

Clean, and safe drinking water must be readily available for any population to survive. Freshwater makes up around 2.5% of the water on earth, whereas salt water makes up the rest, about 97.5%. Approximately 80% of the freshwater on earth is held in soil moisture and ice caps. The amount of freshwater on Earth that can support life is about 0.5% (El-Dessouky & Ettouney, 2002). The unequal distribution of freshwater globally has left communities most in need with insufficient access to this vital resource. As such, the freshwater shortage has become a worldwide problem in the current context. Therefore, creating techniques to turn saltwater into potable water is essential, especially in remote and dry regions. Solar desalination is a promising technology that can use copious solar energy. This method relies heavily on the solar still, an ingenious apparatus that speeds desalination. Furthermore, solar thermal energy may heat water efficiently, improving the efficiency of power plants (Ahmadi *et al.*, 2017). Additional enhancements such as wicks, sponges, and fins were incorporated into a conventional solar basin to enhance its performance. The adjustments improved yield by 9.6, 15.3, and 45.5% (Velmurugan *et al.*, 2008). Unlike regular, pyramid solar stills with curved wick surfaces showed better production and 33.3% more efficiency (Kabeel, 2009). A study by Tanaka and Nakatake (2009) found that incorporating a vertical plate absorber into spinning solar still results in a 57% increase in energy production compared to conventional solar stills. Wick material was tested by Murugavel and Srithar (2011) on absorber plates for solar stills that had differently oriented rectangular fins. Black cotton fabric is the best wick, according to research. Adding a water heater to the absorber shield and cooling the glass with an external fan increased solar still efficiency. The new method was 370% more prolific than other solar stills (Al-Garni, 2012). Different packing materials, like sand, coal, coconut coir, and wooden chips, were used in experiments with stepped solar stills. These tests were done using both experimental and numerical methods. The research showed that solar stills with 2 cm of water depth and coconut coir stuffing produced more yield than other setups (Alaudeen *et al.*, 2014). Also, Gnanadason *et al.* (2015) showed that adding rocks, fins, vacuum pumps, and other changes to solar stills made them more productive and found that solar stills with vacuum fans were more effective than other solar stills. To enhance the output of solar still, Sathyamurthy *et al.* (2015) examined the application of a shield and a semicircular trough absorber. Using a barrier resulted in a 16.6% increase in output from the semicircular trough absorber over conventional stills. In the absorber plate of the solar still, Hansen *et al.* (2015) looked at various wick materials and wire silhouettes. They discovered that stepped wire mesh absorbers were 48.9% more productive than flat absorbers and 72% more effective than flat

* Corresponding author
Email: nskmfg@gmail.com (N. Senthilkumar)

https://doi.org/10.14710/ijred.2023.57327
ISSN: 2252-4940/© 2023.The Author(s). Published by CBIORE

and stepped absorbers. They used a two-layer reflector and wick in a bent absorber solar still. The solar still with the bent absorber made 145.5% more than regular stills that used wick material (Omara *et al.*, 2016). Also, the study by Panchal and Sathyamurthy (2020) had shown that certain wick materials and a pin-finned absorber base can improve solar stills. This study examines a single-basin solar efficacy by comparing its productivity with and without incorporating a porous fin. The study found that adding a porous fin to the pin-finned wick solar system resulted in a 24% increase in output. In addition, adding a porous fin led to a 42.3% rise in solar energy production compared to the standard design. In an earlier work by Haddad *et al.* (2017), a vertically moving wick was used to improve traditional solar stills. The goal of this change was to speed up the cooling process and, as a result, make it still produce more distillate water. The research says that a solar still with a wick that rotates vertically is 46% more proficient than a regular solar still. Nagarajan *et al.* (2017) used theory and experimentation to add barriers to traditional solar stills. The study indicated that solar stills with baffles produced 1.68 times more modified solar still (MSS). A separate experiment examined V-type solar still performance with various fibers. A half-covered wick resulted in an 8.2% increase in production (Suneesh *et al.*, 2017). Several wick materials were tested by Munisamy *et al.* (2017) to increase solar still output; fur material produced 40.8% more productivity than rayon, terry, and jute by 40.8%. Polyester production increased by 26.37%, while terry and jute cloth increased by 6.2%. Pal *et al.* (2018) examined the advantages of double-slope solar in terms of both the environment and economy, emphasizing the design of its specially tailored multi-wick basin. This study examines solar energy's economic and environmental implications, providing important details about its efficiency and longevity. Modi and Modi (2019) suggested that using a jute pile, black cotton fabric, two bowls, and a single slope would still be more effective. It was found that using a jute cloth pile instead of a black cotton fabric pile led to a 15.2% higher distilled yield. Omara *et al.* (2015) investigated the utilization of nanofluid, curved wicks, internal mirrors, and external condensers in solar still systems. The study demonstrated that using curved stems and aluminium oxide nanoparticles in solar stills resulted in a substantial output enhancement. Specifically, the improvement was 255% compared to conventional stills. Evaluated a solar system with a single basin and a double-slope, single-basin solar system with distinct fins. The square concave fin produced 43.86% less energy than the circular open-fin solar still. The highest yield was recorded at a water depth of 10 mm (Jani & Modi, 2019). The research focused on an internally and externally enhanced two-sloped solar distillation system. According to test results, the upgraded solar produced an incredible 171.43% more energy than the standard solar (Gnanaraj & Velmurugan, 2019). It was determined how well a MSS using cotton sacks filled with sand and a circular solar still (CSS) worked at optimum water depth. The findings showed that MSS outperformed CSS (Dumka *et al.*, 2019). A solar still with a single basin and a double slope was used in research by Murugavel *et al.* (2010) to store energy. Iron bits, pieces of cement concrete, washed stones, red brick, and quartzite rock were all put together. The study results show that using 3/4" quartzite rock significantly increased output compared to other materials used for energy storage. According to research by Ismail (2009), the daily usefulness of the solar system went down as the water level in the pond rose. This study was mainly about a hemispherical solar still that worked in various salt conditions. It was found that the conical solar still produced 75.13% more each day than the standard solar still in a comparison study (Gad *et al.*, 2015). According to comparative research, the triple basin square pyramid solar still design generates higher yields than the single and double basin versions (Hamdan *et al.*, 1999). The pyramid-shaped system used by the normal solar system was nevertheless modeled after the Great Pyramid of Giza. The daily output averages for both types of solar stills were similar throughout the year (Fath *et al.*, 2003). Kabeel and Abdelgaied (2020) looked at what would happen to the production rate of pyramid solar devices if copper absorber plates were switched out for graphite absorber plates. The researchers enhanced water vapor generation by reducing the upper glass cover temperature by applying a water layer. Effectiveness-wise, according to the study, the modified square pyramid solar still (MSS) was superior to the standard square pyramid solar still. The production of distilled water rose by 20% when paraffin wax was used as a phase change material (PCM) in a pyramid-shaped still (Sathyamurthy *et al.*, 2014).

Existing literature and prior research highlight that only a few experimentations have explored the impact of varying inlet-contaminated water temperature on the productivity of the pyramid solar still. Most literature focuses on enhancing the solar still design by incorporating fins and insulation materials. This research aims to optimize solar still performance through experimentation and design improvements. This investigation is divided into three parts. The water depth is varied from 2 to 6 cm in the first part to find the optimal depth. The second part of the investigation is the impact of different water inlet temperatures from 30 to 50°C on pyramid solar still yield. The third part concentrates on solar still productivity by adding circular fins at the absorber basin liner.

2. Experimental setup and procedure

This study emphasizes on comparing the production output and quality of potable water obtained from the conventional pyramid solar still and the modified pyramid solar still. The proposed model of pyramid solar still consists of circular fins attached in the absorber basin liner and an external heater for preheating the inlet water and difference in water depth.

2.1 Conventional pyramid solar still

Figure 1 illustrates the schematic view of the conventional solar still. This pyramid solar still has three layers of insulation made of glass covers sandwiched between an interior structure made of galvanized iron sheet and an exterior layer made of galvanized iron sheet (Diabil, 2022). The depth of the glass plate is 7 mm, the height is 30 cm, the width is 65 cm and the slope angle is 35°. The solar base still has an area of 0.38 m^2 and a 35 cm height, with a wall thickness of 1.3 mm, including the galvanized iron sheet. The outer surface area is 0.50 m^2, with a height of 35 cm, and is insulated by a polyethylene layer 6 cm thick.

2.2 Proposed Experimental Setup

2.2.1 Pyramid solar still with varying water depth

The productivity of the solar still is mostly affected by the water depth. Since solar still runs only on solar radiation and requires no additional energy source, its output highly depends on the water depth. The investigation focuses on the effects of different water depths (2–6 cm) on the productivity of solar stills. Based on the experimental findings, it is necessary to establish an optimal water depth for future investigations.

2.2.2 Pyramid solar still with varying water inlet temperature

Changing the water intake temperature may affect the solar desalination system's overall performance and efficiency. Productivity may rise due to warmer water at the intake, as it takes less energy to attain the appropriate evaporation

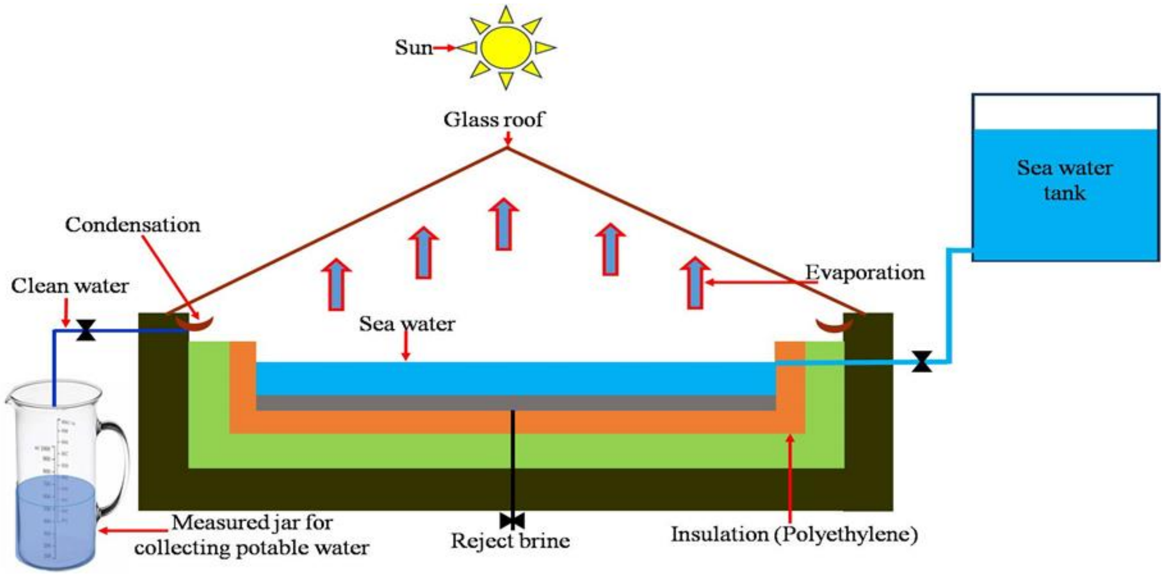

Fig 1 schematic illustration of a traditional pyramid solar still

temperature (Le *et al*. 2021). To raise the productivity of the pyramid solar still, the water intake temperature is adjusted between 30 and 50°C. The external heater heats the inlet water before entering the solar desalination system as shown in Figure 2.

2.2.3 Pyramid solar still with circular fins

Fins are add-ons that may be used to enhance the solar still's surface area. As the water's surface expands, more heat can be transferred to it, causing it to gradually heat up (Aktaş *et al*. 2019). A mild steel circular pipe with 0.04 m diameter and 0.08 m height is incorporated in the absorber basin. Six fins were considered for this experiment. The percentage of space occupied in the pyramid solar still absorber basin was used to calculate the number of fins in the absorber basin. These fins are an essential part of the design to shorten the preheating period before the salty water from the basin evaporates (Yuvaperiyasamy *et al*. 2023). Figure 2 shows the proposed solar still having circular fins and an external heater.

2.3 Experimental Procedure

Before starting the desalination of sea water process at the base, sanitation is an essential step. The water in the ground evaporates as the temperature increases and then condenses on the glass cover. The glass lid contains a container at its base holding condensed water. A digital thermal instrument with an accuracy of +/- 1 degree Celsius is used to monitor the temperatures of the glass and water throughout the experiment to retain reliable data. In addition, a solarimeter that measures solar radiation intensity with an accuracy of +/-1 W/m^2 is used. A digital vane anemometer with an accuracy of +/-0.1 m/s measures wind velocity. The distillate production is determined with a 2-liter container and a 5-milliliter measurement precision (Gad *et al*., 2015). The experiment was conducted in Pongalur, Tamil Nadu, India (10.9729°N, 77.3698°E) from May 15 to 19, 2023. Wind velocity, solar radiation, and basin plate temperature are measured hourly, along with the water temperature to be treated, distilled water, and glass cover.

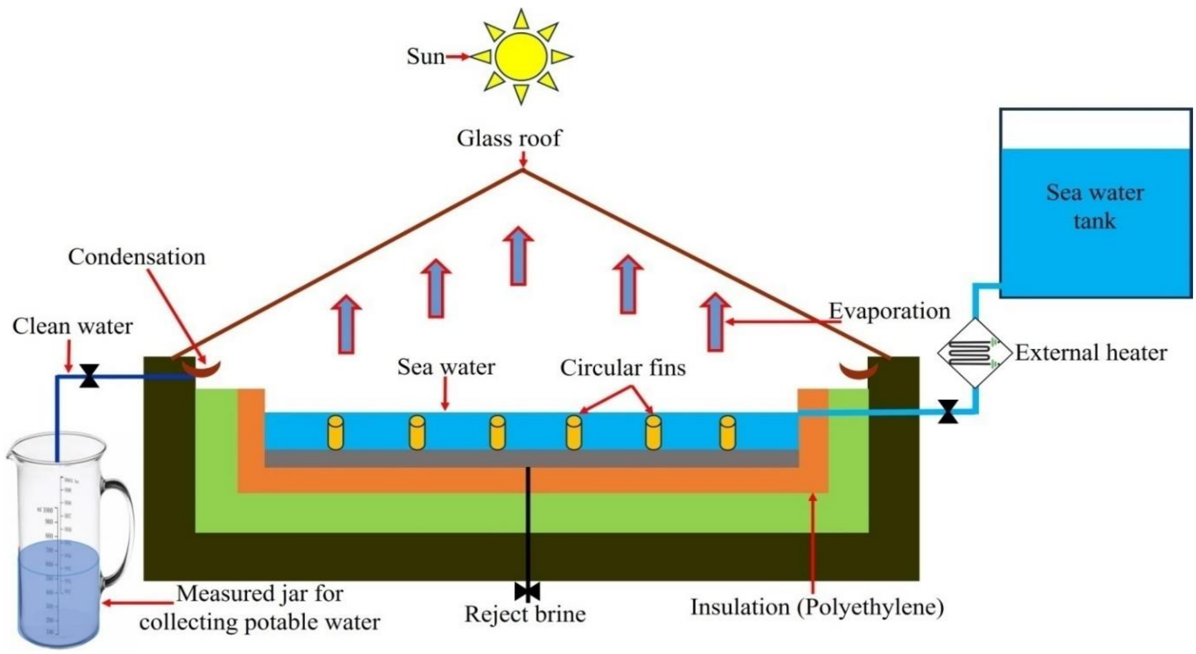

Fig 2 Schematic illustration of the proposed system with circular fin, and external heater

Hourly outputs are determined for both the conventional solar still and the newly constructed pyramid solar still.

3. Result and Discussion

3.1 Solar radiation, water and ambient temperature variations

The experiment is conducted over five days, from May 15 to May 19, 2023, and the hourly variations in solar radiation during these days are measured. The graph demonstrates the hourly fluctuations in solar radiation over these five days.

A consistent pattern in solar radiation is observed across all five days. The highest solar radiation values are recorded around midday, between 13:00 and 14:00 hrs, with readings of 963, 980, 983, 992, and 979 W/m² for each respective day. Based on the solar radiation readings obtained over these five days, we can confirm the consistent efficiency of the system throughout this period. As depicted in Figure 3, solar radiation peaks around midday, between 13:00 and 14:00 hrs, gradually diminishing to its minimum value by 18:00 hrs. The sun is directly above the earth at noon, and solar radiation peaks at that time, which causes sunlight to go through the atmosphere at a shorter route and a perpendicular angle to the earth's surface, reducing absorption and scattering. Because of the sun's lowered angle in the evening, there is less solar radiation intensity because of a shallower angle of incidence and a longer atmospheric path (Sathyamurthy *et al.*, 2015).

Figure 4 displays the experimental results indicating the hourly ambient temperature variations over the five days. The highest temperatures are recorded between 15:00 and 16:00 hrs, with a gradual decrease in temperature during the late afternoon hours. Higher temperatures intensify evaporation by imparting additional thermal energy to water, accelerating the transition of liquid-to-vapor. This increase in vapour production increases the overall production of freshwater. In contrast, lower temperatures cause the vapour to give up its thermal energy and return to liquid form during condensation (Yarramsetty *et al.* 2023). Condensation is facilitated by cooler conditions, maximizing freshwater yield. In a solar still system, optimal temperature regulation is required to balance evaporation and condensation to produce more purified water. The earth's daily heating and cooling cycle, caused by the presence and absence of sunlight, is responsible for the hourly temperature variation. The sun's heat during the day yields an increase in temperatures on earth, reaching their highest point in the afternoon. At night, when there is no direct sunlight, the earth undergoes a cooling process, decreasing temperatures.

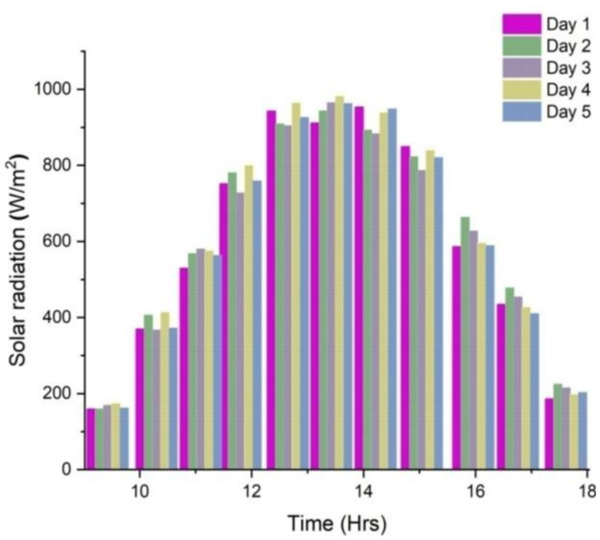

Fig 3 Solar radiation variations with time

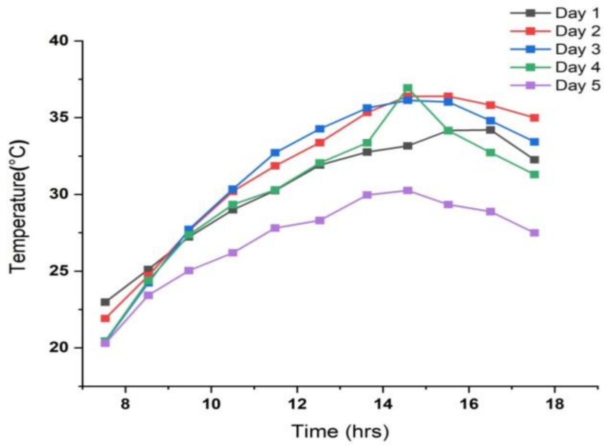

Fig 4 Hourly fluctuations in ambient temperature

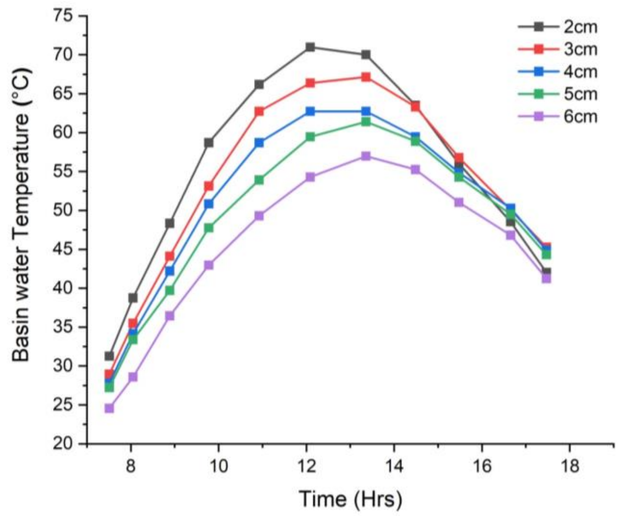

Fig 5 Variation of basin water temperature on an hourly basis

This cooling trend usually reaches its minimum point in the early morning hours (Hansen *et al.*, 2015).

Figure 5 depicts the variation in water temperature across different depths (ranging from 2 cm to 6 cm) within the basin. The water temperature reaches its maximum of 75.4°C at around 13:00 hrs for a water depth of 2 cm. It then gradually decreases to 43.7°C by 18:00 hrs. The water temperature at a depth of 3 cm reaches 69.3°C around 14:00 hrs. Then it drops to 39.2°C by 18:00 hrs. This observation reveals that elevating the depth from 2 cm to 3 cm results in an 8% reduction in maximum temperature during the morning, with a subsequent 1% reduction by the evening. This aspect can be qualified for the thermal storage capacity of the water basin. At 14:00 hrs, the water temperature measures approximately 58°C for the 6 cm depth, decreasing to around 38°C at 18.00 hrs. Because of the reduced thermal mass, a shallower depth causes heating to occur more quickly, raising the temperature during the sun's strongest hours (Larik *et al.* 2019). Conversely, a deeper depth has a larger thermal mass, resulting in lower daytime temperatures and slower heating. The pattern of hourly fluctuations is as follows: during the day, temperature changes occur more quickly at shallower depths. This variation is attributed to the greater thermal inertia of the water basin, as previously reported in existing research (Omara *et al.*, 2016).

3.2 Effect of solar still performance due to change in water depth

The hourly output fluctuation of a pyramid-shaped solar still at different depths, from 2 to 6 cm, with intervals of 1 cm, is shown in Figure 6. The variations in water output resulting from changes in depth in the solar still are recorded as follows: The weights per unit area for different depths are 1.24 kg (3.42 kg/m²) for 2 cm, 1.03 kg (2.89 kg/m²) for 3 cm, 1.02 kg (2.76 kg/m²) for 4 cm, 1.00 kg (2.6 kg/m²) for 5 cm, and 0.74 kg (2.02 kg/m²) for 6 cm. The findings show that around 13:00 hrs, at a depth of 2 cm, the highest freshwater output of 232 mL occurs. In contrast, the highest freshwater yield occurs at 15:00 hrs, with a volume of 124 mL, recorded at a water depth of 6 cm.

Figure 7 shows the total freshwater output of the recommended system at different water depths. At a water depth of 2 cm, the largest yield of 1250.3 mL is achieved, followed by 1046 mL at a depth of 3 cm. At 4 cm depth, the production equals 999 mL, and at 5 cm depth, the production is 911 mL. The lowest output occurs at a water depth of 6 cm, yielding 732 mL. Figure 7 provides further evidence for the water production rates of 70.4% at 2 cm, 43.1% at 3 cm, and 37.6% at 4 cm of water depth. At 5 and 6 cm of water depth, the production rates are 20.23% and 23.5%, respectively. A deeper water depth leads to a thicker water layer, which decreases the amount of sunlight reaching the surface, reducing heat absorption and decelerating evaporation.

Moreover, an increased volume of water necessitates more energy to achieve the boiling temperature, thereby extending the duration required for evaporation to transpire. The greater depth increases heat transfer resistance, which hampers evaporation efficiency (Issaq *et al.* 2023). Therefore, these factors result in a decline in evaporation rates and subsequently reduce the overall freshwater yield from the solar still. The heat accumulated during midday contributes to the highest freshwater production during sunset, particularly at lower water depths (Toghraie *et al.*, 2018; Du *et al.*, 2023).

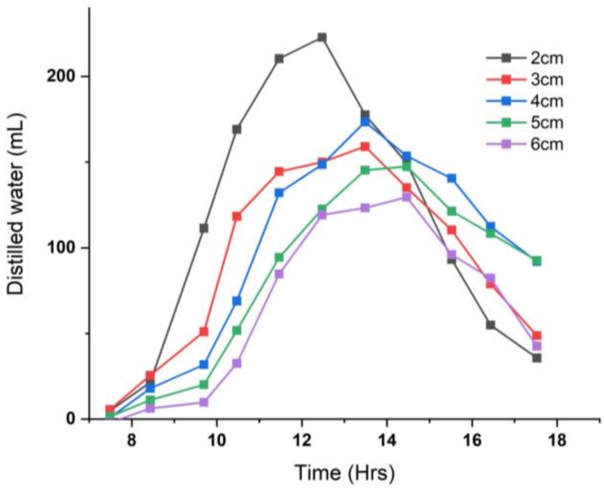

Fig 6 Impact of water depth on the productivity of distilled water

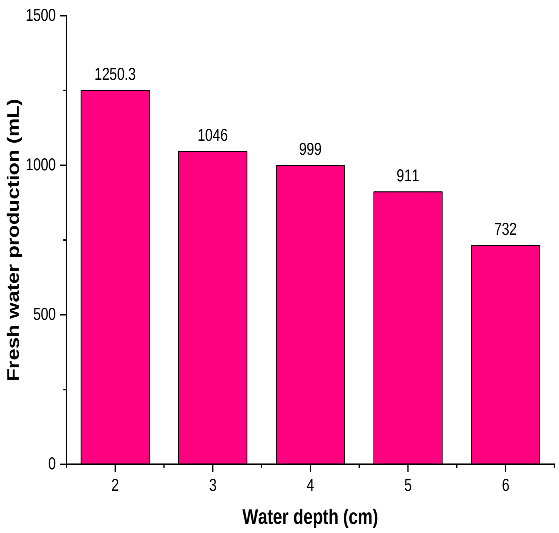

Fig 7 Variation of water depth on cumulative fresh water production

3.3 Effect due to variation in the water inlet temperature

The result of the input water temperature variation from 30 to 50°C is exposed in Figure 8, which demonstrates that the productivity of the still increases as the inlet temperature rises up to 14.00 hrs after which the water production remains the same for some period of time. The water heat volume increases with the inlet's temperature rate. Hence, the yield is improved with the increase in the temperature at the inlet. After 14:00 hrs, the water output reached the same efficiency regardless of the water inlet temperatures. The entering water's temperature significantly impacts the distilled water produced in solar still. Raising the temperature at which water is introduced increases evaporation by increasing the water's thermal energy. The increased energy promotes a faster conversion of liquid to vapour, leading to greater evaporation and freshwater production (AlRubaiea *et al.* 2021).

In contrast, lower water temperatures decrease the evaporation rate, necessitating additional time and energy to achieve the boiling point and initiate efficient evaporation. Consequently, there is a decline in the overall rate of freshwater production. Precise temperature regulation and control of the incoming water is paramount to optimize the efficacy and output of freshwater within a solar still system. The solar still operates more efficiently due to the elevated temperature of the contaminated water (He *et al.*, 2023).

3.4 Effects of Circular fins

Fins on absorber plates are positioned at the foot of the basin to enhance solar radiation absorption in the solar still. The experiment shows that preheating the basin takes less time, which boosts output. Including fins at the bottom increases production by 8.2%, as seen in Figure 9. Fins improve heat

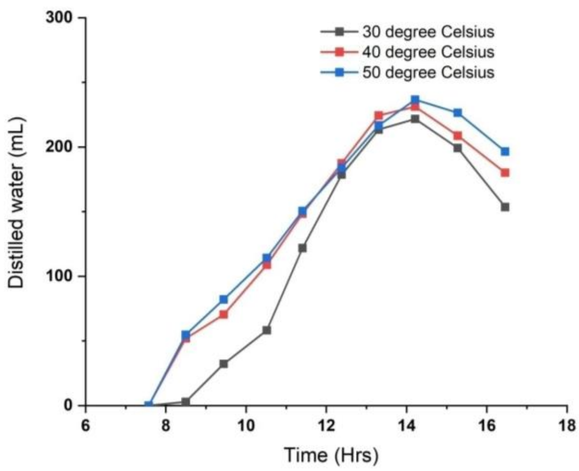

Fig 8 variation of water inlet temperature on distilled water production

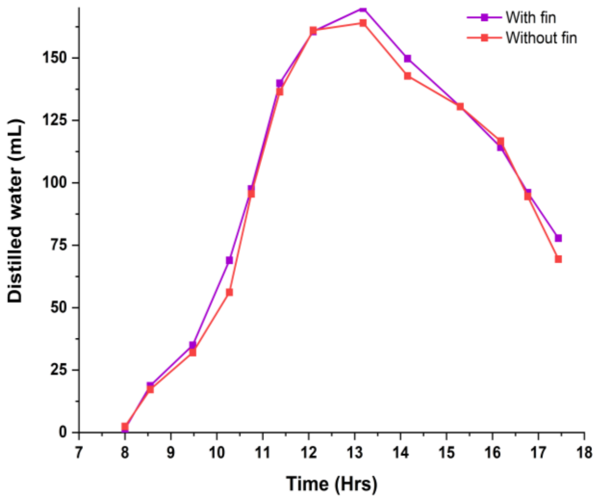

Fig 9 Distilled water output variations with and without fins

dispersion and absorption significantly in a pyramid solar still. The fins, often made of very efficient heat conductors, increase the still's internal temperature and enhance solar radiation absorption. Elevated temperatures accelerate evaporation and condensation, resulting in an augmented yield of distilled water. Despite the lack of fins, the solar still efficiently absorbs heat from the base material, potentially slowing down the condensation and evaporation processes. Lower interior temperatures and a less efficient thermal distribution might reduce the overall effectiveness of water collecting (Hu *et al.*, 2023).

3.5. Analysis of water quality

The water quality test was conducted at the Tamil Nadu Water Supply and Drainage Board (TWDB) in Chennimalai, Tamil Nadu, India. Solar stills' assessment of water produced relies on evaluating its physical and chemical properties. The primary purpose of a solar still is to generate water that meets further drinking standards and is saline-free and to remove various suspended and dissolved particles that cause turbidity. The water in the basin begins to evaporate off the water's surface when it is heated by incoming sun radiation, precipitating all dissolved particles and suspended contaminants identical to boiling water. The distillate potable water obtained from optimal conditions quality is compared with the inlet saline water quality as presented in Table 1.

The desalination process lowered the pH of the sample water from 7.89 (alkaline) to 6.93 (nearly neutral) which makes it suitable for drinking as per the WHO standards. Typically, the total dissolved salts (TDS) in fresh water is below 1,000 ppm. TDS between 1,000 and 10,000 ppm defines brackish water. The TDS range for saltwater is between 10,000 and 35,000. In hypersaline water, the TDS level is more than 35,000. Before desalination of saline water, the TDS measured is 21,000 ppm whereas post-desalination it is drastically reduced to 48 ppm which is well below the WHO standards. Some aquatic organisms can't handle high chloride levels seen in waterways. The likelihood of corrosivity of the water and the overall quality of water for drinking are both worsened by the existence of chloride. Hence it is necessary to measure the chloride ions levels in water before and after desalination. The saline and distilled water chloride levels are 8400 and 14 ppm, respectively, 99.83% of chloride is removed from the sample water by desalination. The reduction in TDS and chloride ions by desalination is due to the effective evaporation of saline water with the proposed experimental setup that produces the quality distillate. As a result of the existence of salt ions, the electrical conductivity of saltwater is typically about 50,000 μS/cm, whereas that of freshwater ranges from 0 and 1,500 μS/cm. The electrical conductivity of the saline water is 29,000 μS/cm, and distilled water is 57 μS/cm. The desalination removes most of the salt ions present in the saline water and hence there is a decrease in electrical conductivity by 99.80%. One measure of water quality is its turbidity, or degree of clarity. Turbidity is often caused by the presence of suspended contaminants in water. The turbidity level of the sample and distilled water are 306 NTU and 0.5 NTU. It shows that 99.83% turbidity is removed from the sample seawater by the desalination process. Water characteristics are greatly improved with over 99% removal of contaminants and dissolved salt after desalination using the proposed pyramid solar still attached with circular fin and an external water heater.

4. Conclusion

The present investigation was carried out in five days of observation, during which hourly fluctuations in sun radiation were meticulously documented. The study demonstrated the intricate relationship between water depth and freshwater productivity. The optimal water depth for achieving the highest productivity was 2 cm, with greater depths resulting in diminishing yields. Water productivity is significantly reduced when the water height is enlarged from 2 cm to 6 cm. The most significant difference of 38% was recorded on altering the water depth from 2 cm to 6 cm. The maximum productivity achieved at the 2cm water depth is 1250.3 mL, whereas the maximum yield at the 6 cm is 732 mL. From this, the water depth has a more significant influence on freshwater production. This underscores the trade-off between depth and productivity, a crucial consideration when designing effective solar still systems. A significant advancement was the strategic integration of absorber plate fins at the base of the basin. The reduction in preheating time, coupled with an 8.2% improvement in productivity, validates the positive impact of these enhancements on system efficiency. This innovative design improvement has the potential to enhance solar still performance substantially. Also, increasing the water temperature at the inlet from 30 to 50 degrees Celsius enhances the water output from 15.3% to 22.2%.

Table 1
Sea and distillate water properties

Properties	Units	Sample seawater	Distilled water	% Removal	Drinking water quality standards from WHO
pH value	-	7.89	6.93	-	7-8
Turbidity	NTU	306	0.51	99.83	5
Electrical conductivity (DHL)	μS/cm	29,000	57	99.80	-
Total dissolved solids (TDS)	ppm	21,000	48	99.77	500
Chloride (ion Cl^-)	ppm	8400	14	99.83	250

These findings contribute to the broader discourse on sustainable freshwater generation using solar energy. The insights gleaned from this study can inform the refinement and implementation of solar still systems in water-stressed regions. As the world seeks novel solutions to pressing environmental challenges, this study's information and empirical evidence provide a pragmatic pathway for optimizing solar still efficiency and advancing our pursuit of a more water-secure future.

Future Work

The efficiency of the solar still may further be enhanced by incorporating different energy storage materials with high specific heat values and thermal conductivity, and environmental or sustainability aspects related to the pyramid solar still will be considered.

References

Ahmadi, G., Toghraie, D., & Akbari, O. A. (2017). Efficiency improvement of a steam power plant through solar repowering. *International Journal of Exergy*, 22(2), 158. https://doi.org/10.1504/ijex.2017.083015

Aktaş, M., Sözen, A., Tuncer, A. D., Arslan, E., Koşan, M., & Çürük, O. (2019). Energy-Exergy Analysis of A Novel Multi-Pass Solar Air Collector With Perforated Fins. *International Journal of Renewable Energy Development*, 8(1), 47. https://doi.org/10.14710/ijred.8.1.47-55

Alaudeen, A., Johnson, K., Ganasundar, P., Syed Abuthahir, A., & Srithar, K. (2014). Study on stepped type basin in a solar still. *Journal of King Saud University - Engineering Sciences*, 26(2), 176–183. https://doi.org/10.1016/j.jksues.2013.05.002

Al-Garni, A. Z. (2012). Productivity Enhancement of Solar Still Using Water Heater and Cooling Fan. *Journal of Solar Energy Engineering*, 134(3). https://doi.org/10.1115/1.4005760

AlRubaiea, J. F., Latteiff, F. A., Mahdi, J. M., Atiya, M. A., & Majdi, H. S. (2021). Desalination of Agricultural Wastewater by Solar Adsorption System: A Numerical Study. *International Journal of Renewable Energy Development*, 10(4), 901–910. https://doi.org/10.14710/ijred.2021.38798

Diabil, H. A. N. (2022). Experimental study to enhance the productivity of single-slope single-basin solar still. *Open Engineering*, 12(1), 157–168. https://doi.org/10.1515/eng-2022-0015

Du, Y., Wen, J., Deng, K., Zou, L., Liu, X., Liu, P., Liu, B., Lv, X., Tian, W., & Ji, J. (2023). Janus film evaporator with improved light-trapping and gradient interfacial hydrophilicity toward sustainable solar-driven desalination and purification. *Separation and Purification Technology*, 322, 124312. https://doi.org/10.1016/j.seppur.2023.124312

Dumka, P., Sharma, A., Kushwah, Y., Raghav, A. S., & Mishra, D. R. (2019). Performance evaluation of single slope solar still augmented with sand-filled cotton bags. *Journal of Energy Storage*, 25, 100888. https://doi.org/10.1016/j.est.2019.100888

El-Dessouky, H. T., & Ettouney, H. M. (2002). Preface. Fundamentals of Salt Water Desalination, VII–X. https://doi.org/10.1016/b978-044450810-2/50001-4

Fath, H. E. S., El-Samanoudy, M., Fahmy, K., & Hassabou, A. (2003). Thermal-economic analysis and comparison between pyramid-shaped and single-slope solar still configurations. *Desalination*, 159(1), 69–79. https://doi.org/10.1016/s0011-9164(03)90046-4

Gad, H. E., Shams El-Din, Sh., Hussien, A. A., & Ramzy, Kh. (2015). Thermal analysis of a conical solar still performance: An experimental study. *Solar Energy*, 122, 900–909. https://doi.org/10.1016/j.solener.2015.10.016

Gnanadason, M. K., Kumar, P. S., Wilson, V. H., & Kumaravel, A. (2014). Productivity enhancement of a-single basin solar still. *Desalination and Water Treatment*, 55(8), 1998–2008. https://doi.org/10.1080/19443994.2014.930701

Gnanaraj, S. J. P., & Velmurugan, V. (2019). An experimental study on the efficacy of modifications in enhancing the performance of single basin double slope solar still. *Desalination*, 467, 12–28. https://doi.org/10.1016/j.desal.2019.05.015

Haddad, Z., Chaker, A., & Rahmani, A. (2017). Improving the basin type solar still performances using a vertical rotating wick. *Desalination*, 418, 71–78. https://doi.org/10.1016/j.desal.2017.05.030

Hamdan, M. A., Musa, A. M., & Jubran, B. A. (1999). Performance of solar still under Jordanian climate. *Energy Conversion and Management*, 40(5), 495–503. https://doi.org/10.1016/s0196-8904(98)00134-4

Hansen, R. S., Narayanan, C. S., & Murugavel, K. K. (2015). Performance analysis on inclined solar still with different new wick materials and wire mesh. *Desalination*, 358, 1–8. https://doi.org/10.1016/j.desal.2014.12.006

He, F., You, H., Liu, X., Shen, X., Zhang, J., & Wang, Z. (2023). Interfacial-heating solar desalination of high-salinity brine: Recent progress on salt management and water production. *Chemical Engineering Journal*, 470, 144332. https://doi.org/10.1016/j.cej.2023.144332

Hu, Z., Wang, J., Huo, E., & Zhang, C. (2023). Investigation of a distillation desalination system driven by solar and ocean thermal energy. *Desalination*, 559, 116649. https://doi.org/10.1016/j.desal.2023.116649

Ismail, B. I. (2009). Design and performance of a transportable hemispherical solar still. *Renewable Energy*, 34(1), 145–150. https://doi.org/10.1016/j.renene.2008.03.013

Issaq, S. Z., Talal, S. K., & Azooz, A. A. (2023). Experimentation on enhancement of solar still performance. *International Journal of Renewable Energy Development*, 12(4), 691–701. https://doi.org/10.14710/ijred.2023.53239

Jakhrani, A. Q., Larik, T. A., Jatoi, A. R., & Mukwana, K. C. (2019). Performance analysis of a fabricated line focusing concentrated solar distillation system. *International Journal of Renewable Energy Development*, 8(2), 185. https://doi.org/10.14710/ijred.8.2.185-192

Jani, H. K., & Modi, K. V. (2019). Experimental performance evaluation of single basin dual slope solar still with circular and square cross-sectional hollow fins. *Solar Energy*, 179, 186–194. https://doi.org/10.1016/j.solener.2018.12.054

Kabeel, A. E. (2009). Performance of solar still with a concave wick evaporation surface. *Energy*, 34(10), 1504–1509. https://doi.org/10.1016/j.energy.2009.06.050

Kabeel, A. E., & Abdelgaied, M. (2020). Enhancement of pyramid-shaped solar stills performance using a high thermal conductivity absorber plate and cooling the glass cover. Renewable *Energy*, 146, 769–775. https://doi.org/10.1016/j.renene.2019.07.020

Le, T. H., Pham, M. T., Hadiyanto, H., Pham, V. V., & Hoang, A. T. (2021). Influence of Various Basin Types on Performance of Passive Solar Still: A Review. *International Journal of Renewable Energy Development*, 10(4), 789–802. https://doi.org/10.14710/ijred.2021.38394

Modi, K. V., & Modi, J. G. (2019). Performance of single-slope double-basin solar stills with small pile of wick materials. *Applied Thermal Engineering*, 149, 723–730. https://doi.org/10.1016/j.applthermaleng.2018.12.071

Munisamy, T. K., Mohan, A., & Veeramanikandan, M. (2017). Experimental investigation of tilted wick solar still using fabrics. *Australian Journal of Mechanical Engineering*, 17(3), 185–190. https://doi.org/10.1080/14484846.2017.1334306

Murugavel, K. K., & Srithar, K. (2011). Performance study on basin type double slope solar still with different wick materials and minimum mass of water. *Renewable Energy*, 36(2), 612–620. https://doi.org/10.1016/j.renene.2010.08.009

Murugavel, K. K., Sivakumar, S., Riaz Ahamed, J., Chockalingam, Kn. K. S. K., & Srithar, K. (2010). Single basin double slope solar still with minimum basin depth and energy storing materials. *Applied Energy*, 87(2), 514–523. https://doi.org/10.1016/j.apenergy.2009.07.023

Nagarajan, P. K., El-Agouz, S. A., DG, H. S., Edwin, M., Madhu, B., Sathyamurthy, R., & Bharathwaaj, R. (2017). Analysis of an inclined solar still with baffles for improving the yield of fresh water. *Process Safety and Environmental Protection*, 105, 326-337. https://doi.org/10.1016/j.psep.2016.11.018

Omara, Z. M., Kabeel, A. E., & Essa, F. A. (2015). Effect of using nanofluids and providing vacuum on the yield of corrugated wick solar still. *Energy Conversion and Management*, 103, 965–972. https://doi.org/10.1016/j.enconman.2015.07.035

Omara, Z. M., Kabeel, A. E., Abdullah, A. S., & Essa, F. A. (2016). Experimental investigation of corrugated absorber solar still with wick and reflectors. *Desalination*, 381, 111–116. https://doi.org/10.1016/j.desal.2015.12.001

Pal, P., Dev, R., Singh, D., & Ahsan, A. (2018). Energy matrices, exergoeconomic and enviroeconomic analysis of modified multi–wick basin type double slope solar still. *Desalination*, 447, 55–73. https://doi.org/10.1016/j.desal.2018.09.006

Panchal, H., & Sathyamurthy, R. (2017). Experimental analysis of single-basin solar still with porous fins. *International Journal of Ambient Energy*, 41(5), 563–569. https://doi.org/10.1080/01430750.2017.1360206

Sathyamurthy, R., Nagarajan, P. K., El-Agouz, S. A., Jaiganesh, V., & Sathish Khanna, P. (2015). Experimental investigation on a semi-circular trough-absorber solar still with baffles for fresh water production. *Energy Conversion and Management*, 97, 235–242. https://doi.org/10.1016/j.enconman.2015.03.052

Sathyamurthy, R., Nagarajan, P. K., Subramani, J., Vijayakumar, D., & Mohammed Ashraf Ali, K. (2014). Effect of Water Mass on Triangular Pyramid Solar Still Using Phase Change Material as Storage Medium. *Energy Procedia*, 61, 2224–2228. https://doi.org/10.1016/j.egypro.2014.12.114

Suneesh, P. U., Jayaprakash, R., Kumar, S., & Denkenberger, D. (2017). Performance analysis of "V"-type solar still with tilt wick and effect of wick coverage. *Cogent Engineering*, 4(1), 1419791. https://doi.org/10.1080/23311916.2017.1419791

Tanaka, H., & Nakatake, Y. (2009). One step azimuth tracking tilted-wick solar still with a vertical flat plate reflector. *Desalination*, 235(1–3), 1–8. https://doi.org/10.1016/j.desal.2008.01.011

Toghraie, D., Karami, A., Afrand, M., & Karimipour, A. (2018). Effects of geometric parameters on the performance of solar chimney power plants. *Energy*, 162, 1052–1061. https://doi.org/10.1016/j.energy.2018.08.086

Velmurugan, V., Gopalakrishnan, M., Raghu, R., & Srithar, K. (2008). Single basin solar still with fin for enhancing productivity. *Energy Conversion and Management*, 49(10), 2602–2608. https://doi.org/10.1016/j.enconman.2008.05.010

Yarramsetty, N., Sharma, N., & Narayana, M. L. (2021). Experimental investigation of a pyramid type solar still with porous material: productivity assessment. *World Journal of Engineering*, 20(1), 178–185. https://doi.org/10.1108/wje-02-2021-0096

Yuvaperiyasamy, M., Senthilkumar, N., & Deepanraj, B. (2023). Experimental and theoretical analysis of solar still with solar pond for enhancing the performance of sea water desalination. *Water Reuse*. https://doi.org/10.2166/wrd.2023.102