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Experimental investigation of seawater volume effect on the performance of a corrugated-V absorber solar still

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Abstract

Limited access to clean water in coastal and remote areas has spurred the development of simple desalination technologies powered by renewable energy. This study analyzes the effect of seawater volume variation on the performance of a solar distillation system employing a corrugated-V absorber plate at a 40° tilt angle. The absorber plate was fabricated from aluminum and coated with matte black paint to enhance solar radiation absorption. Experimental tests were conducted under natural solar radiation conditions with seawater volumes of 5L, 6L, and 7L from 09:00 to 16:00 local time. The observed parameters included estimated solar radiation intensity, absorber plate temperature, basin water temperature, system efficiency, and condensate production. The results indicate that seawater volume significantly influences the thermal characteristics and productivity of the solar still. Among the tested variations, the 6L volume showed the best performance, achieving an average efficiency of 40.54% and a maximum condensate yield of 0.36L. At 5L, the available thermal energy was not effectively utilized, whereas at 7L, the increased water mass resulted in slower heating and evaporation rates. These findings demonstrate that appropriate selection of seawater volume plays an important role in enhancing the performance of solar distillation systems equipped with corrugated-V absorber plates under real outdoor operating conditions.

Keywords:
Desalination, corrugated-V, seawater, efficiency, renewable energy

1 Introduction

Indonesia is the largest archipelagic country in the world, covering an area of approximately 5.19 million km², of which nearly two-thirds is maritime territory. This condition establishes Indonesia as a maritime nation. Nevertheless, many coastal communities still face limitations in accessing clean water [1].

Water is a necessity used for various activities, ranging from drinking, cooking, and washing to applications in commerce, industry, agriculture, and livestock. However, some regions still face difficulties in obtaining clean water. Water treatment is carried out to improve the physical, chemical, and biological quality of raw water, making it suitable for daily consumption and use. With increasing population and growing industrial activity, the demand for clean water continues to rise [2]. Access to and availability of clean water remain uneven across the country, particularly in coastal areas, islands, and remote regions that rely on seawater or brackish water sources. Indonesia has a very high solar energy potential due to its location along the equator. The average solar radiation intensity in Indonesia ranges from 4.8 to 5.1 kWh/m² per day, making it one of the countries with the highest solar exposure in the world[3]. Berau Regency is one of the regions with numerous islands, underscoring the need for simple, affordable, and environmentally friendly technology to treat seawater for potable use. One of the widely developed methods for water purification is solar distillation, a system that utilizes solar energy to purify water. Solar energy is considered an alternative energy source due to its renewable nature and abundance in tropical regions[4].

One of the main components in a solar-powered distillation system is the absorb plate. The absorber plate captures heat from sunlight and transfers it to the seawater in the basin, facilitating evaporation [5]. In several previous research, flat absorber plates have been widely used due to their simple construction and ease of fabrication. However, the flat design is believed to have limitations in absorbing and distributing heat evenly across the water surface. Some research has shown that the inclination angle of the absorb plate significantly affects the system's thermal efficiency. For instance, a 10° inclination was tested in a study in Lampung and demonstrated optimal performance in increasing water temperature and condensate water productivity[6]. In addition to the absorber design, the volume of seawater used also significantly affects the distillation system's performance. A larger volume prolongs the heating process, while a smaller volume causes the water to evaporate quickly but produces only a limited amount of condensate[7].

Solar distillation is a water purification method that uses sunlight to evaporate contaminated water or seawater [8]. This process separates salts, bacteria, and other contaminants that settle to the bottom of the container, producing pure water that is safe for consumption without electricity, machinery, or chemicals. The distillation method is relatively simple, does not require additional chemicals, and can yield water of high purity. The use of solar energy in the distillation process also makes it an environmentally friendly technology, suitable for coastal areas in Indonesia [9]. In the solar distillation process, the absorber plate is positioned at the base of the device. When sunlight passes through the glass cover, the radiation energy is absorbed by the absorb plate and subsequently transferred to the seawater above it. As a result, the water heats up and evaporates, while salt and impurities remain behind. The generated vapor is then condensed into freshwater [10].

The volume of seawater used in a solar distillation system significantly influences the device's performance and efficiency. The larger the volume of water in the basin, the longer it takes to reach the evaporation temperature, as the heat energy from the absorber must raise the temperature of a greater water mass [11].

The study by Kumar et al. demonstrated that optimizing the absorber design to maximize radiation capture and reflection, combined with heat-absorbing materials such as charcoal, directly enhances water heating and the evaporation rate [12]. Other studies have shown that a shallow water depth of 1-3 cm accelerates heat absorption, increases the evaporation temperature, and yields a higher volume of distillate than greater depths [13]. A subsequent study reported that a V-shaped distiller cover yields higher distillate yield than a flat model because it reflects more solar radiation, increases evaporation temperature, and reduces heat loss, resulting in better distillation performance in high-irradiance environments [14].The study by Mohiuddin et al. demonstrated that the application of a Cr-Mn-Fe oxide nanocoating enhances heat absorption, thermal efficiency, and distillate productivity by more than 30%, while simultaneously significantly reducing the cost per liter of freshwater [15].Subsequent research emphasizes that various solar technologies-including solar stills and desalination systems-have significant potential to provide clean water and environmentally friendly energy efficiently, cost-effectively, and sustainably, particularly in hot climate regions [16].Unlike conventional flat absorber designs, the corrugated-V absorber employed in this study provides an increased effective surface area and improved heat distribution within the basin. This configuration enhances solar energy absorption and promotes more efficient heat transfer to the seawater. In addition, the integration of this absorber geometry with seawater volume variation offers a novel approach that has not been widely explored in previous studies. Based on previous research findings, the objective of this research is to analyze the design of a corrugated-V type absorber plate with a 40° inclination angle and variations in seawater volume of 5 and 7 liters in a solar-powered seawater distillation system.

2 Research methodology

This study employs an experimental approach to evaluate the performance of a corrugated-V-type absorber plate inclined at 40° in enhancing solar radiation absorption in a solar distillation system. The absorber plate is fabricated from aluminum and coated with matte black paint to maximize its absorptivity. The seawater volume was set at 5, 6, and 7 liters to assess the effect of water volume on evaporation rate and distillate productivity.

The distiller prototype was installed at 2.1377130°N and 117.4509060°E, with direct solar radiation exposure. Testing was conducted over several days under clear weather conditions. Solar radiation intensity was measured with a lux meter, while water temperature, absorber temperature, and vapor chamber temperature were monitored with type-K thermocouples.

2.1 Research design

The experimental study was conducted using a single-slope solar still equipped with a corrugated-V absorber plate. The system was designed and fabricated to evaluate the influence of seawater volume on thermal performance and freshwater productivity under natural solar radiation conditions.

The basin of the solar still was constructed with dimensions of 500mm×500mm×150mm (length×width×height). The transparent glass cover was installed at an angle of 40° to facilitate transmission of solar radiation and condensate collection.

The absorber plate installed inside the basin was fabricated from aluminum and coated with matte black paint to enhance solar radiation absorption. The absorber had a width of 500mm and an effective unfolded surface length of 2210mm, resulting from the corrugated-V folding geometry. The corrugated configuration was designed to increase the effective heat transfer surface area within the same basin footprint compared to a conventional flat plate, thereby promoting enhanced heat absorption and evaporation.

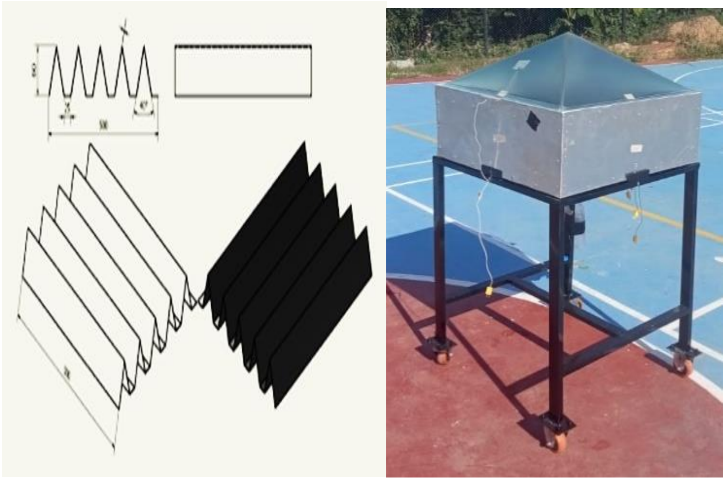


Fig.1. Experimental setup of the solar still with corrugated-V absorber

The experimental variations consisted of seawater volumes of 5L, 6L, and 7L. Temperature measurements were taken at the absorber plate and basin water using digital thermometers at hourly intervals from 09:00 to 16:00 local time. Solar radiation intensity was estimated during the experimental period to support performance evaluation. The distillate output was collected and measured volumetrically to determine system productivity and thermal efficiency.

Performance measurement points in the solar distillation system

Temperature measurements were conducted at fourteen points representing each main component of the solar distillation device. These measurement points included the basin cover, absorber plate, seawater, inner and outer glass panels, solar radiation intensity, ambient temperature, and wind speed as shown in Fig. 2.

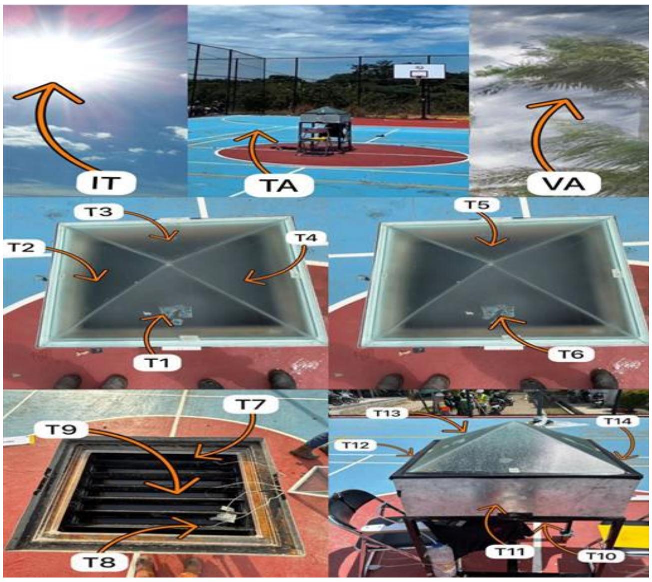


Fig. 2. Measurement points on the distillation system prototype

Description:
IT = Solar radiation intensity
T1-T4 = Outer glass surface temperature
T5-T6 = Condensed water temperature
T7-T8 = Absorber temperature (left and right sides)
T9 = Seawater temperature
T10 = Lower cover temperature
T11-T14 = Outer cover temperature
VA = Wind speed
Ta = Ambient temperature

2.2 Formula

2.2.1 Distillation analysis using the duffie and beckman method

Energy Balance of Basin Water [17][18]:

$$G\tau_c\alpha = q_e + q_{r.b-g} + q_{c.b-g} + q_k + (mC_p)_b \frac{dT_b}{dt} \tag{1}$$

Energy Balance on the Cover:

$$q_e + q_{c.b-g} + q_{c.b-g} = q_{c.g-a} + q_{r.g-a} \tag{2}$$

Duke Equation

$$q_{r-g} = 0.9\sigma(T_b^4 - T_g^4) \tag{3}$$

For Estimation $q_{c.b-g}$

$$N_g = 0.075(R_a)^{1/3} \tag{4}$$

$\Delta \boldsymbol{T}^{/} = for\ equation\ R_a$

$$\Delta T^{/}=(T_b + T_g) + \left[\frac{p_{wb}-p_{wg}}{2016-p_{wb}}\right] T_{wb} \tag{5}$$

p_{wb} and p_{wg} Saturation Vapor Pressure in mmHg at Basin Water Temperature T_b and Cover Temperature T_g, K

$$h_c' = 0{,}884\left[\left(T_b + T_g\right) + \left[\frac{p_{wb}-p_{wg}}{2016-p_{wb}}\right] T_{wb}\right]^{1/3} \quad (6)$$

$$q_{c.b-g} = h_c'\left(T_b - T_g\right) \quad (7)$$

By drawing an analogy between heat transfer and mass transfer, mass transfer is defined as:

$$m_p = 9{,}15 \times 10^{-7} h_c'\left(p_{wb} - p_{wg}\right)[kg/m^2 s] \quad (8)$$

Heat Transfer with Evaporation-Condensation:

$q_e = 9{,}15 \times 10^{-7} h_c'\left(p_{wb} - p_{wg}\right) h_{fg}, h_{fg} =$ Latent heat of vaporization of water [J/g]

Heat Loss to the Ground:

$$q_k = U_G\left(T_b - T_a\right) \quad (9)$$

Instantaneous Efficiency of the Distillation Device:

$$\eta_i = \frac{q_e}{AG} \quad (10)$$

2.3 Data collection and analysis

This study employed an experimental research design to evaluate the thermal performance of a solar still equipped with a corrugated-V absorber under varying seawater volumes. The experimental approach was conducted under natural outdoor solar radiation to simulate realistic operating conditions in coastal environments. Data collection was conducted from 09:00 to 16:00 local time during clear weather. The observed parameters included solar radiation intensity, absorber plate temperature, basin water temperature, ambient temperature, and distillate volume. Solar radiation intensity was measured with a lux meter and converted to W/m² to estimate incoming solar energy [19]. Temperature measurements were recorded using type-K thermocouples installed at designated measurement points within the system. The produced condensate was collected and measured volumetrically at the end of each experimental session.

Future studies are recommended to employ a calibrated pyranometer to obtain more accurate solar irradiance measurements and further validate the performance results.

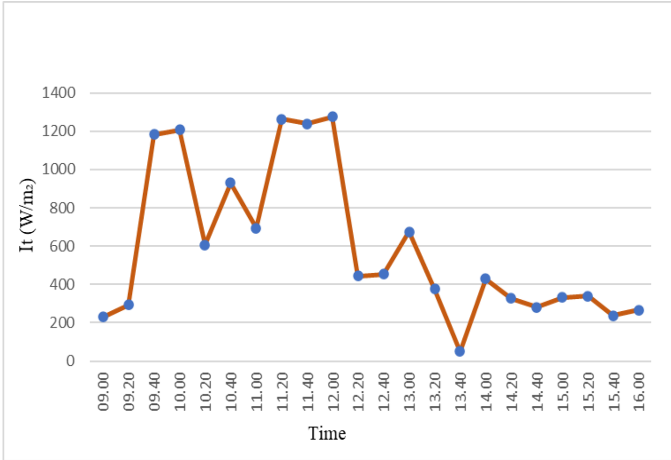
3 Result and discussion

By varying the seawater volume in the solar-powered seawater distillation system, the results will be analyzed using the predetermined formulas.

3.1 Solar radiation intensity

The solar radiation intensity during the experiment reached its minimum value in the morning and afternoon. The maximum solar intensity occurred at midday, as shown in Fig. 3.

The experimental results indicate that the solar radiation intensity in the solar distillation system fluctuated during the observation period from 09:00 to 16:00 local time. For a water volume of 5L, the highest solar radiation intensity was 1262 W/m2 at 11:20 local time, with an average of 596.92 W/m². For a water volume of 6L, the maximum solar intensity was 1337 W/m2 at 12:20 local time, and the average value was 741.9 W/m2, the highest among the variations. Meanwhile, for a water volume of 7L, the maximum solar radiation intensity of 1298 W/m² occurred at 12:20 local time, with an average value of 920.07 W/m². The differences in peak and average solar radiation intensity indicate variations in environmental conditions during the testing, such as changes in cloud cover and the solar incidence angle.



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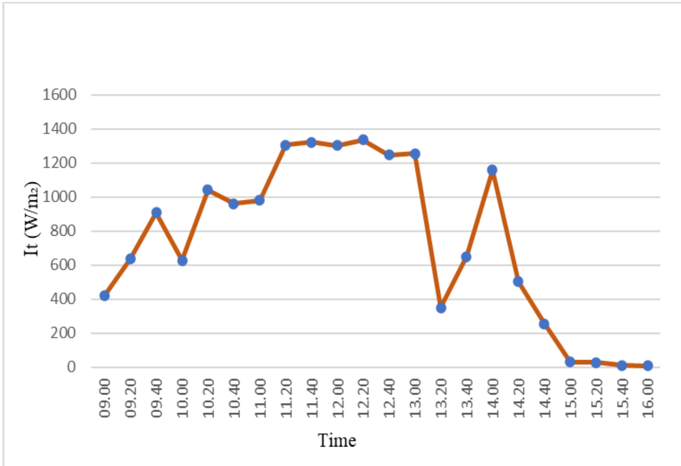

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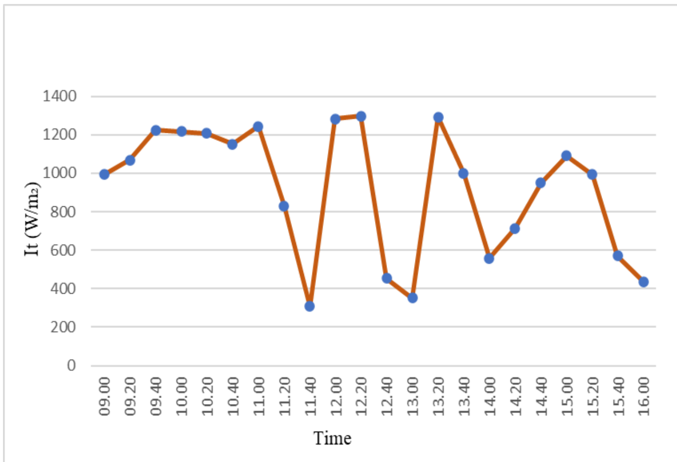


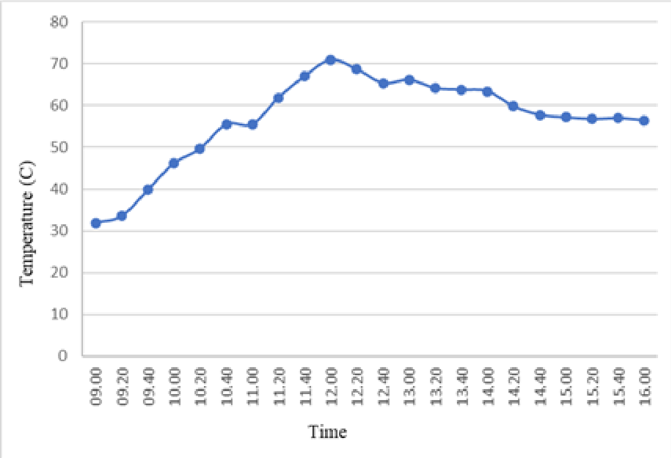
(c)

Fig. 3. Solar radiation intensity at volumes of (a) 5L, (b) 6L, and (c) 7L

In this research, solar radiation was measured using a lux meter and converted to W/m² to estimate solar irradiance. Although this approach does not fully capture the entire solar radiation spectrum, the measured values fall within the typical range of surface solar irradiance. Therefore, the data is considered adequate to represent the daily solar energy variation pattern during the experimental period and to support comparative performance analysis.

3.2 Absorber plate temperature

Along with increasing midday solar radiation intensity, the absorber plate temperature also increased. This is shown in Fig. 4, which illustrates the heat absorbed by the absorber surface during the experiment.



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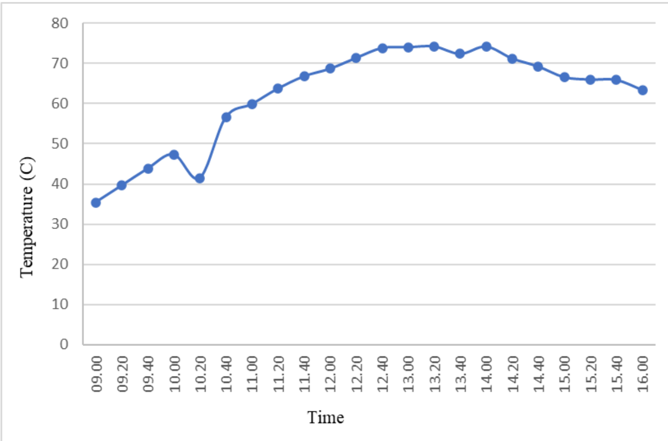

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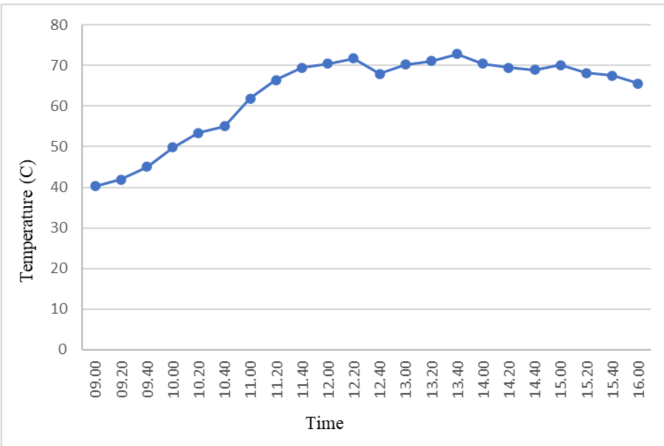


(c)

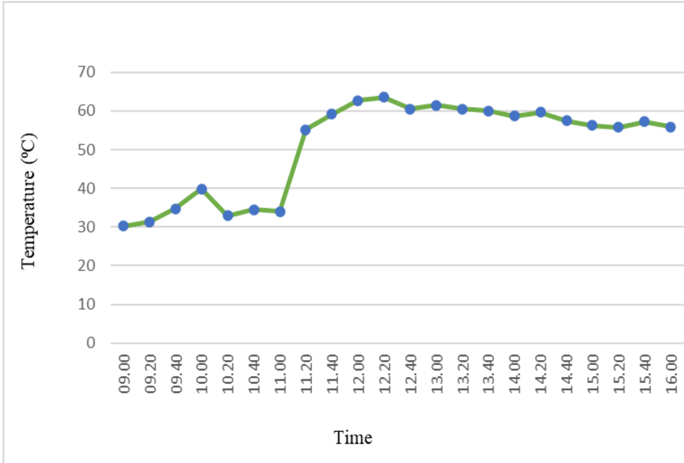
Fig. 4. Absorber plate temperature at volumes of (a) 5L, (b) 6L, and (c) 7L

The experimental results indicate that the average absorb plate temperature increased with increasing water volume in the solar distiller. For a water volume of 5L, the average absorber plate temperature was 56.73°C, increasing to 62.05°C at 6L, and reaching 63.08°C at 7L. These temperature differences demonstrate the influence of water volume variation on the thermal characteristics of the absorber plate.

At higher water volumes, the increased water mass slows heat transfer from the absorber plate to the water, leading to partial heat accumulation on the plate surface and, consequently, higher absorber plate temperature. This phenomenon aligns with previous solar distillation studies, which reported that an increase in water volume tends to elevate the absorber plate temperature[12], Although it may slow down the water temperature rise and evaporation rate, selecting the appropriate water volume is therefore a crucial factor in optimizing the performance of the solar distillation system.

3.3 Basin water temperature

Following the discussion of the absorber plate temperature, the study shifts to the basin water temperature, which determines the evaporation rate in the solar distillation system. The distribution of basin water temperature for each water volume variation is presented in Fig. 5.



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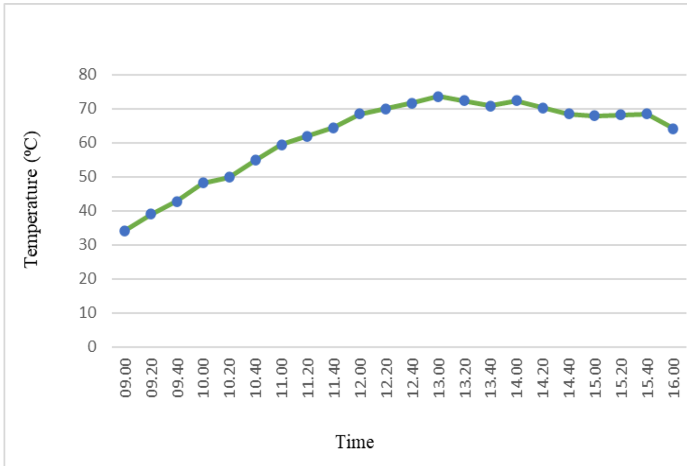

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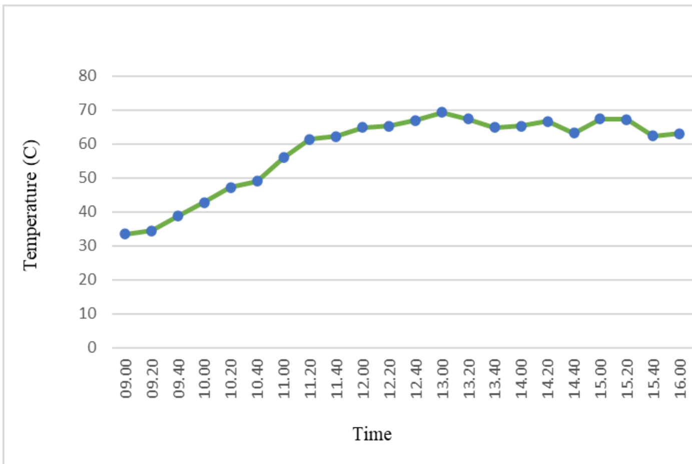


(c)

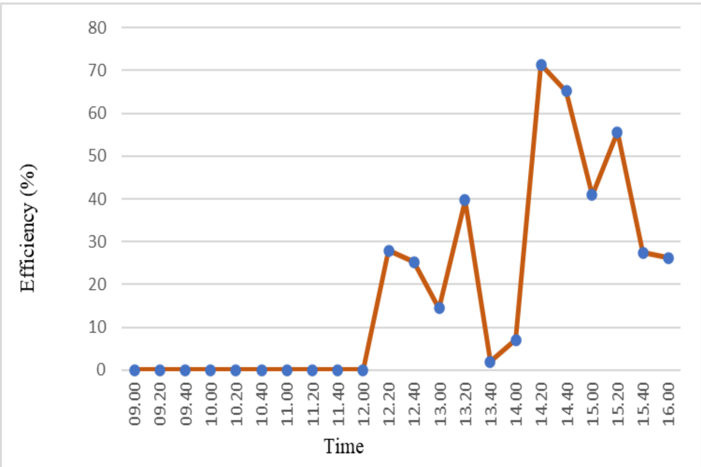
Fig. 5. Basin Water Temperature at Volumes of (a) 5L, (b) 6L, and (c) 7L

The results indicate that the average basin water temperature varied with each water volume. For a volume of 5L, the average water temperature was 51°C, increasing significantly to 62°C at 6L, then decreasing to 58°C at 7L. These differences suggest that the basin water temperature is influenced not only by the water volume but also by variations in solar radiation intensity and absorber plate temperature during the experiment.

For the 5L water volume, although the water mass was relatively small, the lower water temperature compared to the 6L volume indicates that the average solar radiation intensity (703.96 W/m^2) and absorber plate temperature (56.73°C) were not sufficiently optimal to raise the water temperature effectively. In contrast, at the 6L volume, the water temperature reached its highest value in line with the higher average solar radiation intensity (1229 W/m^2) and absorber plate temperature (62.05°C), enabling more effective heat transfer from the plate to the water and resulting in a better increase in basin water temperature. For the 7L water volume, although the absorber plate temperature reached the highest value (63.08 °C) and the average solar radiation intensity was relatively high (1017 W/m^2), the water temperature was lower than that at the 6L volume. This is due to the increased water mass, which requires more thermal energy to reach the same temperature, resulting in a slower rate of rise in water temperature. This phenomenon is consistent with findings from various solar distillation studies, which reported that excessively large water volumes can reduce the effectiveness of water heating despite high absorber temperatures, due to limitations in heat transfer rates and the increased heat capacity of water [20].

3.4 Efficiency

Based on the absorber plate temperature, water temperature, and solar radiation intensity, the efficiency of the solar-powered seawater distillation system was analyzed. The efficiency analysis results for each water volume variation are presented in Fig. 6.



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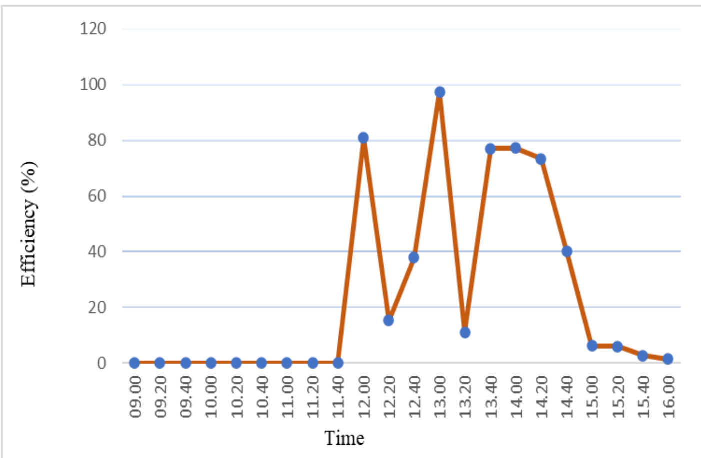

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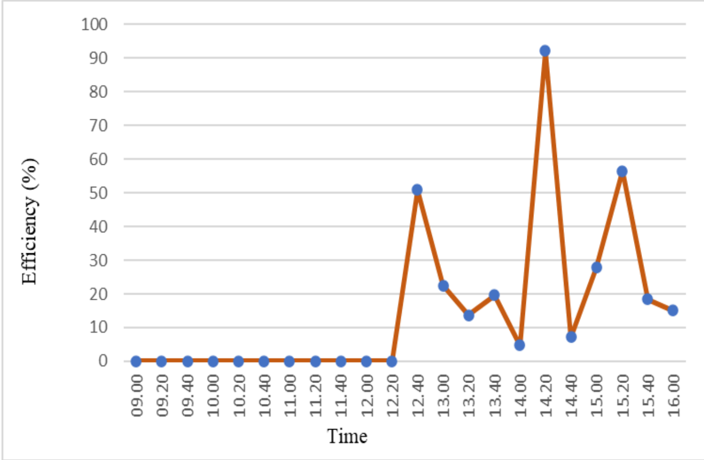

(c)

Fig. 5. Efficiency (a) 5L, (b) 6L, and (c) 7L

Table 1. Efficiency and condensate for various sea water volumes

Sea Water Volume (L)	Average Efficiency (%)	Condensate Water Volume (L)
5	33.59	0.24
6	40.54	0.36
7	29.83	0.29

Based on the experimental results, the optimal water volume for the solar distillation system was 6L, with an average efficiency of 40.54% and a condensate production of 0.36L. At this volume, the optimal water mass enables effective utilization of solar radiation and absorber plate heat, resulting in evaporation and condensation rates reaching their optimal values

The 5L water volume exhibited a lower efficiency of 33.59% and condensate production of 0.24L, due to the available solar energy not being fully utilized for evaporation. Meanwhile, the 7L volume resulted in a decreased efficiency of 29.83% and lower condensate production of 0.29L compared to the 6L volume, as part of the thermal energy was used to heat the larger water mass, reducing the evaporation rate. These findings are consistent with previous research [21], [22].

According to these experimental results, the optimal water volume can enhance the efficiency of the solar distillation system. Determining this volume is a key factor in the system's design and operation to maximize performance. The superior performance at 6L is attributed to the balance between thermal capacity and evaporation dynamics. At 5L, rapid heating occurs due to low thermal mass, but limited water reduces evaporation potential. At 7L, higher thermal inertia slows the rate of temperature rise and evaporation. The 6L condition provides an optimal balance, enhancing evaporation, condensation, and overall system efficiency.

The results of this study are in line with previous findings, highlighting the roles of water depth and thermal behavior in determining solar still performance. It is evident that system efficiency is influenced not only by the amount of heat input but also by the interactions among heat capacity, thermal inertia, and the resulting evaporation process.

In this work, optimizing seawater volume is a key factor in improving system performance, especially when combined with a corrugated-V absorber, which enhances heat distribution within the basin.

One of the strengths of this study is that the experimental evaluation was conducted under real outdoor conditions, providing a more realistic representation of system performance. Nevertheless, a limitation should be noted: solar radiation was estimated using a lux meter and converted to W/m², which may introduce some uncertainty. Future work is therefore suggested to employ more accurate instruments, such as a pyranometer, to improve measurement reliability.

4 Conclusion

This study evaluates the performance of a solar-powered seawater distillation system employing a corrugated-V absorber plate with a 40° tilt angle through an experimental approach, focusing on the effect of seawater volume variation on thermal characteristics, system efficiency, and condensate production. The experiments were conducted under natural solar radiation conditions, monitoring solar radiation intensity, absorber plate temperature, basin water temperature, and distillate volume. The results indicate that seawater volume variation significantly affects heat distribution and the overall performance of the solar still, where an increase in water volume leads to a higher absorber plate temperature due to increased thermal resistance in heat transfer, but does not necessarily result in higher basin water temperatures because larger water masses require greater thermal energy to reach evaporation temperatures. Among all tested conditions, a seawater volume of 6L provided the best performance, achieving the highest average efficiency of 40.54% and the maximum condensate production of 0.36L, as the utilization of solar radiation and heat absorbed by the corrugated-V plate was more effective and optimal.

This study contributes to the scientific community by clarifying the role of absorber geometry and water volume in enhancing solar still performance. In addition, the findings provide practical design guidance for developing efficient, low-cost solar distillation systems that can support sustainable freshwater production in coastal and remote communities.

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References

[1] D. Satriawan and S. D. A. Febriani, "Pengaruh Variasi Material Absorber Terhadap Efisiensi Destilator Air Laut Bertenaga Surya Tipe Sirip," *J. Inov. Teknol. Manufaktur, Energi dan Otomotif*, vol. 1, no. 1, pp. 1–10, 2022.

[2] F. C. Nababan and H. Ambarita, "Rancang Bangun Alat Desalinasi Air Laut Sistem Vakum Natural dengan Media Evaporator dan Kondensor yang Dimodifikasi Flange," *Cylind. J. Ilm. Tek. Mesin*, vol. 3, no. 1, pp. 16–25, 2017.

[3] P. P. T. D. Priatam, M. F. Zambak, S. Suwarno, and P. Harahap, "Analisa Radiasi Sinar Matahari Terhadap Panel Surya 50 WP," *RELE (Rekayasa Elektr. dan Energi) J. Tek. Elektro*, vol. 4, no. 1, pp. 48–54, 2021.

[4] M. Syahri, "Rancang Bangun Sistem Desalinasi Energi Surya Menggunakan Absorber Bentuk Separo ElipMelintang," in *Prosiding Seminar Nasional Teknik Kimia "Kejuangan" 2011*, 2011.

[5] A. Halim, "Analisis Unjuk Kerja Plat Penyerap Corrugated-V pada Sistem Destilasi Surya Air Laut untuk Peningkatan Efisiensi Termal," *ReTII*, pp. 108–114, 2025.

[6] D. Mugisidi, A. Fajar, and O. Heriyani, "Peningkatan Efisiensi Dan Efektivitas Kondensor Pada Solar Still.," *J. Teknosains*, vol. 12, no. 1, 2022.

[7] S. Iqbal, S. Sukmawaty, G. M. D. Putra, and D. A. Setiawati, "Analisis Kinerja Alat Desalinasi Air Laut Penghasil Air Tawar dan Garam dengan Menggunakan Tenaga Surya," *J. Agrotek Ummat*, vol. 6, no. 1, pp. 29–34, 2019.

[8] I. G. Y. Dewantara, B. M. Suyitno, and I. G. E. Lesmana, "Desalinasi Air Laut Berbasis Energi Surya Sebagai Alternatif Penyediaan Air Bersih," *J. Tek. Mesin*, vol. 7, no. 1, pp. 1–4, 2018.

[9] M. Ridwan, N. R. Ismail, D. Hermawan, and P. Suwandono, "Pengaruh Kaca Penutup Double Slope dengan Piramida Menggunakan Pelat Penyerap Sirip terhadap Kinerja Solar Still," *J. Mesin Nusant.*, vol. 6, no. 2, pp. 107–116, 2023.

[10] A. Halim, A. M. Jalaluddin, and E. Arif, "Performance Investigation Of Solar Water Heating System Integrated with PCM storage," *J Mech Eng Res Dev*, vol. 43, no. 3, pp. 291–300, 2020.

[11] A. F. Ojan, B. V Tarigan, and D. G. H. Adoe, "Analisis Pengaruh Variasi Massa Material Arang Terhadap Proses Desalinasi Air Laut Tenaga Surya," *LONTAR J. Tek. Mesin Undana*, vol. 9, no. 01, pp. 101–109, 2022.

[12] S. Kumar *et al.*, "Solar stills: A review for water scarcity solutions," *Heliyon*, vol. 10, no. 19, 2024.

[13] V. K. Chauhan, S. K. Shukla, J. V. Tirkey, and P. K. S. Rathore, "A comprehensive Review Of Direct Solar Desalination Techniques And Its Advancements," *J. Clean. Prod.*, vol. 284, p. 124719, 2021.

[14] O. Bait, "A Critical Review On Triangular Pyramid, Weir–Type, Spherical, And Hemispherical Solar Water Distiller Conceptions," *Sol. Energy*, vol. 269, p. 112322, 2024.

[15] S. A. Mohiuddin, A. K. Kaviti, T. S. Rao, and S. R. Atchuta, "Experimental Assessment Of Productivity And Sustainability Of Nanoporous Cr-Mn-Fe Oxide Nanocoating In Solar-Powered Desalination," *Process Saf. Environ. Prot.*, vol. 162, pp. 61–71, 2022.

[16] R. Manimaran, "A Comprehensive Review Of Solar-Assisted Technologies In India For Clean Water And Clean Energy," *Clean Energy*, vol. 9, no. 2, pp. 12–36, 2025.

[17] S. Himran, *Energi Surya: Konversi Termal & Fotovoltaik*. Penerbit Andi, 2021.

[18] J. A. Duffie and W. A. Beckman, *Solar Engineering Of Thermal Processes*. Wiley New York, 1980.

[19] P. R. Michael, D. E. Johnston, and W. Moreno, "A conversion guide: solar irradiance and lux illuminance," *J. Meas. Eng.*, vol. 8, no. 4, pp. 153–166, 2020.

[20] S. K. Nougriaya, M. K. Chopra, B. Gupta, P. Baredar, and H. Parmar, "Influence of Basin Water Depth and Energy Storage Materials on Productivity of Solar Still: A Review," *Mater. Today Proc.*, vol. 44, pp. 1589–1603, 2021.

[21] G. N. Tiwari and L. Sahota, *Advanced Solar-Distillation Systems: Basic Principles, Thermal Modeling, And Its Application*. Springer, 2017.

[22] Z. M. Omara, W. H. Alawee, S. A. Mohammed, H. A. Dhahad, A. S. Abdullah, and F. A. Essa, "Experimental Study On The Performance Of Pyramid Solar Still With Novel Convex And Dish Absorbers And Wick Materials," *J. Clean. Prod.*, vol. 373, p. 133835, 2022.