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Ethanol Effect on the Performance of a Conventional Solar Still

A. Bellila[1], B. Souyei[1], I. Kermerchou[2], N. Smakdji[3], A. Sadoun[4], N. Elsharif[5], A. Siqueira[6]*

[1] Faculty of Exact Science, University of El Oued, Algeria
[2] Faculty of Applied Sciences, University of Ouargla, Algeria
[3] Applied Microelectronics Laboratory, University Sidi Bel Abbès Algeria
[4] Faculty of Science and Technology, University of Jijel, Algeria
[5]Mechanical Engineering Department, University of Benghazi, Libya
[6]Chemical Engineering Graduate Program, Federal University of Viçosa, Brazil
Correspondence: E-mail: kaderbe3lila3@gmail.com

ABSTRACT

The lack of drinking water is a major problem in many parts of the world, and solar distillation can be an effective solution. Solar distillation is a simple process that uses the energy from the sun to evaporate water and then collect the condensed vapor, leaving behind impurities. Ethanol has a lower boiling point than water, which means it evaporates more easily when exposed to heat. This can improve the efficiency of solar distillation by allowing the water to evaporate more quickly and at a lower temperature, reducing the amount of energy needed from the sun. The results you mentioned, showing a 20% improvement in performance compared to conventional solar stills, are promising. However, specific results and effectiveness of this modification may vary depending on various factors such as the type of still used, the concentration of Ethanol used, and environmental conditions.

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1. INTRODUCTION

Desalination of seawater is a technology that has become increasingly important in countries facing water scarcity and Algeria is one of the countries that have adopted this technology to provide safe drinking water. The completion of ten desalination plants with a total capacity of about two million cubic meters per day since 2005 is a significant achievement. Additionally, the launch of five more plants will further increase the capacity to meet the needs of the growing population. By using desalination technology, Algeria has ensured water security for 25% of its population. This is a significant achievement considering that water scarcity is a major challenge faced by many countries, particularly those in arid and semi-arid regions. (Khechekhouche *et al.*, 2020a; Miloudi *et al.*, 2022).

In addition to desalination plants, Algeria has also invested in wastewater treatment stations throughout the country. This is an important step towards ensuring sustainable water management as treated wastewater can be reused for non-potable purposes such as irrigation, industrial uses, and firefighting (Sefaoui *et al.*, 2021; Khechekhouche *et al.*, 2020b; Zair *et al.*, 2021). Solar stills use solar energy to evaporate water from saltwater, leaving behind salt and other contaminants, and then collect the evaporated water as freshwater. This process can be effective in producing potable water from salt water, particularly in areas where freshwater resources are scarce, and solar energy is abundant.

However, the total freshwater production from solar stills is generally low compared to other water treatment technologies, which limits their use for large-scale applications. Despite this limitation, solar stills can still be a viable option for providing safe drinking water in remote or off-grid areas where access to other water treatment technologies is limited. On-going research and development in solar distillation technology are also improving the efficiency and output of solar stills, making them more effective in producing freshwater from saltwater (Cherraye *et al.*, 2022; Khechekhouche *et al.*, 2017; Khechekhouche *et al.*, 2019a).

New designs for solar stills can include different shapes, sizes, and materials that can capture and concentrate solar energy more efficiently. For example, some researchers are exploring the use of parabolic troughs or Fresnel lenses to focus sunlight onto the still, increasing its productivity (Hitesh *et al.*, 2020; Ghodbane *et al.*, 2020; Yong Ho *et al.*, 2022).

Other researchers are exploring the use of hybrid solar stills that combine photovoltaic cells. Adding thermal storage materials to solar stills can also increase their productivity by storing heat energy during the day and releasing it at night or during periods of low solar radiation. This can help maintain a higher temperature inside the still, increasing its efficiency and productivity. (Kabeel *et al.*, 2018; Bellila *et al.*, 2022a; Khechekhouche *et al.*, 2019b; Khechekhouche *et al.*, 2017; Khechekhouche *et al.*, 2020d; Khamaia *et al.*, 2022; Khechekhouche *et al.*, 2020e; Khechekhouche *et al.*, 2020f). The incorporation of natural or artificial materials into the solar energy pool is a well-known method and has been extensively studied. The use of different materials such as aluminum, zinc, stone, gravel, sand, and palm fibers can enhance the efficiency of solar collectors by improving heat transfer and reducing heat losses (Bellila *et al.*, 2022b; Kermerchou *et al.*, 2022; Sadoun *et al.*, 2022; Khechekhouche *et al*, 2022; Souyei *et al.*, 2022).

Nanofluids, on the other hand, are suspensions of nanoparticles in a base fluid, which have been shown to have excellent heat transfer properties. They can be used in solar collectors to enhance heat transfer and improve the overall efficiency of the system (Modi *et al.*, 2023). Using Ethanol in solar still to increase its performance and the productivity of the system is a unique approach. Ethanol has a lower boiling point than water, which means

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it evaporates faster. This property of Ethanol could potentially increase the rate of evaporation of water in the still, leading to higher productivity. It would be interesting to see the results of your study and how the addition of Ethanol affects the performance of the solar still.

2. METHODS

Ethanol is an organic compound, purchased from the local market in Algeria. Ethanol is a volatile, flammable, colorless liquid with a characteristic wine-like odor and pungent taste. The use of Ethanol in solar distillation is to accelerate the evaporation of water. The experiment consists of exposing two solar stills to the sun, one serving as the CSS reference and the other MSS undergoing an addition of 200 ml of ethanol as shown in **Figure 1**. The experiment will be conducted over 9 hours between 8 and 16 hours on March 18, 2022, with measurements taken hourly. Detailed equipment is reported in a previous study (Khamaia *et al*., 2022).

Figure 1. Experimental setup.

3. RESULTS AND DISCUSSION

3.1. Evolution of Solar Radiation and Ambient Temperature

Solar radiation is a crucial factor in solar distillation. **Figure 2** described can help us understand the ideal time to conduct solar distillation and how much energy can be harnessed from the sun during a given period. It shows that the highest amount of solar radiation is received between 12:00 - 14:00 hours, with a maximum value of 902 W/m^2. This is the time when the sun is at its highest point in the sky, and the radiation received is the most intense. It shows that the maximum ambient temperature is 31 °C at 14:00 hours.

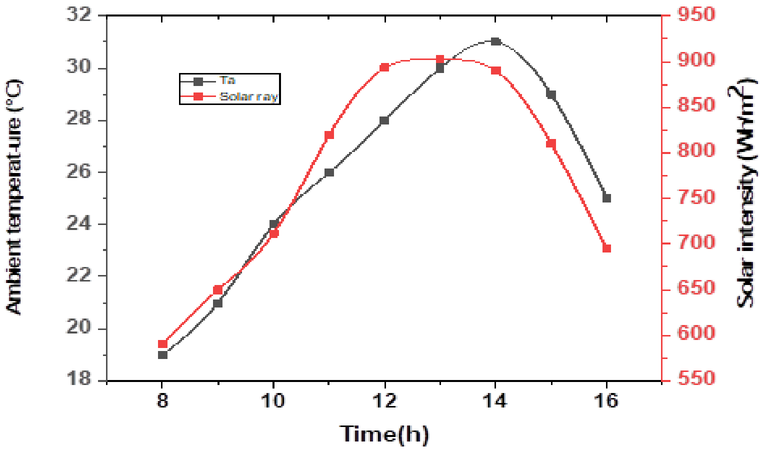

Figure 2. Evolution of solar radiation and ambient temperature.

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3.2. Glass Covers Internal and External Temperature

Figures 3 and **4** are describing a situation where there is a temperature variation on both sides of a cover glass, with the inner face having a higher temperature compared to the outer face. This is shown in **Figure 3**, where the maximum temperatures of the inner face for both CSS and MSS images are 35°C. However, the temperatures of the outer face are almost the same, which is due to the lower ambient temperature and the quick transfer of heat to the outside. This helps the outer face cool down quickly and maintain a relatively constant temperature, despite the wind blowing at considerable speeds, as shown in **Figure 4.**

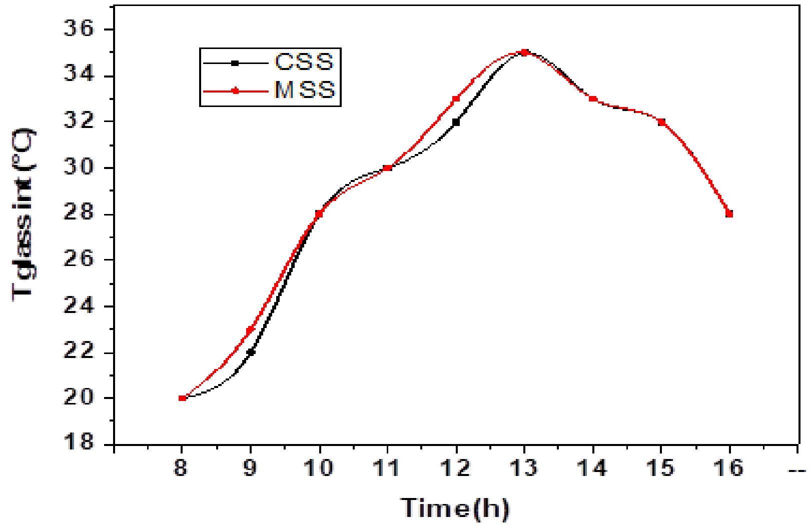

Figure 3. Evolutions of internal glass cover temperature.

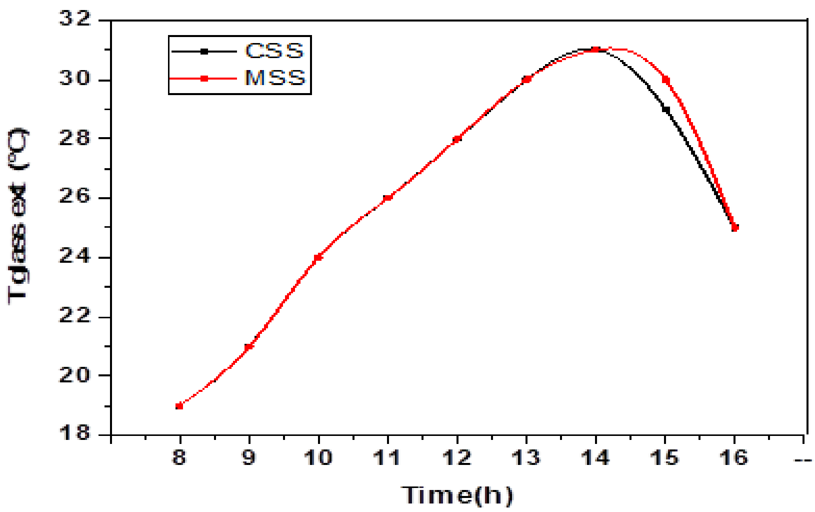

Figure 4. Evolution of external glass covers temperature.

3.3. Water Temperature Evolution

Figure 5 shows the evolution of water temperature over time in two solar stills. The graph indicates that there is a significant difference between the two stills and that the MSS has a higher temperature than the CSS, with the maximum temperature difference occurring between 13:00 and 14:00. During this period, the temperature of the water in the CSS reaches a maximum of 43°C, while the temperature in the MSS reaches a maximum of 45°C.

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Additionally, it seems that the only difference between the two stills is the presence of Ethanol. The pH of the water changed from 7.90 to 7.09, indicating a decrease in alkalinity, while the electrical conductivity changed from 10185 (s/cm) to 28 (s/cm), indicating a significant decrease in the concentration of dissolved salts in the water.

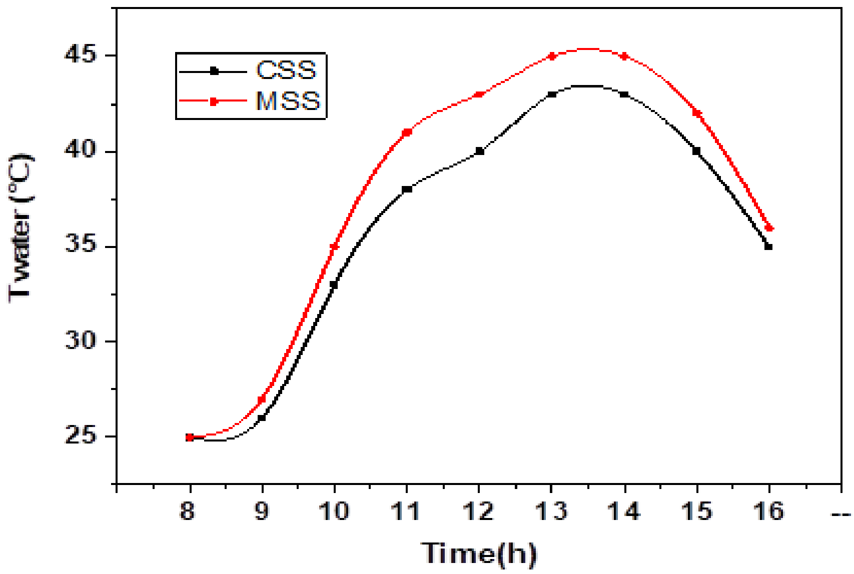

Figure 5. Evolution of water temperature.

3.4. Hourly and Accumulation Output of Pure Water

Figures 6 and **7** show the hourly output and accumulation of pure water for two types of distillers, MSS and CSS, which were measured over some time. The MSS distiller produced higher output values than the CSS distiller in every measure, with the highest output values being 100 mL and 90 mL at 14:00 h for MSS and CSS, respectively. The total accumulation values for both types of distillers were 470 mL and 540 mL for CSS and MSS, respectively. This means that over the entire period, the MSS distiller produced more pure water than the CSS distiller.

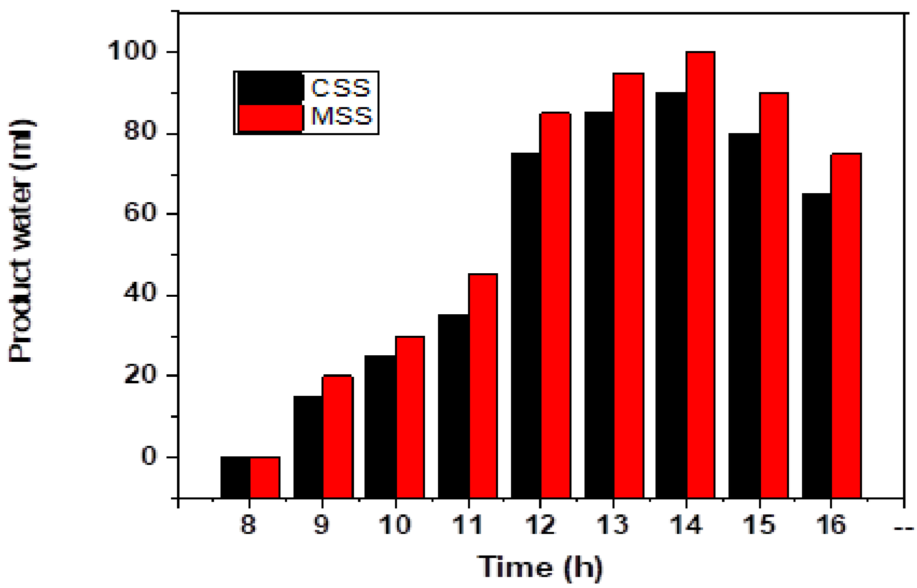

Figure 6. Evolution of hourly output.

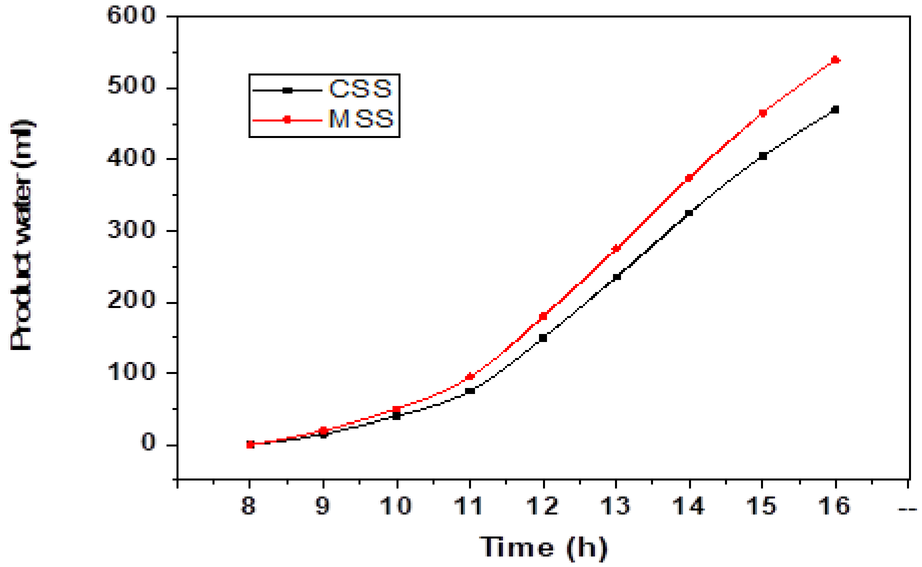

Figure 7. Evolution of accumulation output.

4. CONCLUSION

We successfully compared the performance of two solar panels of the same size, one with modified distilled MSS containing Ethanol and the other as a reference CSS panel. The results show that the MSS had an average basin water temperature of 37.66°C, which is higher than the CSS panel's temperature of 35.8°C. The rate of improvement due to the presence of Ethanol is 20%.

5. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper was free of plagiarism.

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