Cellulose cardboard effect on the performance of a conventional solar still

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Abstract – *The lack of drinking water is a pressing issue in contemporary times, and solar distillation stands out as a simple and effective solution. However, the low yield of solar distillation remains a challenge. Researchers have undertaken various experimental modifications to enhance the thermal performance of solar distillation. In one such modification, Cellulose cardboard was introduced with the aim of improving the system's performance. The experimental results demonstrated a notable improvement of 19.8% in the solar still's efficiency when Cellulose cardboard was employed, compared to conventional solar still designs.*

Keywords*: Solar energy, Solar distillation, Pure water, Evaporation.*

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I. Introduction

Access to clean and safe drinking water is a fundamental requirement for human health and well-being. However, water scarcity and pollution have become pressing global challenges, particularly in regions where traditional water resources are limited or contaminated. The need for effective water treatment methods has never been more critical. Water treatment involves the removal of impurities, contaminants, and harmful microorganisms to ensure water quality and safety for consumption. Various conventional methods such as filtration, chemical treatment, and disinfection have been widely employed to purify water sources. However, these methods often require complex infrastructure, energy inputs, and chemical additives, making them costly and impractical in resource-constrained areas.

In this context, solar distillation has emerged as a simple and sustainable solution for water treatment and purification. Solar distillation utilizes the sun's energy to convert impure or saline water into clean, potable water through the process of evaporation and condensation. It is a natural phenomenon mimicked in a controlled environment, where solar stills or distillers are used to harness solar radiation and generate purified water [1-5].

To enhance the efficiency of solar stills, researchers have been actively exploring innovative approaches and strategies. One such strategy involves the incorporation of high thermal conductivity materials into the water being treated. This approach aims to improve heat transfer within the system, thereby enhancing distillation rates and overall efficiency.

These high thermal conductivity materials can take various forms, such as metallic fins, PCM, sand, metal pouder, metal nanoparticles, or even carbon-based additives. The presence of these materials facilitates the rapid transfer of heat from the solar collector to the water, ensuring efficient evaporation and condensation processes. The enhanced heat transfer reduces the temperature gradient within the system, allowing for more effective utilization of solar energy and higher distillation rates [6-15].

Furthermore, researchers have also explored the utilization of natural materials and other simple and complex techniques to enhance the performance of solar

distillation systems. These approaches aim to leverage readily available resources and sustainable methods to improve water evaporation processes [16-24].
Natural materials, including plant fibers, nuts, dates, olives, and sponge pieces, have garnered significant attention in the field of solar distillation research. These materials have been studied for their potential to enhance the performance of solar distillation systems, leading to improvements in heat transfer, water vaporization, and the output of pure water [25-31]
The objective of this study is to assess the effectiveness of cellulose cardboard in improving the efficiency of solar distillation. By incorporating cellulose cardboard into solar stills, we aim to enhance heat transfer, water vaporization, and the production of pure water. Through experimental investigations, we will evaluate the impact of cellulose cardboard on key performance parameters, such as water temperature, and distillate yield.

II. Methodology

II.1. Shunt active power filter

The use of Cellulose cardboard in solar distillation can be a promising approach to improve the performance of the system. In the experiment described, two solar pieces were exposed to the sun: one served as a reference (CSS solar reference), while the other incorporated modifications using Cellulose cardboard alloys with dimensions of 30×1×0.5 cm as shown in Figure 1. The Cellulose cardboard alloys were evenly distributed on the modified solar distillation system.

Hourly measurements were taken over a period of 9 hours, from 8:00h to 16:00h, on March 18, 2022. The weather conditions during the experiment were documented and can be found in Table 1. These measurements and observations help to assess the efficiency of the modified solar distillation system using Cellulose cardboard in comparison to the reference system.

Table 1: The weather conditions for the experimental day

Date	Sunrise	Sunset	Temp. Ambient
March 18, 2022	06:53 AM	06:58 PM	19-31 °C

Figure 1. Experimental setup

III. Results

III.1. Solar radiation and ambient temperature

Figure 2 provides valuable information about the solar radiation and ambient temperature during the experimental period of the solar distillation system. The graph shows the evolution of solar radiation as a function of time, indicating that the maximum radiation level reached 902 W/m^2 between 12:00h and 14:00h. This period corresponds to the peak solar intensity when the sun is at its highest point in the sky.

Additionally, the graph illustrates the variation in ambient temperature over time. It shows that the maximum ambient temperature recorded during the experiment was 31 °C, which occurred at 14:00h. The ambient temperature is influenced by factors such as solar radiation, air temperature, and other environmental conditions.

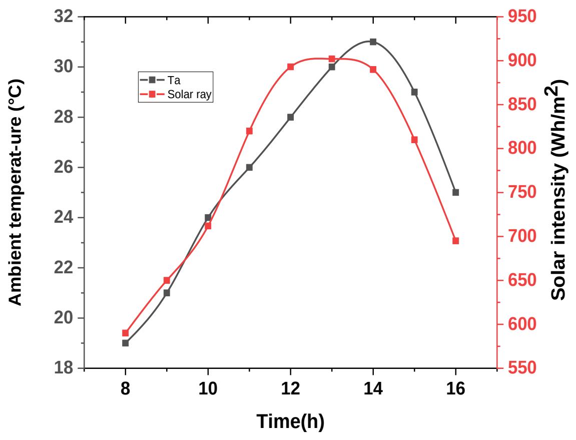

Figure 2. Evolution of solar radiation and ambient temperature

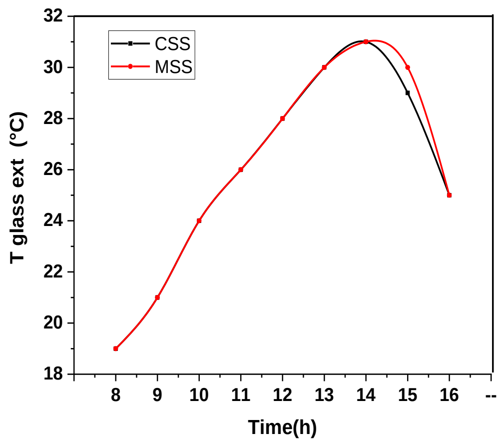

Figure 4. Evolution of external glass cover temperature

III.2. Glass cover internal and external temperature

Figure 3 provides insights into the temperature variation on both sides of the cover glass in the solar distillation system over time. The graph shows that there is a significant difference between the temperatures of the inner face of the glass for both the CSS (Conventional Solar Still) and MSS (Modified Solar Still) configurations. The maximum temperature values reached 35 °C for both CSS and MSS.

In contrast, Figure 4 illustrates the temperatures of the outer face of the glass. The graph indicates that the temperatures of the outer face are relatively similar for both CSS and MSS configurations. This is due to the faster heat transfer from the outer face to the surrounding environment, aided by lower ambient temperatures and the presence of wind that promotes convective cooling. As a result, the outer face of the glass cools down quickly and maintains a relatively stable temperature.

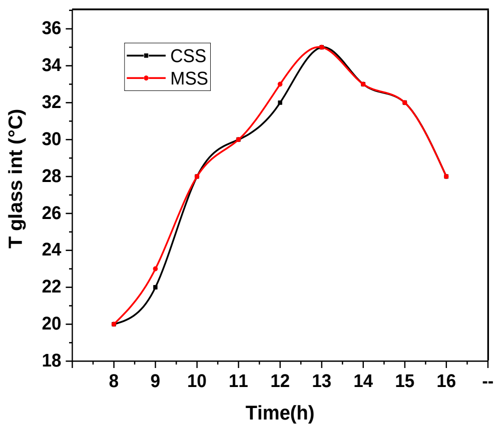

Figure 3. Evolution of internal glass cover temperature

III.3. Water temperature evolution

Figure 5 shows the evolution of water temperature in both the conventional CSS (Conventional Solar Still) and MSS (Modified Solar Still) distillers over time. The graph indicates a significant difference in water temperature between the two configurations throughout the experiment.

The maximum temperature difference between CSS and MSS occurs between 13:00 and 14:00, with values of 43 °C for CSS and 45 °C for MSS. This temperature difference can be attributed to the presence of Cellulose cardboard in the MSS distiller. The Cellulose cardboard, which is distributed within the distiller as mentioned earlier, acts as an additional heat-absorbing material. It absorbs and retains more heat from the solar radiation, leading to a higher water temperature compared to the conventional CSS distiller.

The presence of Cellulose cardboard in the MSS distiller enhances the heat transfer process, resulting in increased water temperature. This modification can positively impact the distillation efficiency by improving the evaporation of water and condensation of distilled water.

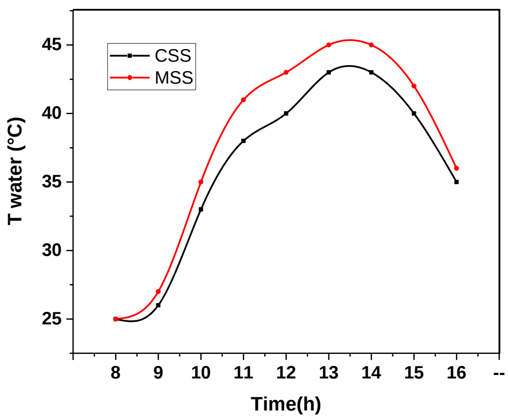

Figure 5. Evolution of water temperature

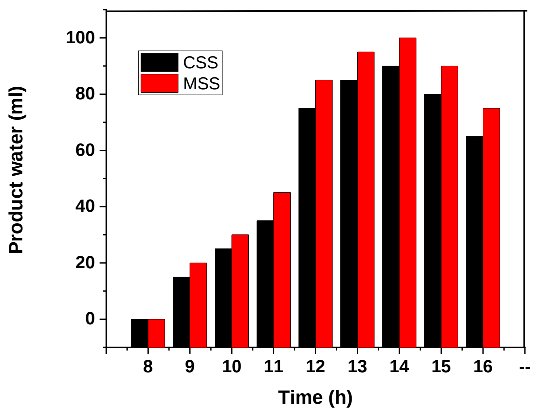

Figure 6. Evolution of hourly output

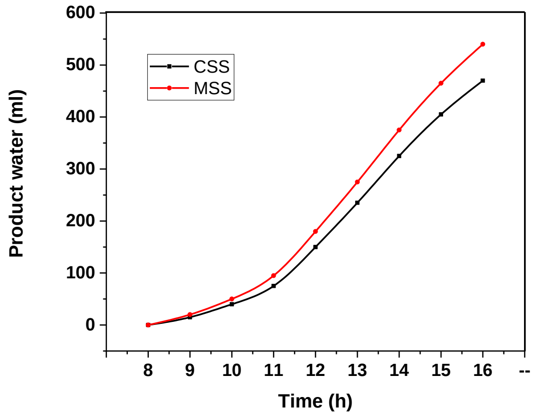

Figure 7. Evolution of accumulation output.

III.4. Hourly and accumulation output of pure water

Figure 6 illustrates the hourly output and accumulation of pure water for both the MSS (Modified Solar Still) and CSS (Conventional Solar Still) distillers over the course of the experiment. The graph indicates that the MSS distiller consistently yields a higher output of pure water compared to the CSS distiller in each measurement.

At 14:00 hours, the highest output value is recorded, with 100 mL of pure water for the MSS distiller and 90 mL for the CSS distiller. This difference in output can be attributed to the presence of Cellulose cardboard in the MSS distiller, which enhances the thermal performance and efficiency of the distillation process, as observed in the previous figures.

Furthermore, Figure 7 presents the total accumulation of pure water for both the MSS and CSS distillers. The total accumulation values are 470 mL for MSS and 540 mL for CSS. This implies that, despite the higher output per measurement in the MSS distiller, the total accumulated amount of pure water is slightly higher in the CSS distiller.

These results highlight the positive impact of the Cellulose cardboard modification on the performance of the solar distillation system, leading to increased output and accumulation of pure water.

IV. Conclusion

The aim of the research, which was to assess the impact of using Cellulose cardboard as a modification in a solar still, has been successfully achieved. The results obtained from the experimental setup consisting of two conventional solar stills, one representing the CSS reference and the other modified as MSS with Cellulose cardboard; demonstrate the positive effects of this modification.

The average basin water temperature of the MSS distiller is measured to be 37.66°C, while for the CSS distiller it is 35.8°C. This indicates that the presence of Cellulose cardboard contributes to an increase in the average water temperature, which is crucial for enhancing the distillation process and improving overall performance.

The research shows that the rate of improvement achieved by incorporating Cellulose cardboard in the MSS distiller is 19.8%. This improvement signifies the enhanced efficiency and effectiveness of the solar still in terms of water collection and production of pure water.

Declaration

- The authors declare that they have no known financial or non-financial competing interests in any material discussed in this paper.
- The authors declare that this article has not been published before and is not in the process of being published in any other journal.
- The authors confirmed that the paper was free of plagiarism.

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