Plenary communication

Three strange things in solar still

Abderrahmane Khechekhouche

Laboratory (LNTDL), Faculty of Technology, University of El Oued, Algeria
E-mail: khechekhouche-abderrahmane@univ-eloued.dz

Abstract
Solar stills are simple and cost-effective technologies for producing potable water, especially in remote or resource-scarce regions. However, their low productivity limits widespread adoption. This study investigates three unconventional modifications to conventional solar stills to improve or evaluate their performance. The first experiment incorporated plastic fins of varying diameters (0.5 cm, 1 cm, and 1.5 cm) into the basin, revealing that a 0.5 cm fin diameter significantly enhanced productivity, achieving 6176 ml/m² per day—a 41.4% improvement over the reference solar still (RSS), which yielded 4368 ml/m² per day. In the second experiment, natural sand from the El Oued South region of Algeria was used as a thermal absorber, unexpectedly reducing productivity by 1.46 times compared to the baseline. The third experiment utilized double-glazing with a 1 cm air gap, leading to a 56.52% reduction in yield. These results highlight the complexities of solar still optimization and emphasize the need for careful evaluation of design innovations to advance sustainable water purification technologies.

Keywords
Solar stills, water purification, plastic fins, evaporation rates, natural sand, double glazing, sustainable technologies, water scarcity, performance optimization, North Africa.

Introduction
Water scarcity is a critical global challenge, particularly in arid and semi-arid regions where access to clean and potable water is limited. Solar distillers, or solar stills, have emerged as a promising solution to this issue due to their simplicity, cost-effectiveness, and reliance on renewable solar energy. These devices harness the principles of evaporation and condensation to purify water, mimicking the natural hydrological cycle. Solar distillers are particularly advantageous in remote areas lacking access to advanced infrastructure or grid electricity, making them ideal for individual households, small communities, and emergency situations.
The concept of solar distillation is not new and can be traced back to the 16th century, with early designs aiming to desalinate seawater for maritime voyages. Over the years, technological advancements and growing concerns about sustainable resource utilization have revitalized interest in solar distillers. Modern designs incorporate innovations to enhance efficiency, productivity, and adaptability to various climates.
A solar distiller typically consists of a shallow basin filled with impure water, a transparent cover to allow sunlight to penetrate, and a collection system for the condensed water. Sunlight heats the water in the basin, causing it to evaporate. The vapor rises, leaving behind impurities such as salts and pathogens, and condenses on the cooler inner surface of the transparent

cover. The condensed water then flows into a collection channel, providing clean, potable water.
Solar distillers are used in diverse contexts. They provide a reliable source of clean water for communities in remote or disaster-affected areas. Purified water from solar distillers can also be used for irrigation or in greenhouses, and small-scale industries utilize solar distillation for processes requiring high-purity water. Furthermore, solar distillers are particularly effective in coastal and desert regions, offering an affordable means to convert saline or brackish water into freshwater.
Solar distillers have numerous benefits, including low operating costs, minimal maintenance, and the use of an abundant and renewable energy source. They also contribute to reducing carbon emissions and promoting sustainable water management. However, their adoption faces challenges such as relatively low productivity compared to conventional desalination methods, dependency on weather conditions, and the need for optimization to improve efficiency.
Ongoing research aims to address these challenges by exploring innovative designs and materials. Modifications such as multi-stage evaporation, integration of thermal energy storage, and the use of advanced materials for better thermal conductivity and condensation efficiency are being investigated. Solar distillers also serve as a valuable educational tool, raising awareness about renewable energy and sustainable practices.
In regions like North Africa, the Middle East, and South Asia, where water scarcity is a pressing issue, solar distillers offer a practical and sustainable solution. They align with global efforts to achieve the United Nations' Sustainable Development Goal 6, which focuses on ensuring access to clean water and sanitation for all. In conclusion, solar distillers represent a vital technology for addressing water scarcity through sustainable and eco-friendly means. With continued innovation and investment, they have the potential to play a significant role in achieving water security worldwide.
The objective of this presentation is to highlight three unconventional and unexpected phenomena observed during experiments in solar distillation, showcasing innovative design modifications that challenge traditional expectations. By examining these "strange things," the presentation aims to uncover the underlying factors behind these surprising outcomes, providing new insights into the complexities of evaporation, heat transfer, and condensation processes. The findings not only emphasize the importance of evidence-based approaches in optimizing solar still performance but also stimulate discussion and inspire future research in sustainable water purification technologies.

Methodology and results

1. **Plastic Fins for Enhanced Evaporation**

The first study investigated the role of surface tension in evaporation rates by introducing plastic fins into the basin of conventional solar stills. The fins, extending above the water layer, aimed to spread water over their surfaces, thereby increasing evaporation rates. Three designs were tested, each with different fin diameters: 0.5 cm, 1 cm, and 1.5 cm, and were compared to a reference solar still (RSS). The results were remarkable: the 0.5 cm fin diameter model (MSS1) achieved the highest productivity of 6176 ml/m² per day—a 41.4% improvement over the RSS, which produced 4368 ml/m² per day. These findings highlight the significant potential of optimizing solar stills through innovative design modifications.
Figure 1 illustrates the effect of surface tension in a solar still containing plastic cups. It can be observed that air bubbles tend to move towards the six cups, enhancing the water's exposure surface area and subsequently increasing its evaporation rate.

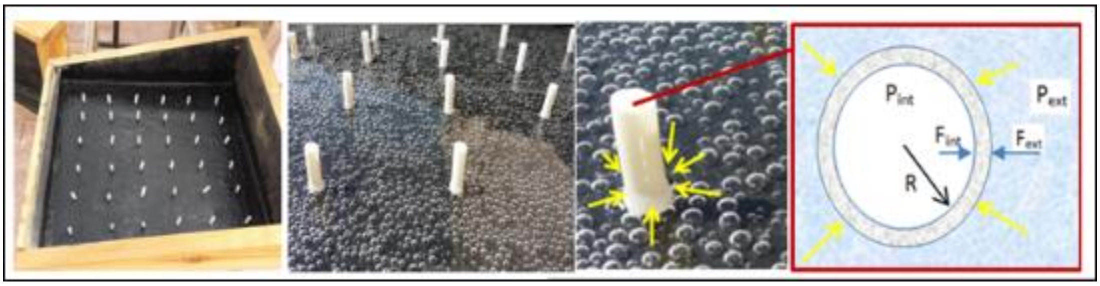

Figure 1. Surface tension in a solar still

2. **Natural Sand Integration: An Unexpected Outcome**

In the second study, natural sand dunes from the El Oued South region of Algeria were tested as a productivity enhancer for a single-slope solar still with a basin water thickness of 1 cm. The sand layer covered the entire basin surface, hypothesized to improve thermal absorption and enhance evaporation. Contrary to expectations, the results showed a 1.46-fold decrease in distilled water productivity compared to the baseline. This counterintuitive outcome suggests that sand's thermal properties or its interaction with water dynamics in the basin might hinder rather than help productivity, necessitating further investigation.

In Figure 2, a quantity of sand is introduced into the solar still. Here, the interaction between the sand grains and the water is notable. Water becomes trapped in the spaces between six sand grains, requiring significant energy to escape due to the physical entrapment. Additionally, hydrogen bonds form between the water molecules and the sand, necessitating extra energy to break these bonds before the water can evaporate. This dynamic highlights the dual challenges of water escape and bond dissociation in the presence of sand.

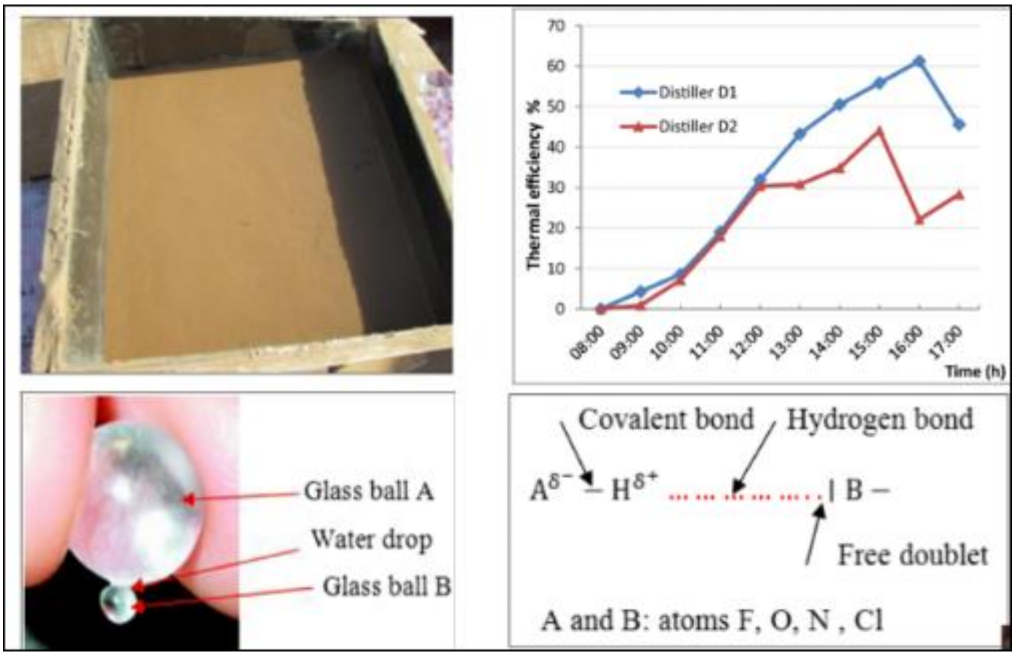

Figure 2. Use of dune sand in a solar still

3. **Double Glazing: A Misstep in Innovation**

The third experiment explored the use of double-glazing technology, commonly employed to improve thermal efficiency in solar collectors, applied to a solar still. A 1 cm gap between two glass covers was introduced in a distiller of 0.5 × 0.5 m dimensions. Surprisingly, this modification resulted in a 56.52% reduction in yield compared to the conventional solar still. This finding underscores the complexity of heat transfer and evaporation dynamics in solar stills and highlights the importance of targeted design modifications over straightforward technology transfers.
Figure 3 demonstrates the significance of the temperature gradient between the water and the glass cover in the solar still. Evaporation increases as this temperature difference grows. However, the figure shows an experiment where the glass temperature was equalized with the water, effectively minimizing the temperature gradient. In this setup, two layers of glass were superimposed, nearly eliminating the evaporation process due to the lack of a significant temperature difference. This highlights the critical role of maintaining a temperature gradient for effective water evaporation in solar stills.

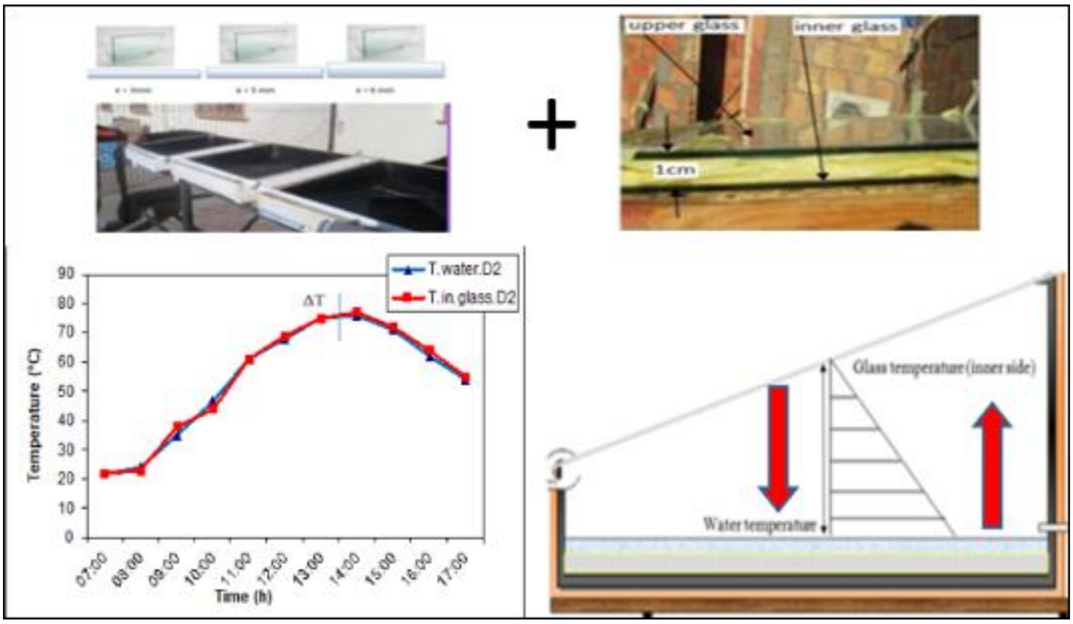

Figure 3. Temperature gradient effect in a solar still

Conclusion

This study provides valuable insights into the intricacies of solar still optimization through three unconventional experiments. The introduction of plastic fins with a 0.5 cm diameter resulted in the highest recorded productivity of 6176 ml/m² per day, a remarkable 41.4% improvement over the reference solar still's 4368 ml/m² per day output. This demonstrates the potential of innovative modifications to enhance solar still efficiency. Conversely, the integration of natural sand into the basin reduced productivity by 1.46 times, and the use of double-glazing technology caused a 56.52% yield reduction. These findings underline the importance of understanding the unique thermal and evaporation dynamics of solar stills. While the success of plastic fins offers a promising avenue for further development, the counterproductive results of sand integration and double glazing highlight the need for targeted and evidence-based design choices. This research contributes to advancing sustainable water purification technologies, particularly in addressing water scarcity in regions such as North Africa.

Reference

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