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"EXPERIMENTAL STUDY ON PRODUCTIVITY IMPROVEMENT OF SEMI-CYLINDRICAL SOLAR STILL"

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ABSTRACT

A semi tubular solar still is a compact and efficient device designed for the sustainable purification of water using solar energy. Unlike conventional flat-plate stills, the tubular configuration maximizes solar radiation capture due to its cylindrical geometry, enabling higher evaporation and condensation rates. This study explores the design, fabrication, and performance evaluation of a tubular solar still under typical climatic conditions. Key performance indicators such as daily water yield, thermal efficiency, and cost-effectiveness are analyzed. The experiments were conducted during the summer and winter seasons on semi- cylindrical solar still with a normal setup, rotating drum arrangement and stepped tray arrangement.. According to the findings, highest energy efficiency, while the normal setups and tray set up show the least. The graph compares the energy efficiency of drum, normal, and tray solar stills during summer and winter seasons. The drum solar still shows the highest efficiency in both seasons, achieving around 66% in summer and 52% in winter due to better heat absorption and retention. The tray solar still performs moderately, with efficiencies of about 50% in summer and 33% in winter, supported by its larger evaporation area. The normal still records the lowest efficiency, dropping to 48% in summer and 29% in winter because of limited thermal performance. Overall, the drum design provides superior and more consistent energy efficiency throughout the year.

Key Words: *Tubular still,, stepped tray, drum Solar, evaporation, yields.*

I. INTRODUCTION

The growing scarcity of potable water has become a critical global concern due to increasing population, industrialization, agricultural expansion, and climate change. Although the Earth is rich in water resources, the majority of this water is saline and unsuitable for direct human consumption. Desalination of seawater and brackish water has therefore emerged as an essential solution to meet freshwater demands, particularly in arid and semi-arid regions. However, conventional desalination technologies such as reverse osmosis and thermal distillation require high energy input, skilled operation, and significant investment costs. These limitations have encouraged the development of renewable energy-based desalination systems, among which solar distillation plays a prominent role.

A solar still is a simple and environmentally friendly device that uses solar energy to purify saline or contaminated water through evaporation and condensation. Traditional solar stills, such as single-slope and double-slope basin types, are easy to construct and maintain but suffer from low efficiency and limited freshwater production. To overcome these drawbacks, researchers have proposed various advanced designs, including stepped, wick, tubular, and semi-cylindrical solar stills. Among these, the semi-cylindrical solar still has gained significant attention due to its improved thermal performance and higher distillate yield.

The semi-cylindrical solar still is characterized by a curved, semi-cylindrical transparent cover placed over a basin

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containing saline water. This geometry allows for better solar radiation interception throughout the day, as the curved surface continuously aligns with the sun's position. Unlike flat glass covers, which experience higher reflection losses during certain hours, the semi-cylindrical cover reduces reflection and enhances transmittance of solar energy into the basin water. This leads to higher water temperatures, increased evaporation rates, and improved overall productivity.

Another major advantage of the semi-cylindrical solar still lies in its enhanced condensation process. The curved cover provides a larger effective condensation area compared to flat covers, enabling more efficient vapor condensation. The condensed water droplets flow naturally along the curved surface due to gravity and are collected through a condensate channel, resulting in higher freshwater output. Additionally, the uniform temperature distribution within the still reduces thermal losses and improves heat utilization.

Extensive experimental and theoretical studies have demonstrated that semi-cylindrical solar stills can achieve 20–40% higher freshwater production than conventional basin-type solar stills under similar climatic conditions. Furthermore, the performance of these systems can be further enhanced by integrating modern techniques such as phase change materials for thermal energy storage, nanofluids to increase thermal conductivity, fins and wick materials to enlarge evaporation area, and hybrid systems combined with solar collectors.

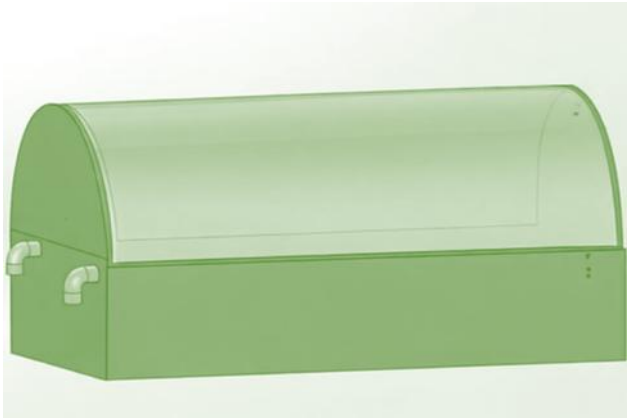

Figure.1 Semi cylindrical solar still

II. Experimental Setup

The experiment for the stepped tray SCSS is performed during summer and winter. The SCSS is fabricated in three parts: basin (GI sheet), middle part (MDF Board) as an insulator, and outer part made of plywood. The transparent glass cover is 5 mm thick. The Experiments are performed at Bhopal, the geographical location 23.2599° N, 77.4126° E. All the experiments are performed for 12 hrs between 7:00 hrs to 17:00 hrs. In solations are measured at different times for calculation purposes. The stepped trays are fabricated with galvanised iron sheets. The water depth inside the tray is maintained at 2 cm to perform experiments. Fig.2.1 mentioned the setup for the experiment.

Figure 2.1 Experimental Set up

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III. Results & Discussion

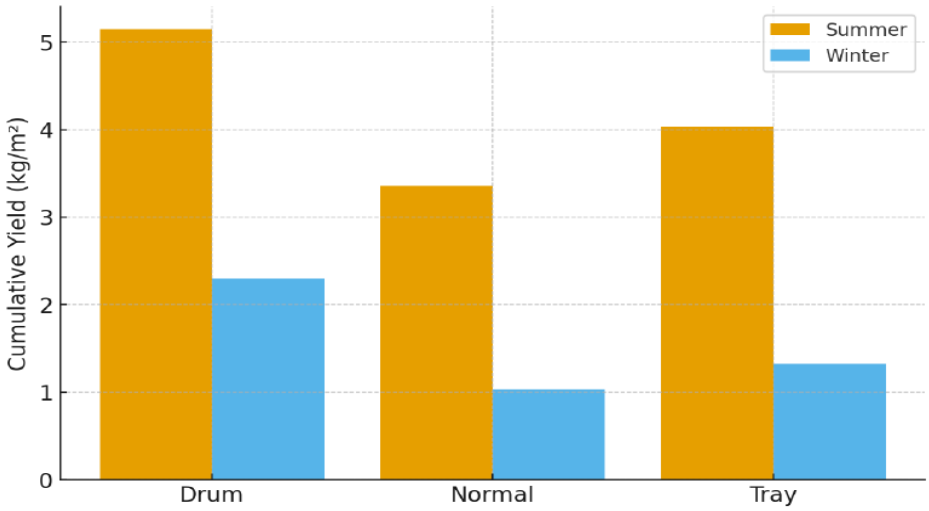

Figure 3.1 Comparative analysis of SCSS setups in summer and winter

The Energy efficiency of the SS in summer depends on different experimental setups, as shown in Fig. 5.8 for summer and winter. It is clear from the figure that the SCSS with the drum setup shows the highest energy efficiency, while the normal setups and tray set up show the least. The graph compares the energy efficiency of drum, normal, and tray solar stills during summer and winter seasons. The drum solar still shows the highest efficiency in both seasons, achieving around 66% in summer and 52% in winter due to better heat absorption and retention. The tray solar still performs moderately, with efficiencies of about 50% in summer and 33% in winter, supported by its larger evaporation area. The normal still records the lowest efficiency, dropping to 48% in summer and 29% in winter because of limited thermal performance. Overall, the drum design provides superior and more consistent energy efficiency throughout the year.

IV. Conclusion

Semi-Cylindrical solar stills offer a sustainable solution for freshwater production. With further research and optimization, they can significantly contribute to addressing global water scarcity. Semi-Cylindrical solar stills represent a promising and sustainable solution for freshwater production using renewable solar energy, particularly in regions facing water scarcity and limited access to conventional energy sources. New designs of the experimental setups are adopted by the scholars to enhance the yield of the SS. There are several experiments have been performed to increase the productivity of the SS. There are 3 experiments performed in summer and winter on the SCSS Setup. The aim behind these experiments is to find its fitment and suitability to fulfil the commercial and household requirements for potable water. The yield is calculated on the basin size of 1x1 m2. The results received for different setups are encouraging. During these experiments, some scrap and waste materials are also utilised to improve the performance of the SCSS. In this chapter, we will discuss the comparative analysis of all the experiments based on energy efficiency, cumulative yield, CPL. The experiments were conducted during the summer and winter seasons on semi- cylindrical solar still with a normal setup, rotating drum arrangement and stepped tray arrangement.

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