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SOLAR DESALINATION INNOVATIONS: A COMPARATIVE ANALYSIS OF PYRAMID AND INCLINED SOLAR STILL

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1. ABSTRACT

Domestic-scale solar stills are designed, manufactured, and examined for comparison. This study explores the practical investigations of two distinct solar still designs, namely the inclined and pyramid solar stills. These configurations encompass the conventional passive solar still, the actual daily yield of the inclined solar still is 71.9 ml/h, and the 113 ml/h from the pyramid solar still. So, the performance of pyramid solar still is better than inclined solar still.

2. INTRODUCTION

The rising cost and adverse environmental impacts associated with fossil fuels have compelled a shift towards renewable energy sources, as shown by the extensive adoption of solar energy worldwide. Solar energy has a wide range of uses, one of which is tackling the current crisis of water shortage. This issue is made worse by the increasing world population and the depletion of freshwater resources [1]. Desalination is an intriguing technique for addressing challenges connected to water scarcity [2].

Consequently, researchers have launched a number of initiatives aimed at developing novel designs for solar stills, particularly to improve their working properties, given that solar stills require no energy other than solar radiation [3]. Utilising solar stills can be vital to significantly increasing the availability of drinking water in dry countries like the Middle East and South Asia, which are marked by a lack of freshwater and high solar intensity [1].The processes of water evaporation and glass condensation are the main factors affecting the effectiveness of solar stills. Increasing the temperature difference between the water and the glass surface causes the water productivity to rise proportionately [4]

The maximum productivity attained was 2.3 liters per square meter every day, at a unit cost of 2.05 US cents per liter [5]. The efficiency of the solar still system is significantly affected by different factors.This comprehensive study makes a substantial contribution to the field of solar desalination and provides useful details about how to improve freshwater production in arid areas. By analyzing these cases, the best methods for utilizing solar energy to solve water scarcity problems can be found, leading to the development of long-lasting and eco-friendly solutions considering the changing global climate.

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3. METHODOLOGY

Two solar still systems were proposed: a single-slope solar still and a pyramid-shaped solar still. These systems incorporate both evaporation and condensation processes concurrently. The present investigation employs a hybrid system for water evaporation within a still tank, utilizing four distinct processes. Figure 1 presents the basic setup of inclined and pyramid solar stills. The fresh water productivity was examined both experimentally and theoretically in the analysis of the systems. The full daytime observations were recorded for several parameters including wind speed, ambient temperature, glass temperature, and basin water temperature with a depth of 0.02 m during average sunny days in July 2023 to test the proposed work.
A precise mathematical model has been formulated to represent heat transfer and associated energy processes accurately. The model incorporates key components essential for a comprehensive understanding of the system. The resulting equation serves as a valuable tool for quantifying the distilled water production. The heat transfer from the water to the glass cover through natural convection and evaporation is determined by calculating the heat flux.

$$q_c = h_c\left(T_w - T_g\right) = h_c \Delta T \quad (1)$$

The estimation of the distillate mass (freshwater) is determined by utilizing the calculated heat transfer coefficient (hc) and the partial pressure of water at both Pw and Pwg.

$$m_d = 9.15\times10^{-7} h_c (\mathrm{P}_w - P_{wg}) \quad (2)$$

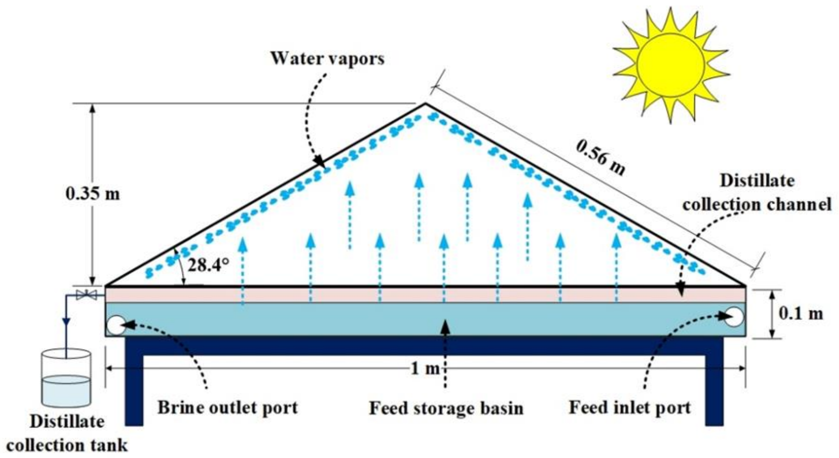

Fig. 1. The basic setup of the single and pyramid solar still [6].

4. RESULTS

Figure 2 presents the productivity comparison between conventional inclined & pyramid solar still. The productivity was noted maximum at mid day due to the maximum solar irradiance and temperature of the glass and basin. At 8:00 AM, the distillate water yield was 0 ml/h for both the conventional inclined and pyramid solar stills. By 2:00 PM, the yields were 140 ml/h for the inclined still and 225 ml/h for the pyramid still. Over 10 hours, the inclined still produced 719 ml (averaging 71.9 ml/h), while the pyramid still produced 1130 ml (averaging 113 ml/h).

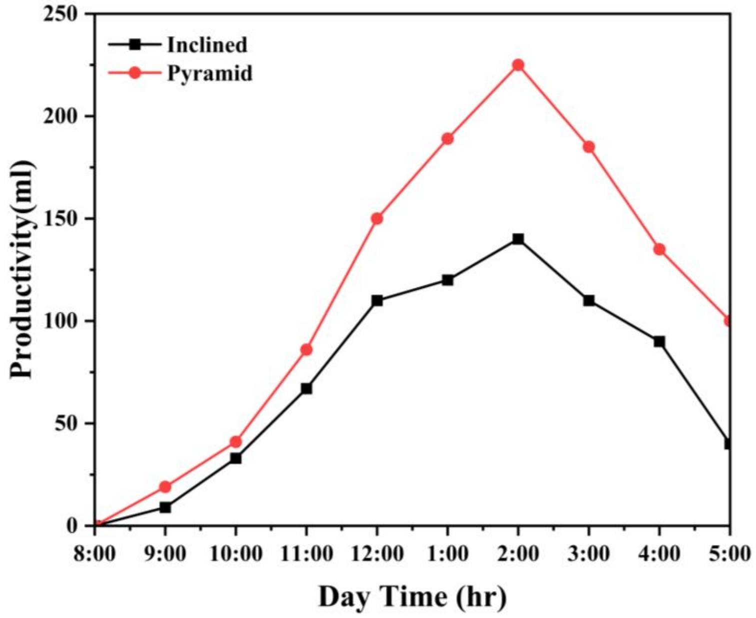

Fig. 2. Productivity comparison between conventional inclined & pyramid solar still.

5. CONCLUSIONS

The study presents practical experiments conducted on two types of solar stills: the inclined solar still and the pyramid solar still. The pyramid solar still performance is better than the inclined solar still and this productivity of solar stills can be improved by increasing the rate of evaporation and condensation.

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