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Proceeding Paper

Enhancing Fresh Water Production in Solar Parabolic Dish Desalination System †

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Abstract: This study presents a solar-powered parabolic dish desalination system with a solar tracking system and conical receiver. It efficiently transforms solar radiation into heat and evaporates saltwater, producing fresh water. The system is sustainable and affordable, making it a viable solution for water desalination in areas with limited access to fresh water. It achieves a high conversion rate from saltwater to fresh water, while consuming minimal energy. The results indicate that the system effectively utilizes solar energy, exhibiting high efficiency levels ranging from 78.56% to 82.77%, with an average efficiency of 80.79%. This system offers an effective solution to meet the growing demand for fresh water in water-scarce regions.

Keywords: desalination; solar dish; solar concentrator; parabolic reflector; thermal performance; tracking system

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1. Introduction

The increasing demand for fresh water due to industrialization and population growth has led to a severe limitation of drinking water resources worldwide, with an estimated 1.8 billion people suffering from water shortages by 2025. To meet this demand, international societies are seeking alternative resources, such as the desalination of saline waters, including ocean waters and brackish waters of lakes and other sources [1–3]. However, today's enormous desalination plants consume a lot of energy to supply fresh water, which cannot be met in many locales due to the high energy costs or the scarcity of affordable energy [4,5]. Additionally, the high energy consumption of traditional desalination plants contributes heavily to global warming, exacerbating current water shortages and not being sustainable in the long term.

This literature review indicates that solar parabolic dish desalination systems with dual-axis tracking mechanisms and conical receivers have gained considerable attention in the field of solar desalination. The integration of efficient tracking mechanisms and optimized conical receiver designs contributes to improved energy capture and enhanced thermal performance [6–9]. This study also reports efficient fresh water production via an exploration of the system's performance over an extended period, especially under varying environmental conditions, could be valuable. Understanding the system's durability, maintenance requirements, and potential degradation of materials over time due to exposure to saltwater and excess heat is essential for its practical implementation.

Further research is needed to address technical challenges, optimize the system parameters, and explore potential commercialization avenues for this technology. Solar parabolic dish desalination shows great promise as an efficient and sustainable solution that is cost-effective and accessible to address water scarcity in various regions [10–14].

2. Materials and Components

This system utilized a point-focus parabolic solar dish with a two-axis sun tracker system. This included a Light-Dependent Resistor (LDR) situated on top of the dish and linked to a microcontroller to control the dish rotation according the sun position (materials were purchased from a local market). The concentrator reflected sun rays onto the receiver (focal point of the parabolic dish). This resulted in an increase in fluid temperature inside a conical cavity receiver comprised of black-coated copper tubes that could withstand high heat levels [15]. The system also included water storage containers for storing both brackish and desalinated water.

3. Methodology

The dish is parabolic in shape, which enables it to concentrate the incoming solar radiation onto a single point, the conical receiver. The specifications of different components of solar parabolic dish are given below in Table 1.

Table 1. Details and specifications of different components.

Sr.	Components	Specifications
1	Parabolic Dish	Diameter = 8 ft
2	Shape	Parabolic
3	Rated Load Rate	10 mm/s
4	Working Stroke	100 mm
5	Power Supply	5 V–35 V
6	Peak Current	2 A
7	Controlling Level	Low = 0.3 V 1.5 High = 2.3 V 55
8	Maximum Power	25 W

The conical receiver is located at the focal point of the dish and is made of copper and stainless steel. This material is used because it is not only a good conductor of heat, but it is also resistant to corrosion during exposure to saltwater.

The receiver is designed in a conical shape because it facilitates the even distribution of saltwater over its surface, which ensures uniform heating and evaporation. To obtain fresh water from saltwater, the conical receiver heats the saltwater as it is concentrated by the parabolic dish. This heating causes the water to evaporate and form steam, which is then collected with a condenser. The condenser is a heat exchanger, which uses cold water to reduce the temperature of the steam, thus causing it to condense and form fresh water. The fresh water is then collected and stored in a separate container, ready for use. The solar tracking system used in this design ensures that the dish is always pointed directly at the sun, optimizing its efficiency. The system relies on a microcontroller that uses real-time data from light sensors to determine the optimal position of the dish. The microcontroller then adjusts the position of the dish using a linear actuator, ensuring that the dish is always pointed towards the sun. A schematic diagram and the experimental setup are given in Figures 1 and 2, respectively.

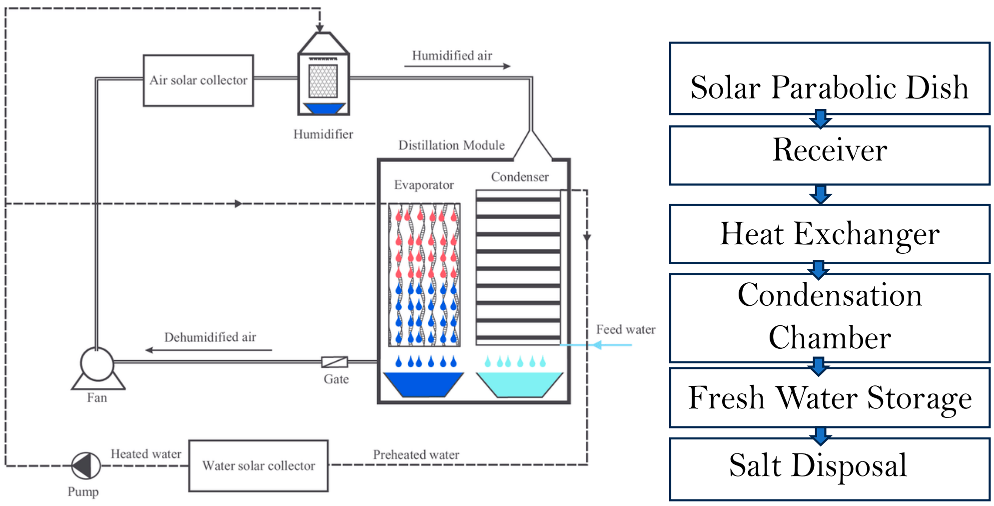


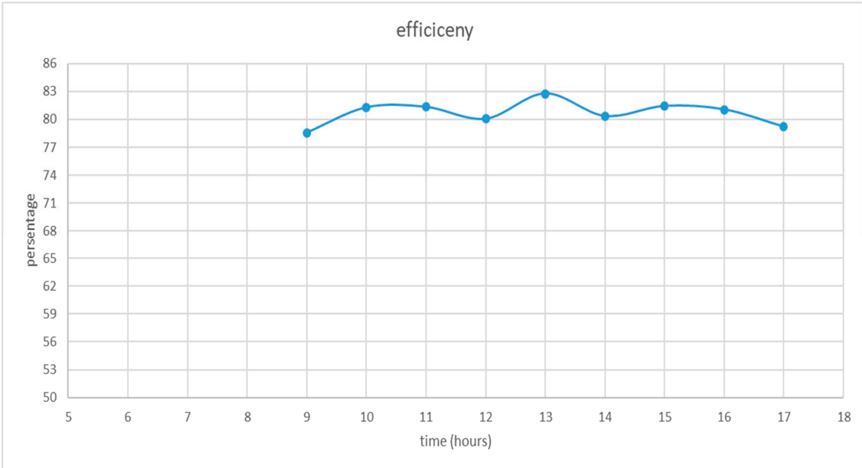
Figure 1. Systemic diagram.

Figure 2. Experimental setup for solar parabolic dish.

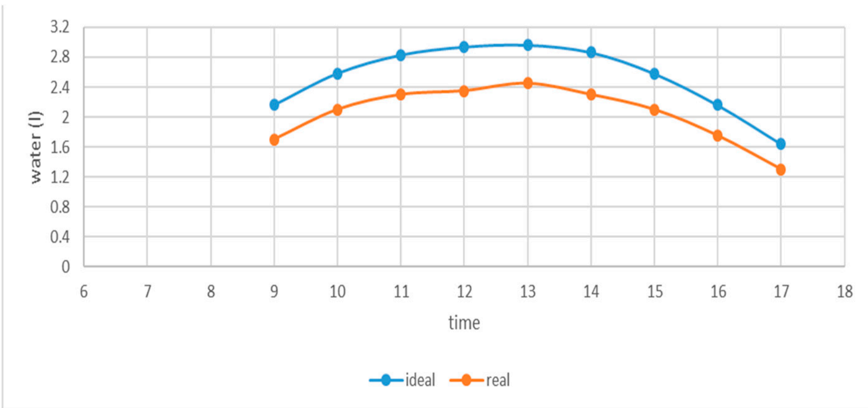
4. Results and Discussion

The solar parabolic dish desalination system was able to successfully desalinate liters of 21 L water per day with a high level of efficiency. The system utilized a parabolic dish collector to concentrate the solar energy and heat up the water to produce steam. The steam was then condensed to produce clean, fresh drinking water. The solar parabolic dish desalination system was evaluated based on the experimental data obtained during the testing phase. The system's performance was measured in terms of solar radiation intensity, water production, and efficiency [16].

The solar radiation intensity varied throughout the day, ranging from a minimum of 217 W/m^2 at 18:00 to a maximum of 606 W/m^2 at 13:00. The water production of the system was recorded for each hour of operation, with values ranging from 1.0599 L at 18:00 to 2.9600 L at 13:00, where the average production of water totaled 10.5 L for the period from 9 a.m. to 3 p.m., and the daily production of water totaled 21 L. To assess the efficiency of the system, the experimental water production values were compared to the theoretical water production values. Theoretical water production was calculated based on the solar radiation intensity using a conversion factor of 1.75 L per hour per square meter of solar radiation. The efficiency of the system was then calculated as the ratio of experimental water production to theoretical water production multiplied by 100. The efficiency of the solar parabolic dish desalination system varied throughout the day, with values ranging from 78.56% at 9:00 to 82.77% at 13:00. Overall, the system demonstrated an average efficiency of 80.79% during the testing period. It is important to note that at 18:00, the water production total was recorded as 0 L, resulting in an efficiency value of 0%. This can be attributed to the low solar radiation intensity during that time, which was insufficient to drive the desalination process. These results indicate that the solar parabolic dish desalination system effectively utilized solar energy to produce fresh water. The system exhibited high efficiency levels, ranging from 78.56% to 82.77%, with an average efficiency of 80.79% during the testing period, and these results align with those in [1,2,16]. The data suggest that the system performed well, considering the variations in solar radiation intensity throughout the day, as shown in Figure 3a,b.



(**a**)



(**b**)

Figure 3. (**a**) Relationship between efficiency in percentage and time; (**b**) relationship between ideal and real water values with respect to time.

5. Conclusions

The experimental results align reasonably well with the theoretical values, demonstrating the feasibility and effectiveness of the solar parabolic dish desalination system. The high efficiency levels indicate that the system has the potential to provide a sustainable and cost-effective solution for fresh water production in regions facing severe water scarcity as it has saved thirty five percentage of PKR as compared to that of the solar membrane distillation systems with 10.75 L capacity. The results of this study highlight the potential of the solar parabolic dish desalination system as a promising technology to address the global water scarcity challenge. The high efficiency levels and reliance on renewable solar energy make it an attractive and sustainable solution for fresh water production.

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