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Research Article

Study and Design of a Double-Sloped Solar Distiller, An Environmentally Friendly and Economical Solution for Arid Regions

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ABSTRACT

Introduction: Access to drinking water has become a major global challenge, exacerbated by increasing pressures on water resources in arid and semi-arid regions. Faced with this problem, solar distillation technologies are emerging as promising solutions for producing pure water from renewable natural resources, such as solar energy. This work focuses on studying the performance of a double-slope solar distiller, designed and experimentally tested in Algeria.

Objectives: The objective of our work is the design and implementation of a double-slope solar distiller, exploring the materials used as well as the different stages of the design and manufacturing process of the double-slope solar distiller. The positive environmental impact of this solution is also highlighted, especially in isolated areas lacking drinking water.

Methods: The experiments were conducted at the northern Algeria. All experiments were performed using a single solar still with two slopes that we designed ourselves. The experiments took place in the same location, with the same position, but with different start times, different types of water, and, of course, under different weather conditions. To better understand the function of the still, we measured the temperature in several parts of the still, in addition to measuring the wind speed and the solar radiation falling on the still's glass. Two tests were carried out, with different water characteristics.

Results: The production of distilled water is influenced by several factors, including solar radiation, the temperature gradient between the water temperature in the basin and the transparent cover, the geometry of the device, and meteorological parameters. The variation in our daily production was monitored for the two trials conducted. For test n°1: the weather conditions were very favorable for collecting a significant quantity of distilled water; maximum sunshine was observed, which promoted solar distillation. For test n°2: the weather conditions were also favorable for collecting a significant quantity of distilled water, averaging 400 ml.
Once the water was distilled, a considerable decrease in TDS (Total Dissolved Solids) was observed, reaching 75.46%. A slight decrease in pH of approximately 0.8 was also noted, due to the loss of dissolved mineral salts and alkaline substances. A decrease in conductivity of 75.66% was also observed after distillation, due to the removal of inorganic salts. Similarly, a decrease of 74.5% in salinity was observed, due to the separation of pure water from the dissolved salts remaining in the unevaporated portion of the water, which was 0.02% in most tests.

Conclusions: In conclusion, this thesis aims to contribute to the advancement of knowledge on sustainable drinking water production technologies, focusing specifically on the efficiency of a double-slope solar still in a localized context. By providing empirical data and in-depth analysis, our study will serve as a reference for the development and adoption of similar technologies in regions facing water security challenges.

Keywords: drinking water, arid regions, solar distillation, solar energy, water security.

INTRODUCTION

One of a person's basic needs is access to clean drinking water. Due to the limited supply of potable water on Earth,

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guaranteeing water availability for society is difficult [1]. Water shortages can be alleviated in remote areas with abundant sunlight through the use of solar desalination equipment; evaporation and condensation are the basic principles of its operation.

Solar distiller theory is a field of study that examines the principles and applications of this distillation technology using solar energy. This work aims to provide a detailed understanding of how solar distillers work, their different types, and their advantages and disadvantages. It also explores the various applications of this technology, such as its use in arid regions, drinking water production, and industrial applications. Furthermore, it examines the factors influencing the efficiency of solar distillers and their environmental impact. Finally, it presents future prospects for improving the efficiency of solar distillers and integrating them into energy production systems. A solar distiller is a device that uses solar energy to heat water and convert it into steam, which is then condensed into distilled water. Essentially, it is a water purification system that removes contaminants and impurities, leaving high-quality water. The operation of a solar still relies on the principles of evaporation and condensation, where solar heat causes water to evaporate, and this vapor then condenses to form pure water. Therefore, the solar still can be considered a sustainable solution for producing drinking water in regions where access to fresh water is limited[2].

The solar distiller is of significant importance due to its ability to provide drinking water in arid regions where freshwater resources are scarce. It purifies water by removing salts, heavy metals, and other contaminants, thus offering a clean and safe water source. Furthermore, this technology offers environmental benefits, as it reduces freshwater consumption and water pollution. Its use can also reduce greenhouse gas emissions. The importance of the solar distiller therefore lies in its ability to provide a clean, sustainable, and environmentally friendly water source.

The operating principle of a solar distiller is based on the conversion of solar energy into heat. The solar energy captured by the glass pane is absorbed by the water and the basin, increasing their temperature and causing evaporation. Because the temperature of the canopy in contact with the atmospheric air is lower than that of the air-water vapor mixture, the water vapor condenses on the inner surface of the inclined canopy. The distilled water thus produced flows along a thin film to be collected separately [3].

OBJECTIVES

Algeria is one of the most water-scarce countries. Due to its location in the Middle East and North Africa (MENA) region and the fact that almost all of its territory (87%) is classified as desert, the average annual rainfall varies from 1600 mm in the far northeast to 12 mm in the far southwest. However, the average rainfall across the country, across all zones, is only around 89 mm. The chart indicates that during the 2019/2020 hydrological year, the rainfall deficit reached 30% compared to the previous year. Consequently, Algeria is ranked among the 13 African countries most affected by water scarcity (National Meteorological Office) and is also classified as a water-poor country, very close to a crisis situation. The largest solar resource in the Mediterranean basin is located locally in Algeria. The Mediterranean basin suffers from poor physical and hydro-climatic characteristics that make it difficult to use solar energy for purposes such as desalination. Solar distillation of brackish water and seawater can provide drinking water, particularly in dry or semi-arid regions, on the scale of a family or even a small town [2].

The objective of this work is the experimental construction of a double-slope solar distiller and to study its thermal performance and efficiency in producing distilled water that meets drinking water standards.

METHODS

Solar distillation, an environmentally friendly and inexpensive method, is proving to be an innovative and sustainable solution to address water scarcity in certain regions of the world. The design of a solar distiller, focusing particularly on the double-slope model, is a device that uses the sun's energy to purify water. Solar distillation systems can be made with readily available local materials and require absolutely no maintenance or ongoing costs. Various models of solar distillers are used to increase the efficiency and productivity of the distillate. The simple design of the simple double-slope solar distiller—our chosen model—consists of a basic configuration that allows for the separation and purification of water using solar distillation principles [4]. This model of solar distiller works by capturing solar energy to heat the contaminated water, causing it to evaporate. The water vapor, now free of impurities, then condenses on the inclined surfaces of the distiller and is collected as distilled water. This type of model is

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distinguished by its two opposing slopes, which allow for better condensation capture and increased efficiency. The various components of the distiller are shown in Figure 1.

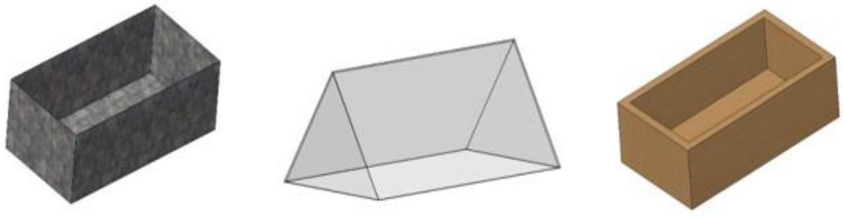

Figure 1 : Components of the solar distiller

1. Description of the Distiller Geometry

The model includes a lower tank, the absorption tank designed to hold the brackish water, topped by two sloping glass panels forming a pitched roof, allowing for the condensation of water vapor. A base structure supports the entire assembly, and a channel is provided at the base of the glass panels for collecting the distilled water. The angle of the glass panels promotes the gravity flow of droplets towards the lateral collectors [5].

a- Absorbent Tank (Simple)

The absorption tank's main function is to efficiently capture incident solar radiation. The thermal energy generated by this absorption is then transferred to the brine via convection. To improve its performance, its surface has been painted matte black, which maximizes absorption through a thermal selectivity effect. This tank is primarily made of galvanized sheet metal and assembled by welding.

b- Glass roof:

The glazing adopts a pyramidal shape with a rectangular base, which optimizes the absorption of solar radiation. The heat from solar radiation is entirely captured by a black material, thus accelerating the evaporation process. Our device offers significant improvements thanks to the optimized geometry of the glazing and better insulation inside the distiller [6].

c- Wooden box:

This is a piece of wood designed to fit the shape of the distiller while protecting the thermal insulation.

d- Thermal insulation:

In most cases, polystyrene is used for the thermal insulation of the distiller. It is essential that the materials used withstand the operating temperatures [7].

e- System assembly:

The main assembly was carried out by integrating all the components of the distiller. Figure 2 shows the model of our distiller. Our solar distiller is strategically positioned at the latitude of 36.8085621° N and the longitude of 7.7173993° E, in Algeria[2].

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(a) In drawing form (b) actual construction

Figure 2: Simple double-slope solar distiller

The weather conditions for the five days of June are shown in Table 1.

Table 1 Weather conditions on the days of the experiments.

	19/06/2024	20/06/2024	22/06/2024	23/06/2024	24/06/2024
Sunrise	05 :10	05 :10	05 :11	05 :11	05 :11
Sunset	19 :50	19 :50	19 :50	19 :50	19 :50
Ambient temperature	25 - 40 °C	20 - 41 °C	16 - 29 °C	18 - 25 °C	19 - 25 °C
Humidity	37.8 %	46 %	50.2 %	60 %	51.2 %
Wind speed	25 km/h	18 km/h	25 km/h	19 km/h	16 km/h

RESULTS

Our experimental section aims to evaluate the prototype's effectiveness and identify factors that positively influence the productivity of distilled water, thereby avoiding factors that negatively impact solar water distillation [8].

1. Monitoring the variation of solar radiation over time:

On the test day, it was a sunny day, with sunrise at 5:10 AM and sunset at 7:50 PM. The variation of solar radiation over time is shown in Figure 3.

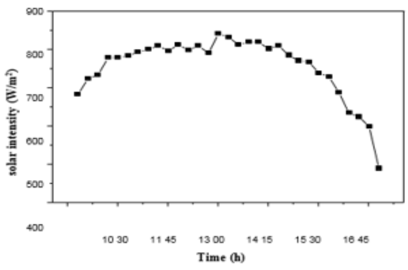

Figure 3 : Sunstroke during the day

2. Monitoring wind speed variation over time:

Air movement affects solar efficiency; the higher the speed, the greater the contribution to cooling, and consequently, the higher the distiller's output. Table 2 summarizes the wind speed variation throughout the test day. The speeds vary between 0.2 m/s and a maximum of 3.77 m/s.

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Table 2: Wind speed variation throughout the day

Standard Deviation	Sum	Minimum	Median	Maximum
0,81203	33,5	0,2	0,8	3,77

3. Monitoring the temperature variation in the middle of the insulation over time

It is known that the lower the thermal conductivity of the insulation, the better the distiller's efficiency. Figure 4 shows the temperature changes in the insulation (polystyrene), which reaches its maximum value between 12:00 and 14:00.

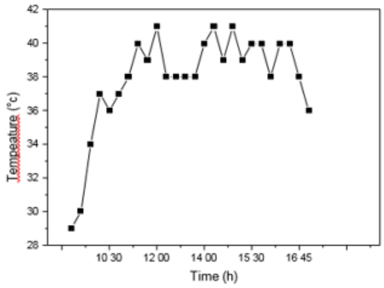

Figure 4: Temperature variations in the middle of the insulation

4.Monitoring the temperature variation of the glazing over time:

Figure 5 shows the evolution of the glazing temperature. All measurements are above 30°C, with a maximum temperature of 47°C at 2:00 PM. The temperatures are almost the same on both sides of the glazing (left and right).

5. Monitoring of water and air temperature variation inside the pool:

Figure 6 shows the evolution of water and air temperature in the pool. All measurements are above 40°C, with a maximum temperature of 53°C at 13:30 and 47°C at 14:00, respectively.

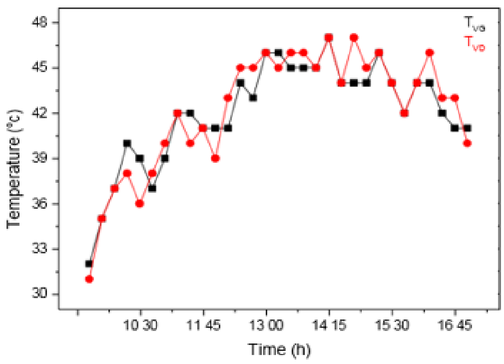

Figure 5: Variation of left (TVG) and right (TVD) glazing temperature over time

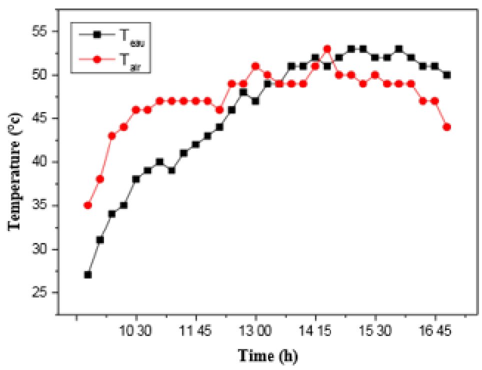

Figure 6: Variation in water and air temperature inside the basin.

6. Quantity of Distilled Water

Distilled water production is influenced by several factors, including solar radiation, the temperature gradient between the water temperature in the basin and the transparent cover, the geometry of the device, and meteorological parameters. Table 3 shows the variation in daily production of our distiller for the two tests conducted. In the test where weather conditions were very favorable for collecting a significant quantity of distilled water, maximum sunshine was observed, which promoted solar distillation [9].

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Table 3: Variation in the amount of distilled water accumulated

Day	**Cumulative Production (ml)**
19/06/2024	660
20 et 21/06/2024	1160

DISCUSSION

This work presents the experimental evaluation of the main parameters influencing the operating characteristics of a double-slope solar still. The temperature curves follow the same trend as solar intensity: they begin to rise in the morning, reach their maximum at midday, and then decrease again in the evening [10]. The water temperature in the still becomes slightly higher than the ambient air temperature after a few hours of exposure to solar radiation, due to the greenhouse effect inside the still [11]. The temperature of the glazing is lower than that of the water in the still due to convective heat exchange with the outside air, thus creating a temperature difference conducive to condensation. Solar intensity values were high from the early hours of the day, reaching their peak in the afternoon and following a downward curve, except for the third day when cloudy weather persisted until 3 p.m. Daily water production is higher when solar radiation is more intense [12]. The results obtained showed a daily production of 650 ml of distilled water. Water distillation clearly depends on incident solar energy, the absorbing surface area, and ambient temperature, as shown by the analysis of the thermal behavior of the distiller observed in Figure 3. There is also a significant temperature gradient between the water table and the glass [13], which promotes condensation and evaporation, as confirmed in Figures 4, 5, and 6.

The problem of producing fresh water using solar energy is important from two perspectives: the need to conserve energy and the need to secure new water resources [1]. In conclusion, our prototype double-slope solar distiller offers significant and appreciable results given the daily production of distilled water collected.

REFRENCES

[1] Océane Bidault « Comment protéger nos ressources en eau ? » article de WaterLogic 23/05/2017.

[2] « L'innovation une problématique de la gestion de l'eau en Algérie Innovation a problem of water management in Algeria » ElWahat pour les Recherches et les Etudes Vol.13 (N°1), (2020) :1264-1285.

[3] A. Safwat Nafey, M. Abdelkader, A. Abdelmotalib, A.A. Mabrouk; Paramètres affecting solar still productivity. Energy Conversion & Management Vol 41 (2000). pp.1797-1809.

[4] M. Malik, G.N. Tiwari, A. Kumar , M.S. Sodha ; Solar distillation. Oxford, UK Pergamon Press ; Vol.2 (1982). pp. 8–17.

[5] KAABI ABDERNACER, SMAKADJI NAFILA. Impact of temperature difference (water solar collector) on solar-still global efficiency. Desalination. PP 229-300, 2007.

[6] M. Boukar, A. Harmim. Parametric study of a vertical solar still under desert climatic conditions. Desalination, Vol 168, 2004, Pages 21-28.

[7] Wiener, J., Khan, M.Z. & Shah, K. Performance enhancement of the solar still using textiles and polyurethane rollers. Sci Rep 14, 5202 (2024).

[8] Dudul Das, Urbashi Bordoloi, Pankaj Kalita, Robert F. Boehm, Akash Dilip Kample, Solar still enhancement techniques and recent developments. Vol 10, 2020.

[9] Shahin Shoeibi, Nader Rahbar, Ahad Abedini Esfahlani, Hadi Kargarsharifabad. A comprehensive review of Enviro-Exergo-economic analysis of solar stills. Renewable and Sustainable Energy Reviews. Vol 149, 20

[10] K. Kalidasa Murugavel, S. Sivakumar, J. Riaz Ahamed, K. Srithar; Single basin double slope solar still with minimum basin depth and energy storing materials. Applied Energy 87 (2010) 514–523.

Journal of Information Systems Engineering and Management
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Research Article

[11] Ayoub, G.M., L. Malaeb, and P.E.J.S.E. Saikaly, Critical variables in the performance of a productivity-enhanced solar still. 2013. 98: p. 472-484.
[12] Rajaseenivasan, T., Elango T., and Murugavel K. K., Comparative study of double basin and single basin solar stills. 2013. 309: p. 27-31.
[13] Shankar, P., S.J.V.I.J.o.M. Kumar, Automobile, and P. Engineering, Solar distillation–A parametric review. 2012. 2(1): p. 17-33.