Theoretical Investigation for the Influence of Various Parameters on the Performance of a Novel Concentration-Based Solar Desalination System

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Abstract

This study aims to investigate the influence of various parameters on the freshwater yield and efficiency of a novel concentration-based solar desalination system. The system performance under the summer and winter climatic conditions of Rabat city, Morocco is evaluated. The design parameters are glass cover thickness, absorber basin thickness, brackish water mass, and absorber basin material. The climatic parameters are wind velocity, ambient temperature, and solar radiation. Numerical studies on different system parameters are done by examining the effect of system component parameters on the system performance. Through the MATLAB code, the equations for the freshwater yield and efficiency of the new system are constructed and solved. The results show that the system gives the best performance with 6 mm glass cover thickness, 2 mm absorber basin thickness, and 40 kg brackish water mass.

Keywords: solar desalination system, parabolic trough concentrator, design parameters, freshwater yield, system efficiency

1. Introduction

Water is an essential element for the life of living organisms on the face of the Earth. By using clean water, humans get an environment free from diseases and the spread of epidemics. In many arid places of the world, freshwater scarcity has been a vital problem and additional water supplies will become important in the future. Seawater desalination is typically seen as a dependable solution in arid places for meeting the constantly increasing needs for water caused by population growth as well as economic and social changes and for reducing the reliance on groundwater supplies [1]. Desalination is one of the primitive forms of water handling, and it remains a common treatment solution around the world today [2]. Desalination of sufficient seawater is regarded as one of the most important technical solutions to water scarcity in many areas of the world [3].

In previous research, some researchers have studied solar distillers without concentrator technology, and others have studied them with concentrator technology and with different designs. In this research, a new design in which a parabolic trough concentrator (PTC) is under the solar desalination system is developed. After that, the effect of design parameters (glass cover thickness, absorber basin thickness, brackish water mass, and absorber basin materials) and climatic parameters (wind speed, ambient temperature, and solar radiation) on the performance of the developed system is studied. Some researchers have done recent review studies of different desalination systems using nuclear desalination [4] and microbial desalination cells (MDCs) [5].

In this research, the influence of various parameters on the freshwater yield and efficiency of a novel concentration-based solar desalination system is theoretically investigated to evaluate the performance of the system under the summer and winter climatic conditions of Rabat city, Morocco. The parameters of glass cover thickness (2, 4, and 6 mm), absorber basin thickness

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(2, 4, and 6 mm), brackish water mass (40, 60, and 80 kg), and absorber basin material (aluminum and copper) are the design parameters, and the parameters of wind velocity, ambient temperature, and solar radiation are the climatic parameters. Numerical studies on different parameters of the system are done by examining the effect of system component parameters on the system performance. Through the MATLAB code, the equations for the freshwater yield and efficiency of the new system are constructed and solved.

2. Literature Review

Many research and review articles have been written about solar stills and the various parameters that influence the performance of solar distillation. Nguyen [6] investigated the factors that influence the stills' distillate yields, including subjective factors (i.e., design elements and operation factors) and environmental factors (i.e., external or natural factors) for conventional passive solar stills and active (forced circulation) stills with enhanced heat recovery. The results showed that the distillate outputs of solar stills were increased from 30% to 68% compared with traditional distillation systems. Azooz and Younis [3] demonstrated the performance of ten solar stills with various glass inclination angles in an experimental study. The inclination angles chosen are 10°-55° in 5-degree increments. Experimental results proved that the angles between 30° and 35° are associated with the worst still performance, while those between 20° and 25° provide the best clean water productivity and cost-effectiveness.

Younis et al. [7] proposed a solar distillation model and tested it using the parameters listed below: water depth (6, 9, and 12 cm), water salinity (28, 35, and 58 mmoh/cm), cover thickness (2, 4, and 6 mm), daylight percentage (43.7, 47.4, and 52.1%), solar radiation, relative humidity, ambient air temperature, and wind speed. The results showed that at 6 cm water depth, 6 mm glass cover thickness, 28 mmoh/cm water salinity, and 52.1% daylight percentage, the maximum distillation yield was around 5 L/m^2.day. Bouzaid et al. [8] proposed and evaluated a new solar still with a stepped-slope absorber plate and baffles, as well as its productivity impact. The findings demonstrated that by introducing new modifications, the thermal performance of the modified stepped solar still can be significantly improved.

Gawande and Bhuyar [9] tested three different stepped-type solar stills with different absorber surface areas due to differences in the shape of the basin surface, which were flat, concave, and convex, respectively. It is found that the average daily water production for the concave and convex type stepped solar stills are 29.24% and 56.60% higher than that of flat type stepped solar still, respectively. Islam et al. [10] investigated how the heat removal factor, collector efficiency factor, mass flow rate, and collector aperture area affect the collector thermal efficiency in a parabolic-trough concentrating solar system. For the study, three fluids were used: carbon dioxide, ammonia, and nitrogen. For a concentrator with a 1.5 m aperture and 2 m length, the optimum receiver size (diameter) (providing the highest efficiency) was discovered to be 51.8 mm. With different mass flow rates of 0.0192 kg s^{-1}, 0.0362 kg s^{-1}, and 0.0491 kg s^{-1} for ammonia, nitrogen, and carbon dioxide, respectively, the maximum collector efficiencies were 67.05%, 66.81%, and 67.22% at the same aperture area of 2.836 m^2.

Panchal and Patel [11] carried out a comprehensive review to study the effect of various design parameters (water depth, condensing cover material, thickness and inclination, and type of solar still), climatic parameters (wind velocity, ambient temperature, and solar radiation), and operational parameters (salinity of water) on the distillate yield of solar stills. It is found that the lower condensing glass cover thickness, minimum brine depth, high intensity of solar radiation, and increasing wind speed give the better yield of the solar stills. Also, the larger cover tilt angle should be preferred in winter and a smaller angle should be preferred in summer.

Senthil et al. [12] carried out an experimental comparison between the cavity surface contour and plain surface contour of the solar absorber surface to investigate the impact of design parameters on the thermal performance of concentrated solar collectors. The results proved that the contoured plain surface produces a little uniform temperature distribution and a lower rate of heat

absorption than the cavity surface. The energy efficiency of the plain surface absorber and the cavity surface absorber is 61.84% and 67.65%, respectively. Hoque et al. [13] conducted experimental investigations for the effect of the basin water amount and salt concentration on freshwater production of solar still for saline water desalination for low-income coastal areas in the context of Bangladesh. Experimental studies show that when the amount of basin water increases, the water production decreases, and when the salt concentration in the water to be desalinated decreases, the freshwater production increases.

Goshayeshi and Safaei [14] carried out an experimental study for the effect of two basin geometries (flat and convex) at different inclination angles of the cover on the heat transfer and effectiveness of the desalination process for stepped solar stills. The results revealed that the maximum heat transfer and more desalination processes take place in the convex solar still. The solar still performance improved as the angle was increased from 25° to 35°. The best angle of inclination for solar stills is 32.5° to the horizontal axis. Al-Othman et al. [15] conducted a simulation study of a multi-stage flash (MSF) desalination plant that works utilizing the solar pond and parabolic trough collectors to completely satisfy the energy requirements in the United Arab Emirates (UAE). The findings indicate that two PTCs with a total aperture area of 3160 m2 can supply 76% of the MSF energy needs. A solar pond with a 4-meter depth and a surface area of 0.53 km^2 provides the remaining.

Tawalbeh et al. [16] presented a detailed review of pressure current delayed osmosis (PRO) when mixing two streams of different salinities and when generating Gibbs-free mixing power. Some technical problems were studied, namely (1) membrane material, (2) water transfer in the membrane, (3) process efficiency, (4) fouling, and (5) technical-economic feasibility. The efficiency and energy density of PRO are directly affected by several process parameters such as temperature, feed concentration, membrane type, and draw solution type. This review showed that the power density that can be harvested from PRO is controlled by numerous variables, including membranes, which have attracted a lot of attention in the literature. Studies showed that with the development of the proper membrane, power density can be boosted by orders of magnitude from about 2 W/m^2 to 47 W/m^2. This research indicated that PRO is still dealing with several issues that must be addressed.

From the literature survey, it has been demonstrated that changing design parameters and climatic parameters have a significant impact on the system performance. In this research, the effect of design and climatic parameters on the new system's performance will be investigated.

3. Thermal Analysis

Fig. 1 indicates a schematic depiction of the proposed novel concentration-based solar desalination system. The distiller's half-cylinder basin diameter is 0.3 m and it is made of a black-painted aluminum sheet with a thickness of 0.004 m. It is located in the focal line of PTC, which is 1 m from the vertex (V) and 2.25 m from the system aperture (W). The rim angle of the system is 58.72°. The basin is half-cylindrical in shape to help collect desalinated water and to reflect the sun's rays from the solar concentrator system installed on it.
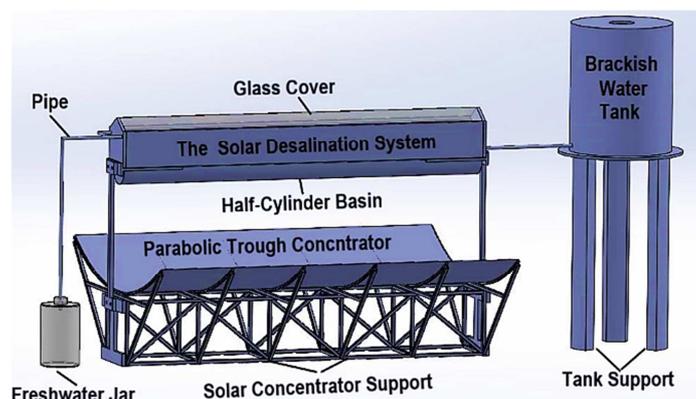
Fig. 1 Schematic view of the novel concentration-based solar desalination system

The solar distiller's walls are insulated by a 2 cm layer of sawdust encased in a 1 cm thick wooden frame. The solar distiller's top surface is covered with a 0.36 m × 3 m glass cover. The top cover is made of 0.002 mm thick transparent glass. With a doubly inclined 30° angle inclination, it fits over the grooves. Freshwater collecting segments with a length of 3 m and a width of 0.030 m are placed on either side of the solar distiller. The concentration ratio is the area of the PTC aperture divided by the area of the absorber. The concentration ratio for the new system is 4.8 [17-19].

In two areas, solar irradiance will enter the new system [17-19]:

(1) Solar irradiance will drop into the solar distillation device, where a small part of the solar radiation is absorbed by the glass cover and most of it transmits through the glass cover to the inside of the distiller. The water and absorber basin absorb a portion of the solar radiation that is transmitted.

(2) The amount of sunlight will fall into the parabolic reflector, where the sunlight will be redirected into the solar distiller's absorber basin. The PTC's focal line is in the middle of the half-cylindrical absorber basin. The concentrated solar radiation on the absorber basin heats the water and raises its temperature by convection. The absorber basin loses minimal heat to the environment once more due to convection.

In this process, water evaporation, convection, and radiation transport the thermal energy acquired by the basin water to the interior glass surface. The water evaporates and increases as it is heated until it reaches the internal glass cover layer. The water vapor on the inside surface of the glass cover subsequently condenses and forms the freshwater, which is collected in the segments on either side of the distiller. The glass cover releases heat to the environment once more by convection and radiation [17-19].

4. Hourly Freshwater Yield and Efficiency of the System

4.1. *Hourly freshwater yield*

The hourly freshwater yield per m^2 of the novel system is given by:

$$M_{ev} = \frac{3600 \times Q_{e,\,w-g}}{h_{fg}} \tag{1}$$

where $Q_{e,\,w\text{-}g}$ is the heat transfer amount by evaporation between the brackish water and the glass cover and is computed as follows.

$$Q_{e,\,w-g} = h_{e,\,w-g} A_w (T_w - T_g) \tag{2}$$

where A_w, T_g, and T_w are the water area, glass temperature, and water temperature, respectively. $h_{e,\,w\text{-}g}$ is the thermal transfer coefficient through evaporation [20-21].

$$h_{e,\,w-g} = 0.016273 \times h_{c,\,w-g} \times \frac{P_W - P}{T_W - T_g} \tag{3}$$

where $h_{c,\,w\text{-}g}$ is the thermal transfer coefficient through convection [20-21].

$$h_{c,\,w-g} = 0.884 \times \left[(T_w - T_g) + \frac{(P_w - P_g)(T_w + 273)}{268.9 \times 10^3 - P_g} \right]^{1/3} \tag{4}$$

The saturated water vapor pressures at the glass cover and the water temperature are indicated by P_g and P_w, respectively.

$$P_g = \exp\left(25.317 + \frac{5144}{T_g + 273.15}\right) \tag{5}$$

$$P_w = \exp\left(25.317 + \frac{5144}{T_w + 273.15}\right) \tag{6}$$

where h_{fg} is the latent heat of water evaporation given by Zoori et al. [22].

$$h_{fg} = \begin{Bmatrix} 3.165 \times [10^6 - (761.6 \times T_f)], \; if \; T_f \geq 70°C \\ 2.4935 \times \{10^6 - [(947.79 \times T_f) + (0.013132 \times T_f^2) - (0.0047974 \times T_f^3)]\}, \; if \; T_f < 70°C \end{Bmatrix} \tag{7}$$

The temperature of the air-water mixture is calculated using the mathematical mean value of the glass cover and the water temperature T_f.

$$T_f = \frac{T_g + T_w}{2} \tag{8}$$

4.2. Efficiency

The solar distiller's overall thermal efficiency is the ratio of evaporative heat transfer to solar radiation on the half-cylinder absorber that can be written in the following form [22]:

$$\eta_{th} = \frac{\sum M_{ev} h_{fg}}{3600 A_b \sum I_{(t)}} \tag{9}$$

Using Eqs. (1) and (2) for the overall solar thermal efficiency, the following equation is derived:

$$\eta_{th} = \frac{h_{e,w-g} A_w (T_w - T_g)}{A_b \sum I_{(t)}} \tag{10}$$

5. Average Weather Conditions for the Rabat Region in Morocco

Morocco's Rabat-Sale-Kenitra, which has a particularly fascinating geographical location, is taken into account in this study. The solar radiation data are obtained from the Weather Spark website for a typical day in winter (15 January) and summer (15 July) with meteorological parameters [23-24].

(a) Winter day (15 January)   (b) Summer day (15 July)
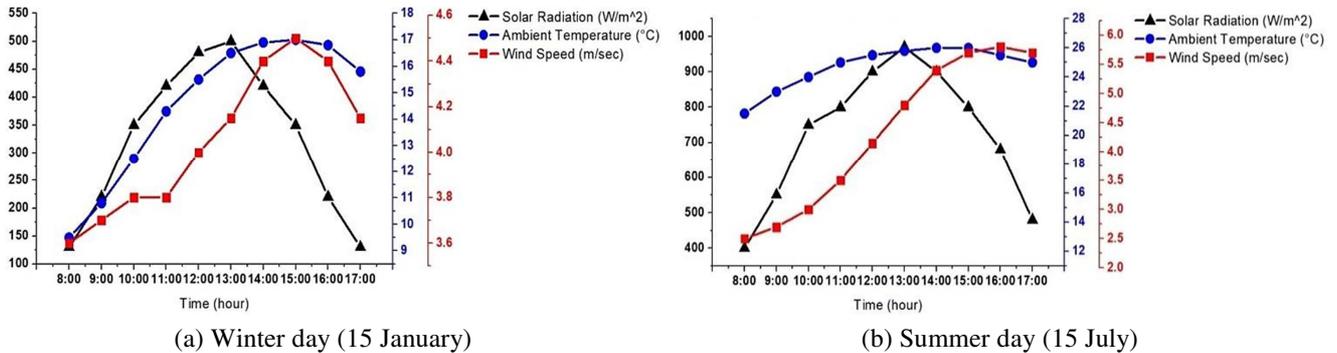
Fig. 2 Hourly variation in the solar radiation, ambient temperature, and wind speed on the winter day and summer day of the Rabat region in Morocco

It is observed from Fig. 2 that the incident solar radiation on 15 January increases gradually from 8:00 until its maximum value 500 W/m² at 13:00 as shown in Fig. 2 (a), and the incident solar radiation on 15 July increases gradually from 8:00 until its maximum value 970 W/m² at 13:00 as shown in Fig. 2(b); after that, it starts decreasing gradually until 17:00.

Furthermore, the variation in wind speed and ambient temperature over time is also taken into consideration as shown in Fig. 2. The maximal wind speed 4.5 m/s is recorded at 15:00 on the winter day and the maximal wind speed 5.8 m/s is recorded at 16:00 on the summer day. The maximal ambient temperature 17°C is recorded at 15:00 on the winter day and the maximal ambient temperature 26°C is recorded at 14:00 and 15:00 on the summer day.

6. Numerical Resolution

Through the MATLAB code, the freshwater yield and the efficiency of the device are determined by using Eqs. (1) and (10). The total duration of 10 hours for iteration starts from 8:00 to 17:00 on 15 January in winter and 15 July in summer. The freshwater yield during the day as well as the daily efficiency may then be calculated for the design parameters and climatic parameters. Fig. 3 depicts a flowchart of the study's full methodology. The thermophysical properties and design parameters of the glass cover, brackish water, and absorber basin as well as the technical characteristics of PTC are listed in Tables 1-4.
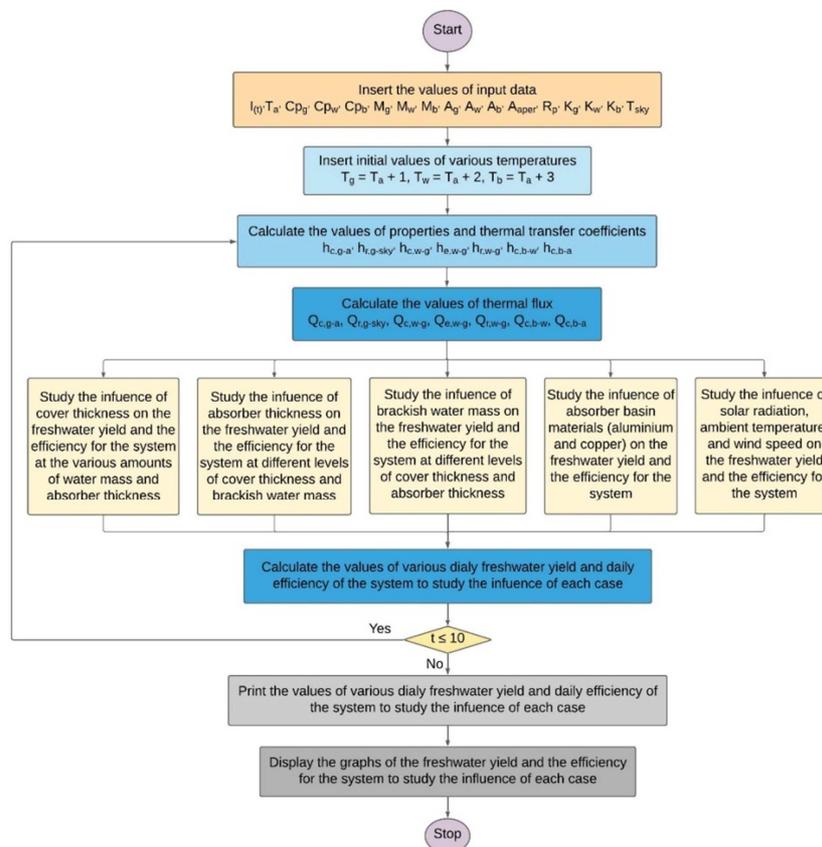
Fig. 3 Flowchart of the study's methodology

Table 1 Thermophysical properties and design parameters of glass cover [17-19]

Property	Value	Glass cover thickness (mm)	Glass cover mass (kg)
Cp_g (J/kg.K)	800	2	5.374
k_g (W/m.K)	1.02	4	10.747
ρ_g (kg/m³)	2530	6	16.121
α_g	0.05	-	-
τ_g	0.90	-	-
A_g	1.062	-	-
ε_g	0.86	-	-

Table 2 Thermophysical properties and design parameters of brackish water [17-19]

Property	Value	Property	Value
Cp_w (J/kg.K)	4190	τ_w	0.95
k_w (W/m.K)	0.67	A_w	0.9
ρ_w (kg/m^3)	1002	ε_w	0.95
Water mass (kg)	40, 60, and 80	α_w	0.05

Table 3 Thermophysical properties and design parameters of absorber basin [17-19]

Property	Value	Absorber basin thickness (mm)	Absorber basin mass (kg)
Cp_b (J/kg.K)	896	2	8.861
k_b (W/m.K)	204	4	17.722
ρ_b (kg/m^3)	2530	6	26.584
α_b	0.90	-	-
A_b	1.641	-	-

Table 4 Technical characteristics of PTC

Property	Value
Length (m)	3
Aperture (m)	2.25
Focal line (m)	1
Area (m^2)	6.75
Reflectivity	0.90

To study the impact of parameters on the freshwater yield and efficiency of the new system, it is necessary to make the following hypotheses [17-19]:

(1) The PTC has a symmetrical shape and the influence of the distiller shadow on the PTC is negligible.

(2) The physical characteristics of various materials are constant.

(3) The side and bottom walls' heat capacity and the effect of glass cover tilt are ignored.

(4) With the depth of the water and the thickness of the glass cover, a constant temperature gradient is maintained.

(5) Ideal gases include dry air and water vapor, and there is no vapor leaking inside the system device.

(6) The internal glass-cover surface is the only place where condensation occurs.

(7) Segmental and wall-side losses are not taken into account.

7. Results and Discussion

7.1. Theoretical investigation for the influence of design parameters on the system performance

7.1.1. The influence of glass cover thickness

Freshwater yield and system efficiency increase as the cover glass thickness increases from 2 mm to 4 and 6 mm. With the 6 mm glass cover thickness, the system shows the highest freshwater yield and efficiency as shown in Fig. 4. The high cover thickness limits the influence of solar radiation and causes a decrease in temperature at an internal glass-cover surface. The temperature difference between the glass cover and water increases dramatically, which promotes the condensation of water vapor and thus increases the yield of distilled water. It also could be attributable to the fact that the energy loss to the surroundings with 6 mm cover thickness is lower than that with 4 or 2 mm thickness, and the highest thermal resistance is achieved with 6 mm cover thickness. This could be caused by the fact that the heat amount in 2 mm, 4 mm, and 6 mm glass cover thicknesses is nearly equivalent, owing to the nearly similar absorption coefficient and transmittance for the glass cover.

It is also noticeable from Fig. 4 that the greater the mass of water and the thickness of the absorber basin, the lower the freshwater yield and efficiency of the new system. The maximum daily yield and efficiency are about 11.22 kg/m^2.day and 6.86% during the summer day and about 2.59 kg/m^2.day and 2.89% during the winter day with the greatest glass cover thickness 6 mm.
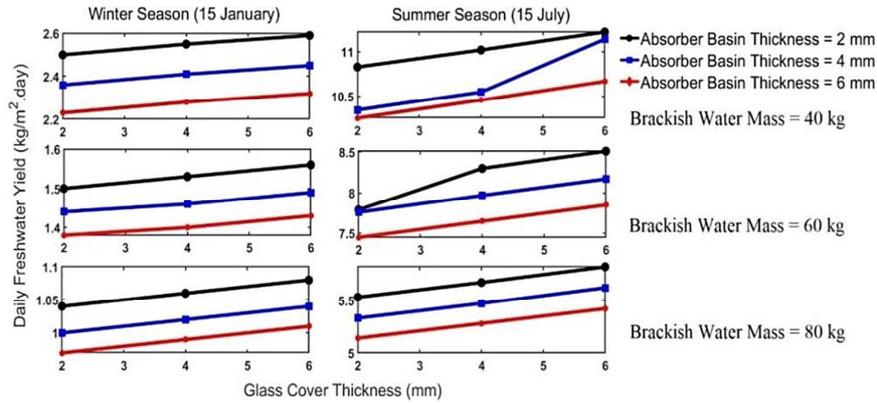
(a) Freshwater yield
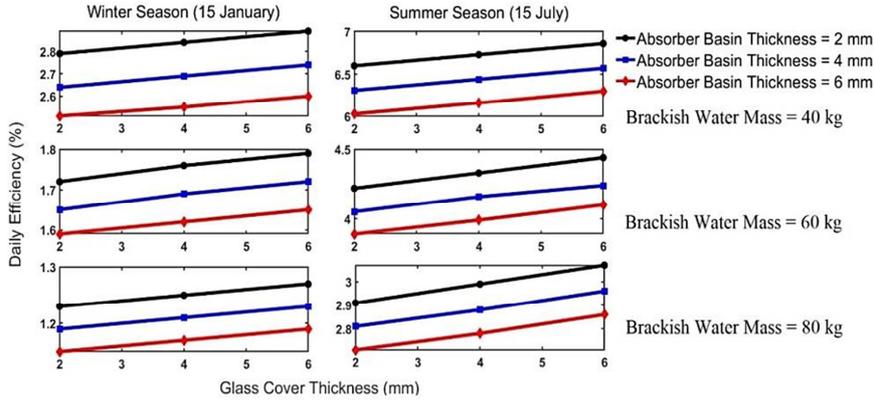
(b) Efficiency

Fig. 4 The influence of cover thickness on the freshwater yield and efficiency of the system at various amounts of water mass and absorber basin thickness for the winter day and summer day

7.1.2. The influence of absorber basin thickness

Fig. 5 illustrates the influence of absorber basin thickness on the freshwater yield and efficiency of the system. As can be seen, the yield and efficiency decrease with the increasing absorber thickness from 2 mm to 4 mm and 6 mm. However, the 2 mm absorber thickness produces the highest daily freshwater yield and daily efficiency, which are 11.22 kg/m^2.day and 6.86% during the summer day and about 2.59 kg/m^2.day and 2.89% during the winter day with 40 kg brackish water mass and 6 mm glass cover thickness. The increase in the absorber thickness leads to an increase of thermal conduction resistance. This reduces the heat transfer to brackish water, and leads to a decrease in the temperature of the basin. Therefore, the temperature of the water to be desalinated decreases, which negatively affects the water productivity and the system efficiency.
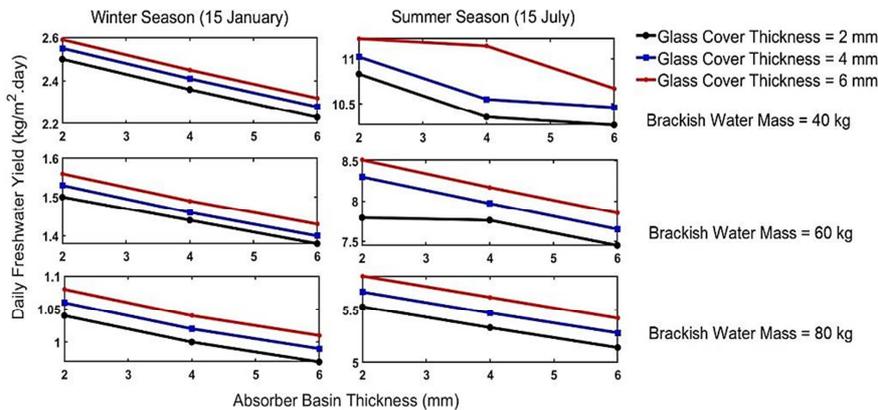
(a) Freshwater yield

Fig. 5 The influence of absorber thickness on the freshwater yield and efficiency of the system at different levels of cover thickness and brackish water mass for the winter day and summer day
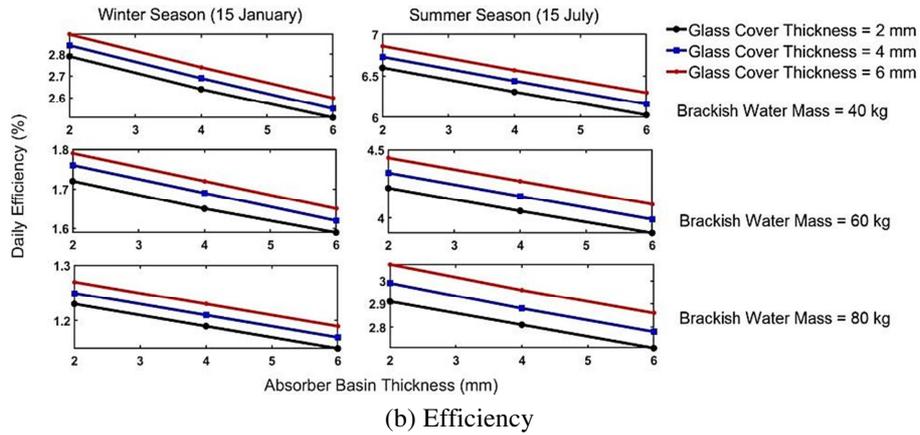
(b) Efficiency

Fig. 5 The influence of absorber thickness on the freshwater yield and efficiency of the system at different levels of cover thickness and brackish water mass for the winter day and summer day (continued)

7.1.3. The influence of brackish water mass

Fig. 6 indicates the influence of brackish water mass on the freshwater yield and efficiency of the system with each glass cover thickness and absorber basin thickness for the typical day in winter and summer. The freshwater yield and efficiency are inversely proportional to the difference in the mass of brackish water, which means that the greater the mass of the water to be desalinated, the lower the freshwater yield and efficiency, as concluded with the same observations in previous studies [7, 11, 18].

Therefore, the large mass of brackish water has an increase in heat storage in the water and a longer time for evaporation, which reduces the freshwater yield and efficiency of the system. The highest value of the freshwater yield and efficiency achieved with 40 kg water mass, 2 mm absorber basin thickness, and 6 mm glass cover thickness are 11.22 kg/m^2.day and 6.86% during the summer day and about 2.59 kg/m^2.day and 2.89% during the winter day, as shown in Fig. 6(a) and Fig. 6(b).
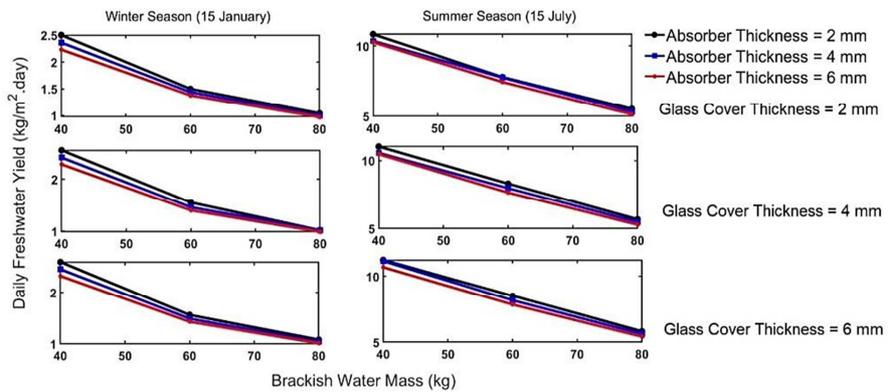
(a) Freshwater yield
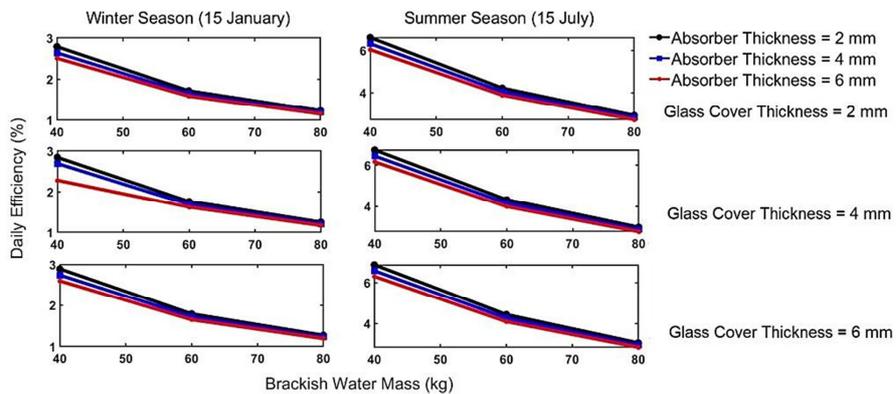
(b) Efficiency

Fig. 6 The influence of brackish water mass on the freshwater yield and efficiency of the system at different levels of cover thickness and absorber basin thickness for the winter day and summer day

In general, it is noticed from Fig. 4 that the freshwater yield and efficiency of the new system increase with the increase in the thickness of the glass cover. It is also observed from Figs. 5-6 that the freshwater yield and efficiency of the new system decrease with the increase in the mass of the water to be desalinated and the thickness of the absorber basin.

It is concluded that the freshwater yield and efficiency of the novel design of the concentration-based solar desalination system increase with the increase in the thickness of the glass cover, the decrease in the thickness of the absorber basin, and the decrease in the mass of the water to be desalinated.

7.1.4. The influence of absorber basin material

The difference in the material of the absorber basin affects the freshwater yield and efficiency of the system, as shown in Fig. 7. The physical properties of aluminum and copper for the absorber basin are different, and this confirms their impact on the freshwater yield and efficiency of the system. The freshwater yield and efficiency of the system with the copper material of the absorber basin are higher than the system with the aluminum material of the absorber basin because the thermal conductivity value of copper is two times higher than that of aluminum.

The maximum value of hourly freshwater yield and efficiency of the system with the aluminum material of the absorber basin is 1.69 kg/m^2.hr and 87% on 15 July (summer) and 0.54 kg/m^2.hr and 44% on 15 January (winter). The maximum value of hourly freshwater yield and efficiency of the system with the copper material of the absorber basin is 1.75 kg/m^2.hr and 90% on 15 July (summer) and 0.56 kg/m^2.hr and 46% on 15 January (winter).

(a) Freshwater yield
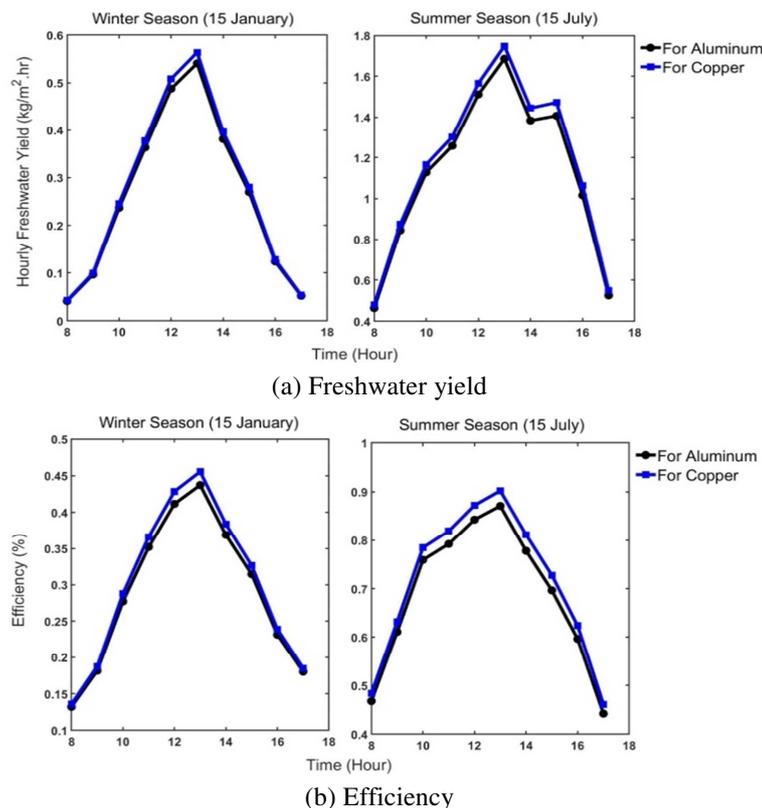
(b) Efficiency

Fig. 7 Variation in the hourly freshwater yield and efficiency with different absorber basin materials (aluminum and copper) for the winter day and summer day

7.2. Theoretical investigation for the influence of climatic parameters on the system performance

7.2.1. The influence of solar radiation

Distillation needs the use of heat energy to evaporate the water, and this heat energy is generated from solar radiation, which is plentiful, never-ending, and pollution-free. However, the intensity of the sun changes from day to day and season to

season, affecting the freshwater yield and efficiency of the new solar distiller. In the distillation process, solar radiation is quite important. As a result, various studies on the impact of this parameter on freshwater yield have been conducted. The findings of Nguyen [6] and Panchal et al. [11] certainly demonstrate a great rise in the distilled water production created by the increase in solar radiation intensity. Therefore, the higher the amount of solar radiation, the higher the freshwater yield and efficiency of the system.

7.2.2. *The influence of wind speed*

Wind speed affects freshwater productivity and system efficiency as the system performance increases with the increase in the wind speed blowing on the glass cover and with the decrease in the wind speed blowing on the absorber basin. Due to the increase in wind speed on the surface of the glass cover, the heat transfer coefficient increases from the glass cover to the surrounding. Therefore, the temperature of the glass cover decreases and leads to an increase in vapor condensation, and the amount of distilled water increases. Thus, the freshwater yield and efficiency of the system increase when the wind speed increases on the surface of the glass cover. On the surface of the absorber basin, the higher the wind speed, the higher the convection heat transfer coefficient value. This increases the heat flux in the absorber basin to the ambient air and produces the heat loss to the surroundings. Therefore, the temperature of the absorber basin decreases and leads to a decrease in water evaporation, and the amount of distilled water decreases.

7.2.3. *The influence of ambient temperature*

The influence of ambient temperature is opposite to that of wind speed. The system performance increases with a decrease in the ambient temperature on the glass cover and with the increase in the ambient temperature on the absorber basin. The glass cover will cool faster if the ambient temperature is lower. Therefore, the temperature of the glass cover decreases and leads to an increase in vapor condensation, and the amount of distilled water increases. However, the absorber basin will heat if the ambient temperature is higher. Therefore, the temperature of the absorber basin increases and leads to an increase in water evaporation, and the amount of distilled water increases.

It is observed in Fig. 2 that the solar radiation, wind speed, and ambient temperature are higher on the summer day than on the winter day, affecting the performance of the system. The freshwater yield and efficiency are higher on the summer day than on the winter day, as shown in Figs. 4-7.

8. Conclusions

The research indicates how the design and climatic parameters influence the freshwater yield and efficiency of a novel concentration-based solar desalination system. The parameters are investigated on a typical day in winter and summer. The finding of this study can be summarized as follows.

(1) The design and climatic parameters have a vital impact on the performance of the new system.

(2) The freshwater yield and the system efficiency on the summer day are higher than that on the winter day because the solar radiation falling on the system device on the summer day is higher.

(3) The freshwater yield and the system efficiency are improved with the increase in the thickness of the glass cover. The system with 6 mm glass cover thickness shows better freshwater yield and efficiency than with 4 mm and 2 mm glass cover thickness.

(4) The absorber thickness is inversely proportional to the freshwater yield and the system efficiency. With the lowest absorber thickness (2 mm), high freshwater yield and efficiency are obtained.

(5) The greater the mass of brackish water is, the lower the freshwater yield and the system efficiency are. With the minimum mass of water (40 kg), the maximum freshwater yield and system efficiency are achieved.

(6) With 6 mm glass cover thickness, 2 mm absorber basin thickness, and 40 kg brackish water mass, daily freshwater yield and daily efficiency of the system are high. The maximum daily freshwater yield and daily efficiency are about 11.22 kg/m^2.day and 6.86% during the summer day, and are about 2.59 kg/m^2.day and 2.89% during the winter day.

(7) The increase in the value of solar radiation leads to an increase in the freshwater yield and efficiency of the system.

(8) The increase in wind speed and the decrease in the ambient temperature on the glass cover of the system lead to an increase in the freshwater yield and system efficiency. The opposite happens in the absorber basin.

9. Suggestions and Recommendations

It is suggested that future research focus on the use of solar concentration modules with solar distillers. It is recommended to improve various design parameters of the solar distillers to get the best performance. In the future, the use of optimization algorithm methods can be considered to obtain the optimal design of concentration-based solar distiller systems.

Conflicts of Interest

The authors declare no conflict of interest

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