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# Seasonal effect on solar distillation in the El-Oued region of south-east Algeria

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**Abstract** – *In the present purely experimental work, we tested a solar distiller with a simple slope in the region of El-Oued located in the south-east of Algeria, during the winter then the summer seasons at the same place. Dimensions of the studied device are 1000 x 500 mm, while the depth of the water to be distilled is 1 cm, the glazing thickness is 4 mm, and the tilt angle with respect to the horizontal is 10 °.The aim of this work is to compare distillation between winter (January) and summer (May) to show that weather factors such as solar radiation, ambient temperature and humidity are influential on the distiller productivity. The amount of distilled water in winter was about 119 ml per day. However, that in summer was 1127 ml per day in total, so it is an increase of more than 9 times the production of distilled water.*

**Key words**: *solar distiller, solar radiation, humidity, distilled water, productivity*
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## I. Introduction

Desalination technology has become very developed due to the new techniques that often appear, but each technique has its advantages and disadvantages [1, 2]. The most economical way to purify or desalt water is by solar distillation. The efficiency of this technique is relatively low compared to the other distillation modes, but this drawback is compensated for by the fact that this process only requires the sun's radiation to function.
Several researchers have studied and improved flat solar distillers by adding a black absorber, a mirror, or preheating. Others have doubled the glass of the distiller [3], whilst others have played the angle of the glazing [4]. The water desalination technology has its advantages and disadvantages [5]. Elango et al. [6] studied the performance of a single slope solar distiller with and without nanofluids. The distillers were tested with three nanofluids ($Al_2O_3$, $ZnO$, $SnO_2$) with different concentrations. Using $Al_2O_3$ nano-water fluid at 0.1% concentration gave 29.95% more distillate output due to its higher thermal conductivity. The preparation of nanofluids is a costly and dangerous technique.

This work gives us a clear experimental response on the solar radiation and also the ambient temperature influences on solar distillation with a simple effect.

## II. Materials and method

### *II.1. Description of the solar distiller*

The single slope solar distiller (see Figure 1) is a well-known device, with simple design and construction because its components are available in all world's markets.

Figure 1. Single slope solar distiller

### *II.2. Operating principle*

The increase in temperature due to the greenhouse effect causes the air to warm up above the saline water, which in turn evaporates. This evaporation capacity increases as the temperature rises until the air reaches its saturation with water vapour: the relative humidity is then 100%. The steam contained in the hot air condenses in contact with the cold glazing (Figure 2). This contact led to the formation of water droplets, which flow towards the lower part of the sloped glazing. A collector (tube) groups these droplets and then led them to be accumulated into a storage tank.

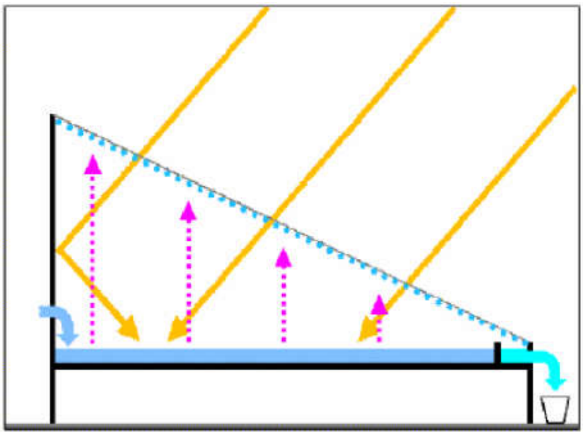

Figure 2. The prototype distiller

*II.3. Essential experimental system components*

The solar distiller is essentially composed of:

• A box of wood having the dimensions (1000 x 500 mm), the lid slope is 10° with respect to the horizontal direction, in the way to have the maximum of sunshine.

• An ordinary glass lid (1000 x 600 mm) with a thickness of 4 mm.

• A PVC plastic tube of 1100 mm length and 25 mm in diameter.

*II.4. Thermocouples locations*

Temperature measurements are made by means of five thermocouples positioned as perfected in Figure 3:

• Temperature of the inside face of the glazing.

• Temperature of the outside face of the glazing.

• Temperature inside the distiller.

• Temperature of the water to be distilled.

• Ambient temperature.

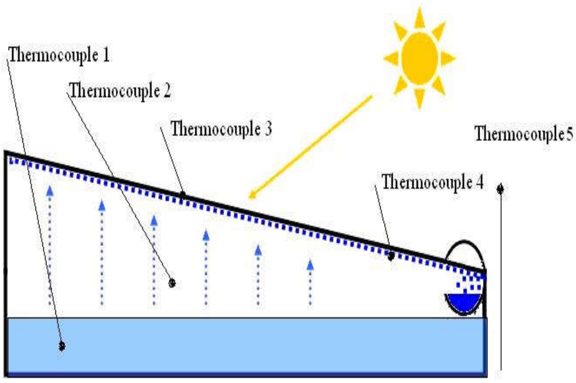


Figure 3. Locations of the used thermocouples

*II.5. Meteorological conditions of the experiments*

Two experiments were carried out at the University of El-Oued (south-east Algeria). The first on January 13, 2017 and the second on May 5, 2017 during the summer. Table 1 shows the meteorological conditions of the experiments.

TABLE 1
METEOROLOGICAL CONDITIONS IN SUMMER AND WINTER

| | May (Summer 2017) | January (Winter 2017) |
|---|---|---|
| Sunrise | 05:41 am | 07:38 am |
| Sunset | 07:19 pm | 05:46 pm |
| Ambient temperature | 26-35°C | 11-17°C |
| Atmospheric pressure | 1013 mb | 1031 mb |

*II.6. Conduct of the experiment*

The experiments are made according to the geographical coordinates of the city of El-Oued located at 33.3676° N latitude and 6.8516° E longitude.

The same distiller was exposed to the sun in the same place, same position, same water nature and the same water quantity to be distilled, but in two different seasons.

The first experiment was carried out in January 2017 (in winter), while the second in May 2017 (in summer) in order to see the influence of meteorological effects on the phenomenon of solar distillation. Temperature sampling was carried out every one hour during the period from 9:30 am to 4:10 pm for both experiments, so the same period of sunshine was maintained to eliminate any ambiguities in relation to this factor (i.e. sunshine duration).

## III. Results and discussion

Meteorological factors such as solar radiation, ambient temperature and humidity influence the distiller operating. The results obtained are illustrated in the following figures.

Figure 4 shows the solar radiation evolution in Wh/m$^2$ during the day time (in hours) for both experiments, one in winter and the other in summer. The radiation increases gradually in both cases until reaching a maximum value between noon and 2:00 pm with the only difference that the solar radiation in winter has not exceeded the value of 600 Wh/m$^2$ but in summer it has reached the value of 1000 Wh/m$^2$. Solar radiation is the key parameter in solar distillation.

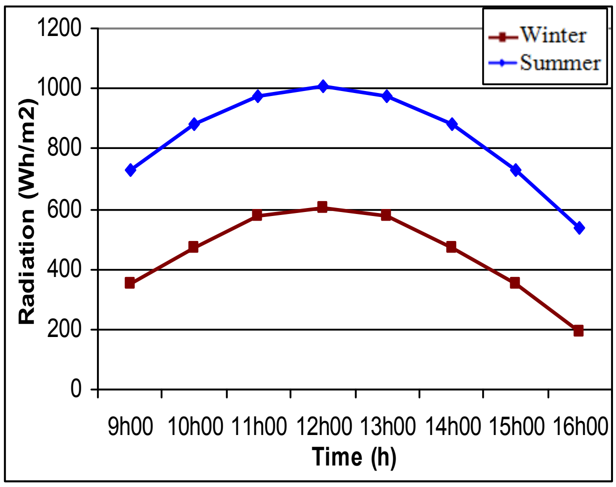


Figure 4. Evolution of solar radiation

Figure 5 shows the relationship between the day time (hours) and the ambient temperature for the two experiments. The latter increases gradually until reaching a maximum constant value between 01:00 pm and 04:00 pm [7]. Figure 5 also shows that the ambient temperature is greater in summer where it has exceeded 30 °C, than that in winter which has not reached the value of 18 °C. The ambient temperature is also a crucial factor influencing the phenomenon of solar distillation.

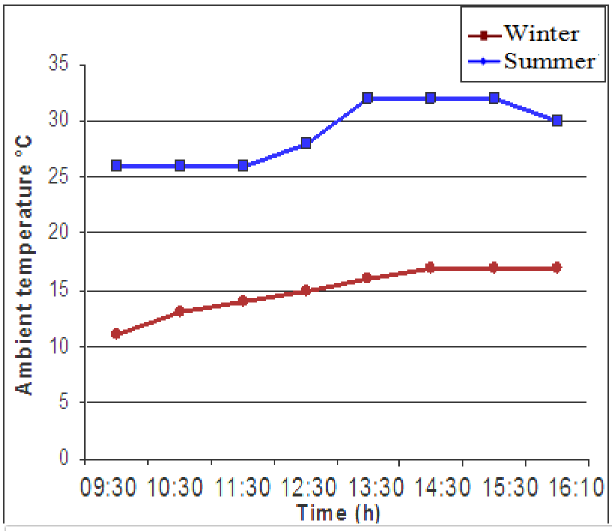


Figure 5. The evolution of the ambient temperature

Figures 6 and 7 illustrate the dependence between the day time (hours) and the interior temperature of the glazing for water distiller in the experiments. We can see that the temperature difference between the basin water and the inner glazing temperature is also another important factor for the distillation process. The mean temperature difference between the inner glazing and the basin water in the first experiment (carried out in winter) is of the order of 32 °C. However, it is of the order of 130 °C in the second experiment (carried out in summer). This large difference is favorable for the improvement of the productivity of distilled water due to the evaporation phenomenon of water.

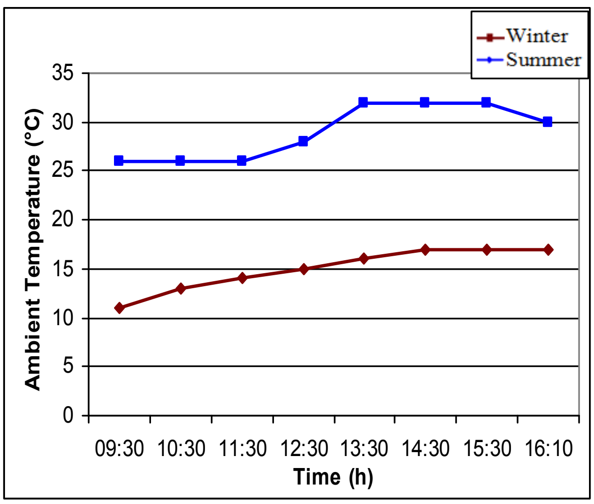


Figure 6. Time evolution of the inner glazing temperature

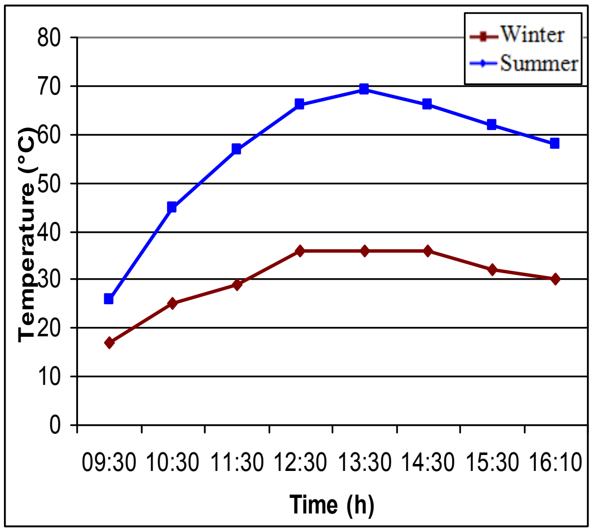


Figure 7. Time evolution of the basin water temperature

Figure 7 shows that the temperature evolution of the basin water in summer is very high, and exceeds the value of 50 °C to reach a maximum temperature of 73 °C at 01:30 pm. All temperatures in winter are below the value of 40 °C. The temperature of the water to be distilled in the basin is an essential factor in the phenomenon of solar distillation.

Figure 8 shows the temporal evolution of the internal temperature of the distiller in the two seasons. This temperature is maximal between 12:30 am and 03: 30 pm. Also, high difference between summer temperatures and those taken in winter is obvious.

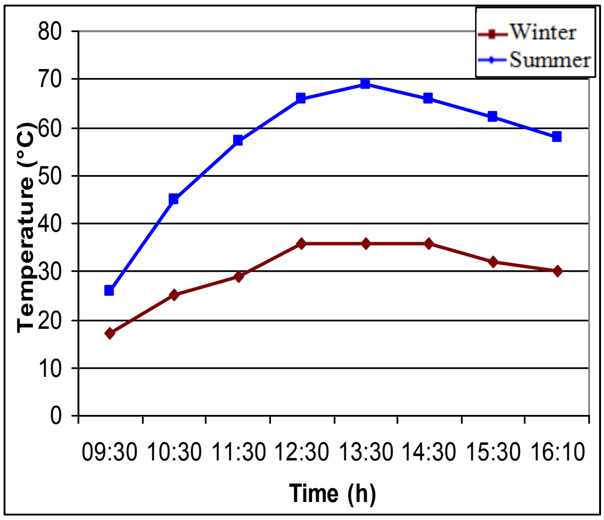


Figure 8. Temperature evolution inside the distiller during winter and summer

Figure 9 illustrates the relation between the day time and the outer glazing temperature, where the phenomenon of natural convection between the glazing and the atmosphere takes place. The temperature increases until reaching a maximum value between noon and 04:00 pm.

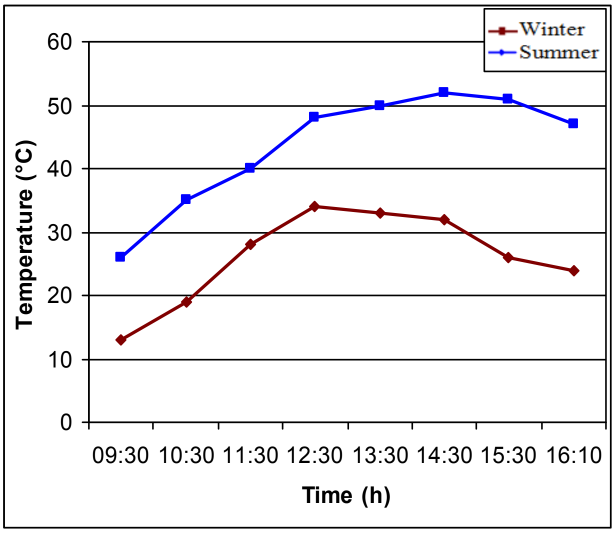


Figure 9. Evolution of the glazing temperature on its external face

Obviously, from figure 10 we can see the dependence of the productivity of the distilled water on daytime and season for both experiments. Note that the first 4 sunshine hours in the winter did not trigger the distillation, but the first hour of sunshine in the summer triggered the distillation. Consequently, the production of distilled water in summer is more profitable than in winter.

The total amount of water produced by the winter experiment was 119 ml, and that in summer was 1127 ml over a period of 6 hours and 40 minutes. The distillate yield increased by 1008 ml / day in the summer.

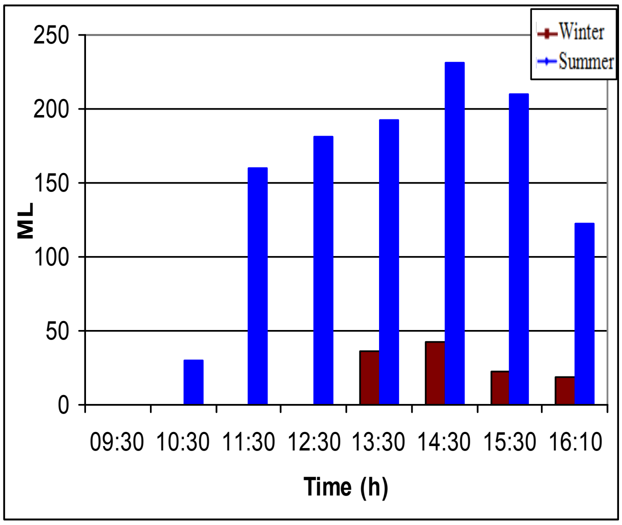


Figure.10. Productivity of distilled water through experiments

## IV. Conclusion

According to the results obtained in the present work, solar distillation is more productive and more favorable in the summer period than in the winter period. This fact is due to the increase of the solar radiation. The maximum distilled water quantity for 6 hours and 40 minutes is recorded in May 2017 (in summer) for an amount of 1127 ml, whereas in January 2017 (in winter), the yielded quantity is about 119 ml. Those results demonstrate manifestly the difference in distilled water productivity between the two seasons. Therefore, any increase in solar radiation necessarily yields an increase in the distilled water productivity, without neglecting other key parameters such as ambient temperature.

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