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Small iron pieces effect on the output of single slope solar still

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Abstract
Solar distillation is an environmental technique that uses solar energy to treat polluted water. In this context, two solar stills of the same size (0.5 x 0.5 m) were exposed to the sun i.e., under the same weather conditions to see the effect of small iron parts on the production of pure water. The results showed that the modified solar still SSM which contained iron pieces had an improvement rate of 23.46% compared to the reference solar still SSR.

Keywords: Solar energy, Solar distillation, Pure water, Water temperature.

1. Introduction

Solar energy is a very abundant, free and environmental energy. This energy has been used by human beings for a long time and in various necessities of life, such as heating, water heating, and food drying. It is dispersed over our globe in a heterogeneous way [1-3], just like groundwater [4-7]. This subterranean water is not always safe to drink. It is sometimes affected and polluted, which requires a treatment. Solar distillation uses free solar energy to purify dirty water and represents one of the greatest and most cost-effective and environmentally friendly approaches.

Solar distillation is a simple technique and within the reach of everyone and the construction of the solar still is very easy [8]. The solar still is influenced by solar radiation but it is also influenced by two factors, the glass cover, and the water in the basin. All scientific research is based on two factors. There have been many experiments on how to cool this blanket with water on a pyramid still. The results show that depending on the cooling method used, the improvement rates vary between 105.9 and 107.7% [9,10]. Other experiments consist in varying the angle of the glass lid with respect to the horizontal. To have the best output in pure water, the results suggest that the best angle is between 15 and 30° [11].

According to statistics, increasing the thickness of the glass decreases the performance of the solar still because the resistance to heat transmission increases, which leads the glass to cool more slowly and delays the condensation of the water value [12]. According to another research on the thickness of the cover glass, thicknesses of 4 to 5 mm gave an improvement of 27%, while the thickness of 6 mm gave only 12% [13]. To confirm that any increase in the thickness of the glass leads to a decrease in the output of pure water, a study used a double cover, i.e. an air chamber separated by 1 cm between two glass plates. According to the results, the production decreased remarkably by 56.52% [14-16].

Other research has been based on the second factor, the water that is in the basin of the still. To heat this water, the researchers used internal and external refractors. The results reveal a significant improvement, ranging from 42 to 45%. In the same context, studies have shown that a solar still with an internal reflector has an improvement rate that varies between 20 and 64% [17-19].

The researchers used local metallic elements to raise the temperature of the water and speed up its evaporation in the solar still basin. The use of iron, zinc and copper plates boosted the effectiveness of the solar still by 5.5, 6.3, and 7.35 kg/m^2/day, respectively [20]. The uses of natural products such as palm fibres and coal blocks have been tested in distillation. The results show that the rate of improvement varies between 8 to 38% [21,22]. A group of researchers employed aluminum balls fabricated from commercial aluminum sheets in the solar still's basin. Others have used dune sand as an enhancing material; however, the results show that when compared to a solar still without sand, pure water yield is reduced by 1.45 times [23-26].

Solar distillation has progressed thanks to the employment of PCM phase change materials and the nanofluid technique. These two revolutionary technologies were integrated into the domain due to their importance and influence on all energy devices. The thermal nature of different materials PCM and, in the case of nano-fluids, their concentrations, govern on the rate of improvement [27-30].

Our work is purely experimental, intending to determine the impact of small pieces of iron on the output of a conventional solar still in the El Oued climate in Algeria's southeast.

2. Material and methods

The experiment was done at the University of El Oued in Fev 16. 2022. The experiment consists of exposing two conventional solar stills of dimensions (0.50 X0.50 m) and under the same climatic conditions. One still is taken as a reference still SSR and the other a modified solar still SSM, which contains iron pieces. The objective of the experiment is to see the improvement rate of output of the conventional solar still.

The temperature measurements are made every hour by type K thermocouples and measurements of the quantity of pure water produced is also measured every hour and throughout the experiment.

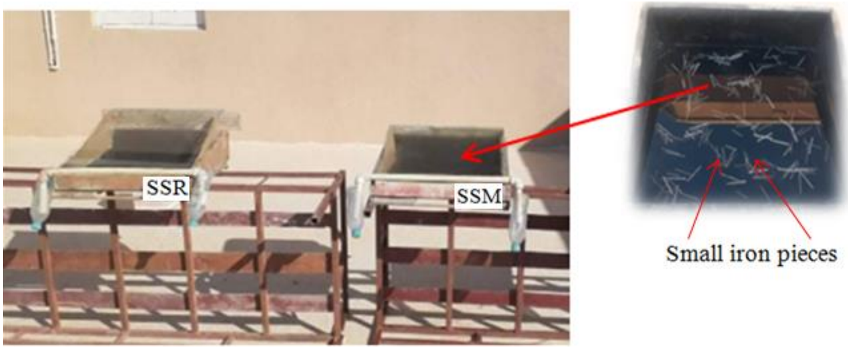

Figure 1. Experiment Setup

3. Results and discussion

3.1. Solar radiation and ambient temperature

The variation of solar radiation and ambient temperature in the region of El Oued is shown in Figure 2 and this is vis-à-vis the time of the experiment. The average value of solar radiation is 500W/m^2 and the average value of ambient temperature is 25°C. At 13:00h, the values are at a maximum of 750 W for the radiation at 12:00h and 17°C for the ambient temperature at 14:00h.

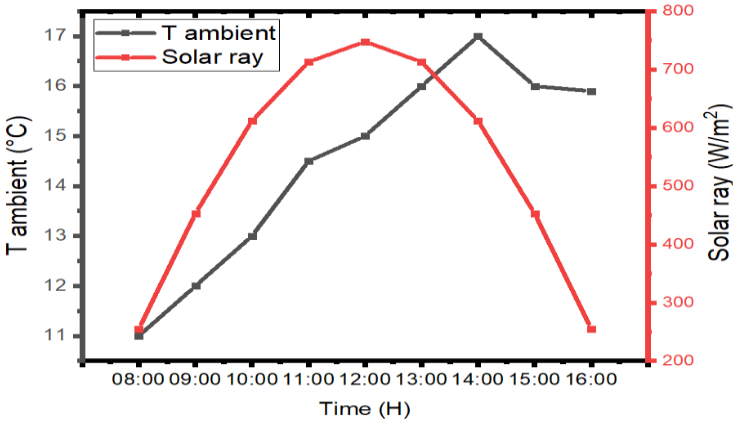

Figure 2. Evolution of solar radiation and ambient temperature

3.2. External and internal glass temperature evolution

Figure 3 represents the evolution of the temperature of the glass cover as a function of time. We notice that the temperature increases gradually until reaching its maximum at 14:00h with a value of 21°C for SSM and 20°C for SSR while the maximum value of the temperature on the outside is almost the same 18° C for the two solar stills and this as shown in Figure 4, which represents the evolution of the temperature of the glass cover on the outside. We see that the two graphs are superimposed, and that this is due to the low ambient temperature. Therefore, the external face of the glass cools quickly resulting in the external temperature of the glass being almost the same.

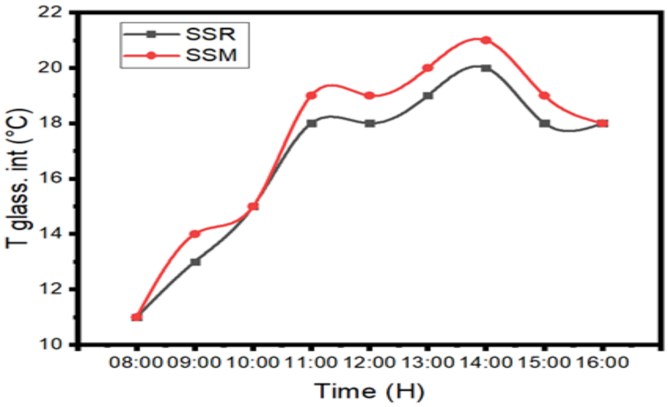

Figure 3. Internal glass temperature evolution

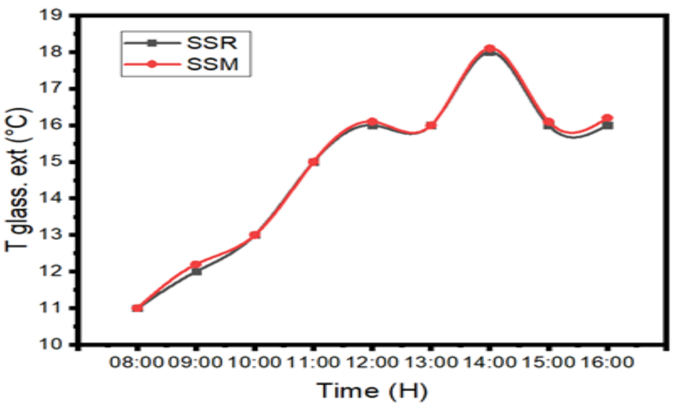

Figure 4. External glass temperature evolution

3.3. Water temperature evolution

Figure 5 depicts the water temperature variation of the two solar stills in real-time. It should be observed that the water temperature in the SSM is significantly higher than that in the SSR. This difference is due to the existence of the iron pieces, which is the only variation between the two stills. This result generally indicates that the pure water output of SSM will be greater than the output of SSR because the evaporation of the basin's water increases as the temperature rises.

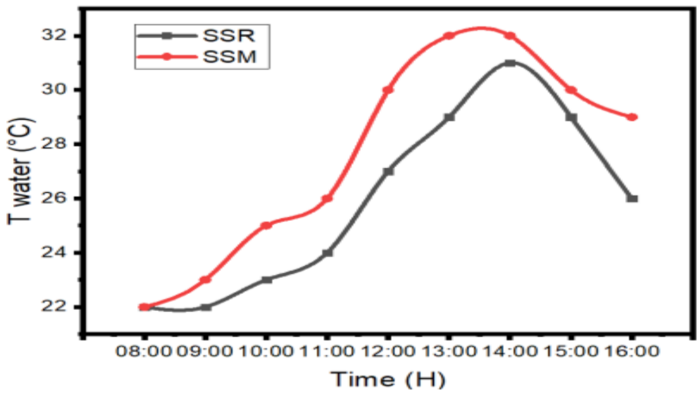

Figure 5. Water temperature evolution

3.4. Hourly output of pure water

Figure 6 represents the hourly variation in the pure water of the two solar stills as a function of time. Note that the amount of pure water collected each hour by the SSM is greater than that of the SSR still, and this lasts for the 8 hours of the experiment. This difference is because the SSM has iron pieces in its water basin. The maximum value produced (90ml) is noted at 14:00h for SSM and it is 80ml for SSR.
Figure 7 shows the accumulation of pure water as a function of time in our experiment. The SSR accumulated 422 ml per day, while the Modified Still SSM accumulated 521 ml per day. The presence of iron pieces in SSM accounts for the disparity between the two values.

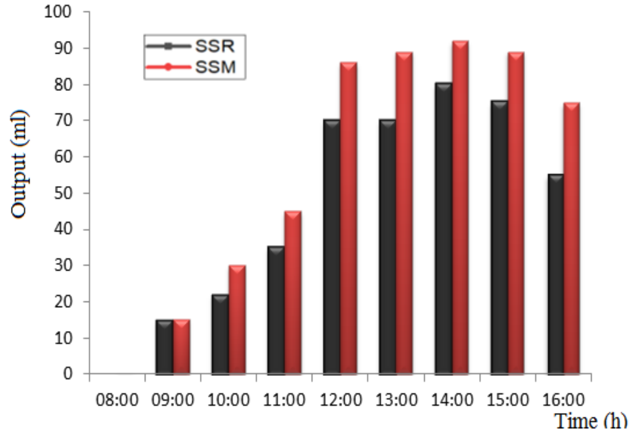

Figure 6. Hourly output of pure water

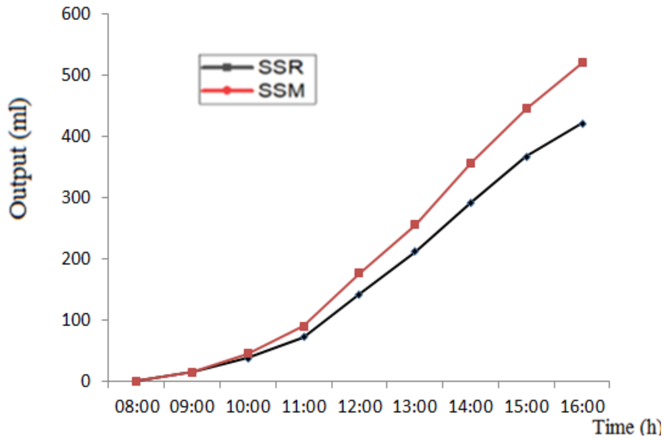

Figure 7. Accumulation output of pure water

3.5. Discussion

The research on solar distillation that used iron as an enhancement factor is summarized in Table 1. The first three works used natural materials as an enhancement factor. The yields obtained vary between 8 and 35.6%. The last three works used metallic materials. Solar stills have an improvement in pure water in proportions ranging from 1.5 to 20.75%. Our work has an improvement rate of 23.46%, which indicates that it is interesting.

Table 1. Comparison Table

S. N°	Authors name	Materials	Results
[21]	Kemerchou et al, 2022	Palm Fibers	35.6 %
[22]	Sadoun et al, 2022	Charcoal	8 %
[25]	Khamaia et al, 2022	Sand	Negative effect
[20]	Attia et al, 2021	Iron tray	14.58%
[31]	Aram Mohammed Ahmed et al, 2018	Iron filings	20.75%
[32]	Mugisidi et al, 2019	Iron sand	1.5%
	Our work	Iron pieces	23.46%

4. Conclusion

Two conventional solar stills of the same dimensions are tested under the same weather conditions **to** see the influence of iron pieces on the performance of the modified SSM solar still. The result shows that the output SSR is 422 ml and that of the SSM is 521 ml. The rate of improvement is 23,46 % and this is due to the presence of iron pieces.

Declaration of competing interest

The authors declared that they have no conflicts of interest in this work. The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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