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Polluted Groundwater Treatment in Southeastern Algeria by Solar Distillation

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ABSTRACT/RESUME

Abstract: *Drinking water has become a real global problem. Drinking water is defined as odourless and colorless wate. According to the World Health Organization (WHO), drinking water contains minerals shall not have more than 0.5 g/l of salinity, hardness (TH) of between 1.5 and 3 degrees and shall not contain more than 200 mg/l of chlorine, neither more than 75 mg/Lof calcium nor more than 50 mg/l of magnesium nor more than 150 mg/l of sulphates. In the region of El Oued in south-eastern Algeria, the waters contain very high concentrations of the products mentioned above, which is why solar distillation is one of the suggested solutions to solve this problem. Solar distillation is an environmental, economical and simple technique. It uses free sunlight to treat polluted water to have a drinking waterin the proportions are the pH = 7.12 and the electrical conductivity = 0.0231 s/m. A conventional solar still of 0.5* x *0.5 m has been designed to confirm this result.*

I. Introduction

Polluted groundwater treatment methods can be classified into physicochemical method such as: Groundwater treatment methods are based on physicochemical methods such as: coagulation, flocculation, sedimentation, filtration, membrane processes, ion exchange technology, adsorption, degassing; oxidation, reduction and solar desalination. All these methods use an outside energy to work except the solar desalination.

Desalination is a highly developed technology but each technique has its advantages and disadvantages [1, 2]. Solar distillation is the most economical way to purify or quench water is solar distillation. The efficiency of this technique is relatively low compared to other distillation modes, but this process only requires the sun's radiation to function. The variation of seasons has a remarkable influence on this type of technique [3]. Several researchers have studied and improved flat solar distillers by taking advantage of geometrical and metrological factors [4-6]. Other researchers have reduced the depth of water in the solar distiller basin and they are using an outdoor refractor to accelerate the heating of the water [7, 8]. Solar collectors and vacuum tubes have been integrated with the solar distiller to improve productivity [9-12]. Other studies have used latent storage materials as a means of improvement [13, 16]. Using nanofluids appeared in solar distillation to increase the efficiency of the distiller [17- 19].

In this work we want to show that the treatment of polluted water can be done by an environmental method, economic, simple and free. This method is solar distillation.

II. Experimental Methodology

II.1 Groundwater distribution in the region

The valley of El Oued is located in the south-east of Algeria with an area of 54573 Km^2 and more than 700000 inhabitants. The geographical coordinates in decimals are: 33.3683° of latitude and 6.8674° of longitude with an average altitude of 60 m. The region is very rich in groundwater but unfortunately this water is polluted. The National Institute of Public Health (1977) prolonged exposure to excessive fluoridated intoxication of drinking water in the Souf valley with levels exceeding 3.16 mg/l and in some localities of the Souf [20] which is much higher than the norm 0.7 mg/l. Figure 1 shows the distribution of groundwater in the valley of El Oued

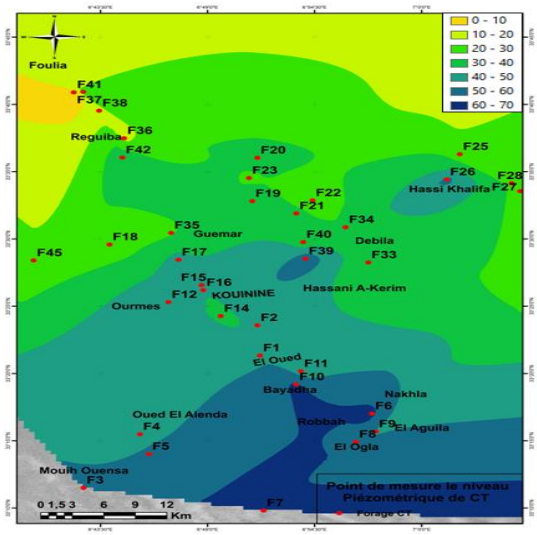

***Figure 1**. Water Disposal Map [20]*

II.2 Caracteristique des eaux de la region

The underground waters of the El Oued valley are very rich in fluors and many other pollutants. The high concentration of its products which exceeds the international standard causes a health problem at the level of the inhabitants. In the report of the World Health Organization, excess fluoride in drinking water can cause fluorosis that alters teeth and potentially serious bone problems [21]. Table 1 shows the concentrations excess of fluoride in different municipalities in the regionand we note that some municipalities widely exceed the norm.

***Table 1.** Concentrations of pollutants in El Oued water.*

Cites	Water table	F content mg/l	Maximum acceptable content mg/l
El-Oued	Pontian	2.17	0.7
Guemar	Pontian	1.91	0.7
Debila	Pontian	2.17	0.7
Hamraya	Pontian	1.97	0.7
Oued El-Allanda	Ground Water	3.16	0.7
Debila	Ground Water	3.09	0.7
Hassani Abdelkarim	Ground Water	2.91	0.7
Ourmas	Ground Water	2.91	0.7
Taghzout	Ground Water	2.51	0.7
Bayada	Ground Water	2.88	0.7
Rabbah	Ground Water	3.16	0.7

II.3 Solar still description

Figure 2 presents a conventional salor distiller. It is composed of:

- A wooden box with a thickness greater than 0.25 m and this to ensure good thermal insulation.
- A cover of glass transparent to solar rays so the thickness is between 0.003 and 0.004 m.
- A black absorber placed at the bottom of the wooden box. The absorber has the role of increasing the temperature of the distiller chamber. The absorber can be a black metal plate (this is the case of our work) but it can be engraved black, black sponge or other.
- A PCV tube placed in the lower part of the distiller. The tube collects the distilled water and the return to the collection tank.

***Figure 2**. Solar distillar*

II.4 The Principe of fonctionment

- The sun's rays pass through the glass cover to reach the black absorber at the bottom of the distiller's chamber.
- The temperature of the absorber begins to increase and a heat transfer will be performed between the black absorber and the polluted water.
- The water starts to heat up and then it evaporates. The hot steam will arrive at the level of the cold glass.
- Condensation of this vapor and that will give droplets of water. Since the glass cover is inclined at an angle of 20°, the droplets will

slip under the effect of gravity to accumulate in the PCV tube. The tube transmits the accumulated amount to the accumulation tank.

Figure 3 shows a croquisof our system. Temperature sampling is done with thermal sensors LM 35 types connect to an electronic card (Ardunio card). This card is connected to a PC. The values of the temperatures and the quantity of water produced are measured every hour.

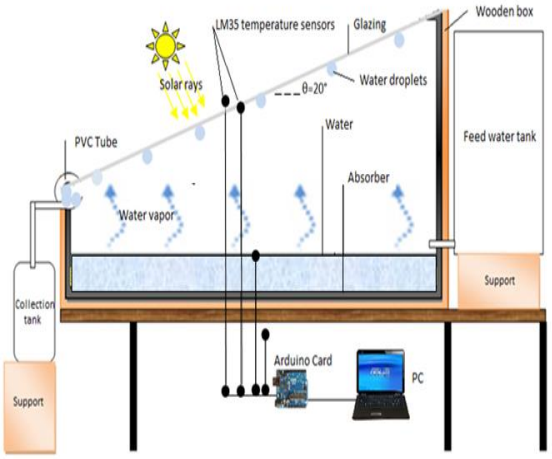

Figure 3*. Croquis view of the experimental set-up*

III. Method and experience

The main factor of the solar distillation is the solar rays but there are other factors like the ambient temperature, the wind, the thickness of the polluted water in the distiller, the type of absorber, the volume of the distiller's room, the salinity of the water and many others.
The index that shows that our system works well is the temperature gradient between the water and the inside of the glazing. The water is hot and the glazing is cold. To determine the proper functioning will measure the solar radiation, the ambient temperature, the temperatures of both sides of the glazing and the temperature of the water.

III.1 Solar radiation and ambient temperature

Figure 4 represents the variation of the solar radiation and the variation of the ambient temperature of the region as a function of time. It is noted that the solar radiation increases until reaching a maximum value 1010 Wh/m^2 around 13:00 and then it goes down after noon until reaching until reaching a minimum value of 200 Wh/m^2 towards 18h. The room temperature also rises to a maximum value of 32°C towards 14: 00h and then drops slightly to reach 27 °C at 18: 00h.

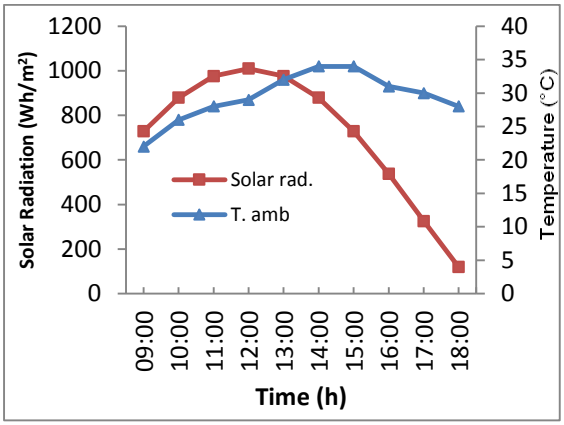

Figure 4. *Evolution of Solar radistion and ambient temperature*

III.2 water and glazing temperatures

The temperature gradient between water and the inside of the glass is the important factor in solar distillation. When this difference is big it gives us an idea that the productivity of drinking water is great. Figure 5 shows the difference represented by the arrows between the two graphs and we see that between 11: 00h and 16: 00h the productivity of the distiller is large because this difference is large.

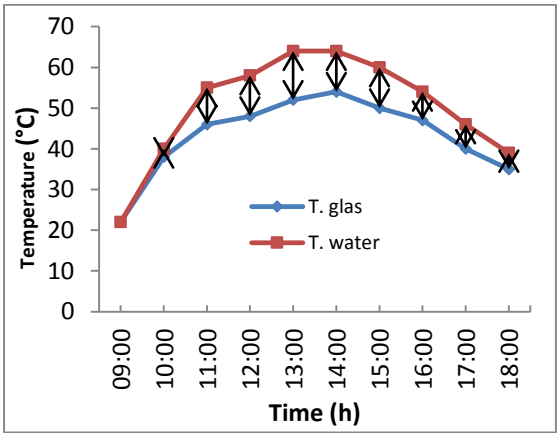

Figure 5*. Evolution of water and glazing temperatures*

III.3 Accumulation of drinking water

The accumulating evolution of pure water in the storage tank between 9:00h and 18:00h is represented in Figure 6. This amount is 3890,4 ml/m^2/day. We see that productivity increases with time.

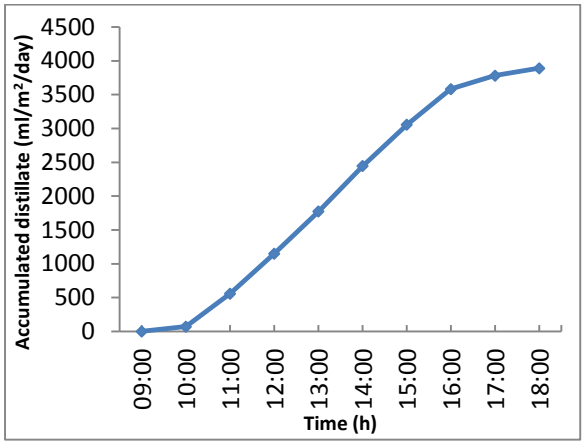

***Figure 6**. Accumulation ofdrinking water*

III.4 Productivity of drinking water

Figure 7 shows the productivity of pure water as a function of time. We note that the productivity is maximum between 11: 00h and 16: 00h and it is exactly where the temperature gradient between the polluting water and the distiller glazing is great which proves that this factor and very important in the phenomenon of distillation solar.

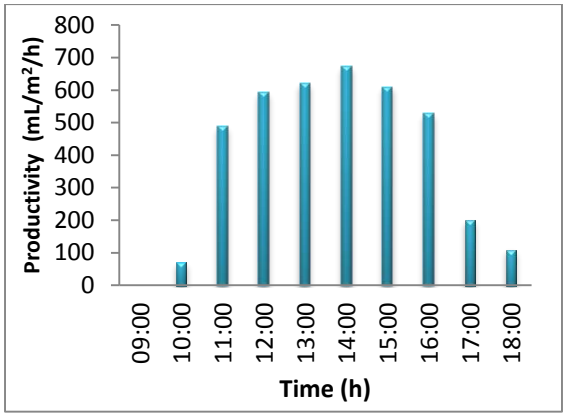

***Figure 7.** Evolution of water productivity*

IV. Water before and after distillation

The table gathers information on polluted water before and after solar distillation. It can be seen that there is a change in pH from 5.58 to 7.12 and it can be seen that the electrical conductivity also changed from 0.471 s / m before distillation to 0.0231 s / m. which shows that the water has become distilled and that impurities and pollutants are no longer in the water. This proves that the technique of solar distillation is effective in removing impurities and pollutants.

***Table 2**. Water before and after the distillation*

Water before distillation	Water after distillation
pH = 5.58 Eclectic Conductivity = 0, 471 s/m	pH = 7.12 Eclectic Conductivity = 0.0231 s/m

V. analysis of cost

To see that our system will be economically profitable we do a little analysis that includes the amount invested on the system and its maintenance. The table 3 shows that we can recover the amount invested 10000 Da in 42 days, that is to say our project is very profitable.

***Table 3**. Cost analysis*

	Algerian Dinar DA	Euro	
Total cost	10000	73.51	
Pure water Cost (l)	100	0.73	
Productivity (l/m² /day)			3.894
Water produced cost per day	289.4	2.13	
Cost of maintenance	50	0.37	
Net Profit	239.4	1.76	
Recovery period			42 days

V. Conclusion

The magorit of the underground is infected and polluted. The treatment of water by solar distillation is one of the solutions. This technique has shown that:

- The results obtained experimentally under the climate of El Oued southeast Algeria show that the polluted water has become pure water after the solar distillation (pH= 7 and Eclectic Conductivity = 0.0231 s/m).
- This technique does not use any external energy, it uses free solar rays.
- This technique is environmental, ecological, economical and very simple.
- We can recover the sum invested on a mini solar station after 42 days which shows that the project is very profitable.
- We can say that the climate of El Oued is very favorable for this technique we can say that the climate of El Oued is very favorable for this technique because with a simple solar distiller of 1 x 1 meter and without any parameter of improvement it is possible to produce almost 4 liter per day.

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