Performance Evaluation of a Solar Water Distillation System.

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ABSTRACT

There is an urgent need for clean potable water in many countries of the world including Nigeria. While most urban populations have access to clean potable water, many people in rural areas do not. There are many ways that can be used to improve the quality of water and one way is through distillation. This work aimed at producing potable water from brackish water for both rural and urban dwellers. The solar distillation plant used in this experiment has collecting area of 0.68 m^2. The emissivity of glass cover and absorptivity of the absorber plate are 0.85 and 0.93, respectively. The experiment performed gave maximum distillate of 2.3 liters on day 5 and maximum temperature of 54°C on day 5. It was observed that as solar intensity increases the higher the production of distillate.

(Keywords: solar still, solar distillation, potable water, absorptivity, purification)

INTRODUCTION

The need for good drinking water is on increase over the years due to importance of good health. The rising waves of water born disease have also affected mankind as result of poor quality water intake in the society. Water consumption in the world increases every day due to geometric world population increase. The world population is estimated to be 7 billion [1] with China and India having the greater number in this estimated value. The world health organization (WHO) and other health organization estimated that one individual should take at least two liters of water every day [2]. Therefore water consumption for 7 billion people is estimated to be 14 billion liters.

Most people in the world have no access to good drinking water. The sea water and some rivers are not good for drinking due to salt in it and other impurities. Hence the need for solar water distillation otherwise called solar still.

Distillation is one of many processes that can be used for water purification [3]. Most commercial stills and water purification systems require electrical or other fossil-fueled power sources [4]. The use of electricity in distillation apparatus, like in fractional distillation, is energy intensive. Air pollution, acid rain, global warming and climate change are but a few of the consequences that are attributed to use of fossil fuels and have been widely investigated [5-6].

Solar energy can be used to supply the energy required to heat water by making use of a solar still [3]. A solar still operates on the same principle as that of rain formation [7]: water from the ocean evaporates, then cools, condenses, and returns to earth as rainwater. Water to be cleaned is poured into the still to partially fill the basin. The glass cover allows the solar radiation to pass into the still, which is mostly absorbed by the blackened base [7]. This interior surface uses a blackened material to improve absorption of the sunrays. The water begins to heat up and the moisture content of the air trapped between the water surface and the glass cover increases [7]. The heated water vapor evaporates from the basin and condenses on the inside of the glass cover. In this process, the salts and microbes that were in the original water are left behind. Condensed water trickles down the inclined glass cover to an interior collection trough and out to a storage bottle. Feed water should be added each day that roughly exceeds the distillate production to provide proper flushing of the basin water and to clean out excess salts left behind during the evaporation process. If the still produced 4 liters of water, 12 liters of make-up water should be added, of which 8 liters leaves the still as excess to flush the basin.

MATERIALS AND METHODS.

Collection of Water

The water used in this experiment was obtained from pit water located at Opi Uno in Nsukka, Local Government Area, Enugu state. The pit was dug to prevent erosion and slow down water flow.

Experimental Method

The 10 liters brackish water was poured into a container having sieve on it to remove some material that might block the solar still tap during discharge. The sieved water was then poured into distillation basin. The set up was exposed to the sun to receive the sun radiation. The essence of exposing it to sun is that the solar radiation provides the energy which will heat the absorber basin painted black. The water in the basin will receive energy and increase in temperature. As the temperature of the water rises, vapor evaporates to the glass and condenses; it then trickles down from the sliding glass cover to the storage basin, where the pure water is collected.

Statistical Analysis

ANOVA test was performed with software SPSS 16.0 to see the statistical significant differences between the pre-treatment with difference substrates. The statistical significance level was selected at p-value<0.05.

RESULTS AND DISCUSSION

The result obtained showed that condensate output depend on the intensity of solar radiation. Figures 2-6 show temperature of brackish water recorded at the course of the experiment while Tables 2-6 indicate the temperature value. The output in day 3 was higher because solar intensity was as well higher than the other days. The graph of Table 1 was not steady due unsteady nature of sun intensity.

Tiwari and Tiwari (2005) found a daily yield of up to 1.714 kgm^{-2} in their study [8]. Also Tenthani (2012) collected 2.549 kgm^{-2} average of distilled water daily with the improved solar still they performed experiment with in Malawi [3]. Ozuomba (2012) obtained maximum condensate of 78ml and maximum temperature he recorded was 40°C [9].

Using $E = APH/3600G$.The efficiency of the solar still was calculated to be 18.9%.

Where A=collecting Area= Daily production, H= latent heat of vaporization and G=Daily total Insolation.

Table 1: Volume of Distilled Water Obtained.

S/N	Day	Volume (liters)
1	1	1.5
2	2	1.2
3	3	1.7
4	4	1.1
5	5	2.3

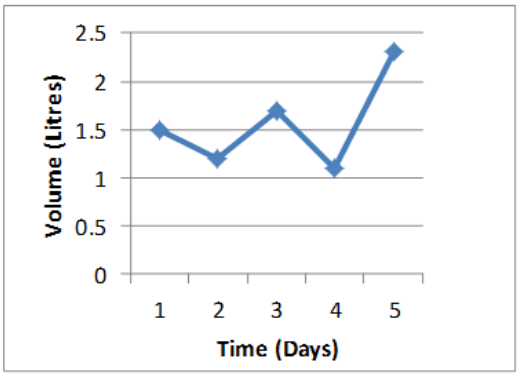

Figure 1: A Graph of Volume (liters) versus Time (days).

Table 2: Temperature of Brackish Water at Day 1.

Time	Temp. Brackish Water (°C)
8am	22
9am	26
10am	27
11am	36
12pm	42
1pm	51
2pm	54
3pm	48
4pm	40

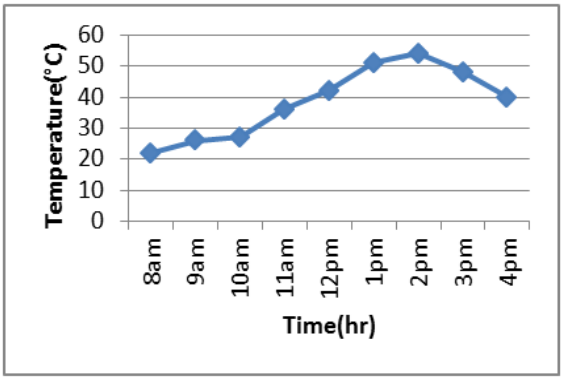

Figure 2: A Graph of Temperature (°C) versus Time (hr).

Table 3: Temperature of Brackish water on Day 2.

Time	Temp. Of Brackish Water (°C)
8am	21
9am	24
10am	26
11am	33
12pm	39
1pm	48
2pm	50
3pm	46
4pm	37

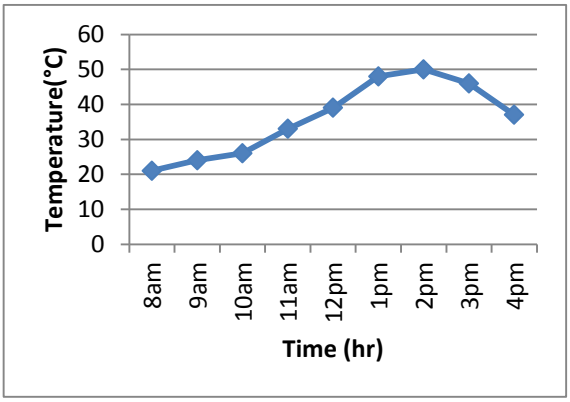

Figure 3: A Graph of Temperature (°C) versus Time (hr).

Table 4: Temperature of Brackish Water on Day 3.

Time	Temp. Brackish Water (°C)
8am	23
9am	27
10am	29
11am	38
12pm	43
1pm	53
2pm	55
3pm	48
4pm	42

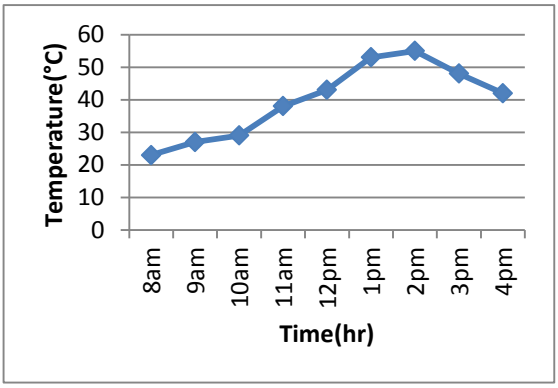

Figure 4: A Graph of Temperature (°C) versus Time (hr)

Table 5: Temperature of Brackish Water on Day 4.

Time	Temp. Brackish Water (°C)
8am	20
9am	24
10am	25
11am	30
12pm	35
1pm	41
2pm	45
3pm	36
4pm	34

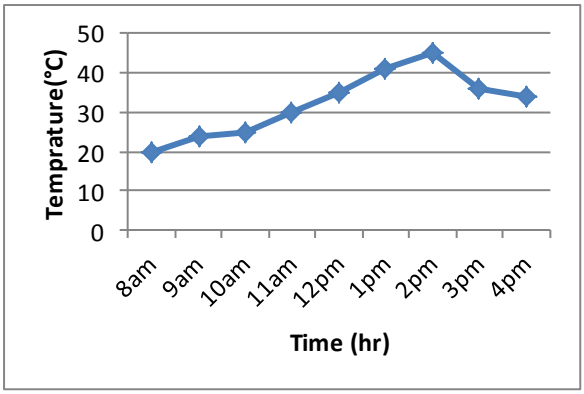

Figure 5: A Graph of Temperature (°C) versus Time (hr).

Table 6: Temperature of Brackish Water on Day 5.

Time	Temp. Brackish Water (°C)
8am	25
9am	29
10am	32
11am	37
12pm	48
1pm	52
2pm	54
3pm	49
4pm	42

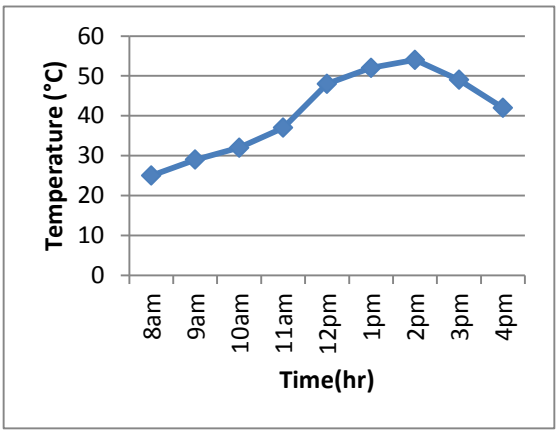

Figure 6: A Graph of Temperature (°C) versus Time (hr).

CONCLUSION

Distilled water could be obtained from dirty/brackish water by simply evaporating the water in an enclosed dish painted black and also covered with glass cover inclined to an angle. The water that evaporated drip down the glass cover and is collected in storage tank, this is called solar distillation. The experiment performed with this solar distillation plant recorded 2.3 liters as maximum volume of distillate and maximum temperature was recorded on day 5 as 54°C.

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