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Short Communication

The Performance of a Solar Water Distillation Kit fabricated from Local materials

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Abstract

There is an urgent need for clean, pure drinking water in many countries. Often water sources are brackish and there are many costal locations where sea water is abundant but potable water is not abundant. Pure water is also needed in some industries, hospitals and schools. Distillation is one of the processes that can be used for water purification and solar radiation can be the source of heat energy. A roof-type solar water distillation (RSWD) kit was fabricated and tested under actual environmental conditions of Urualla, an ancient town in the Eastern part of Nigeria. The system includes four major components; a rectangular wooden basin, an absorber surface, a glass roof and a condensate channel. The RSWD was able to generate 2.3m^3 of distilled water within six days. Though the condensate was not large enough compared to human need as is peculiar to many solar stills, the efficiency can be enhanced by using large solar absorber surface and by any method that can increase radiant energy.

Key words: water distillation, solar energy, potable water, solar still.

Introduction

Water is a renewable natural resource of earth and is extremely essential for the survival of all living organisms[1-2]. In nature, more than 97% of water sources are brackish but potable water is not abundant[1,3]. Therefore, controlling of water quality is one of the essential issues of drinking water management[4-7]. Distillation is the most widely used process for water purification[8].

Naturally, solar energy heats water in the seas and lakes, and then evaporation takes place. Water vapour condenses in the atmosphere and returns to earth as rain water. Solar distillation represents one of the oldest techniques and is useful for the production of fresh water from brackish or saline water in many parts of the world[9]. Among the many factors considered in the design and fabrication of a solar water distillation system are cost implication and efficiency. As a supporting technique for water purification, various types of solar stills have been developed and are being applied worldwide[10-13]. Generally, solar still systems have the advantage of low operating and maintenance costs and the shortcoming of low thermal efficiencies[14].

In this research work, we designed a roof-type solar water distillation (RSWD) kit to replicate the natural process of evaporation and condensation. In the RSWD system, a wooden rectangular box covered with black polyethylene absorber surface was the water tank. A glass roof was designed to rest onto the water tank. Beneath the glass roof was a gutter or condensate channel for driving out distilled water. The heating and evaporation took place on the absorber surface, while condensing process took place on the glass roof.

Material and Methods

Figure 1 shows a schematic diagram of a RSWD water basin whose interior has been covered with black polyethylene. The 91cm x 56cm rectangular water tank is 22cm deep. The water tap is for discharging of untreated water sample should the need arise. The condensate channel was made of aluminium sheets, while the wooden frame that formed the water basin also served as thermal insulator.

Figure 2 shows the glass roof, outlets for distilled water and RSWD stand. Two sheets of glass, about 90.8cm long, 61.2cm wide and 3mm thick were rightly placed to form the glass roof. Each of the two edges of the glass roof was covered with a triangular glass sheet of two equal sides and a base of 57.8cm. A 2-in-1 chemmer fast epoxy glue was used to hold the glass roof in place.

Solar energy warms the absorber surface and some of the water evaporates and condenses on the glass roof. The condensate flows into the condensate channel and is taken out through a hose pipe. The volume of distilled water produced hourly by the RSWD kit was measured for six consecutive days. The water sample was obtained from Urasi River. Urasi is one of the popular rivers located in the Eastern part of Nigeria. Hourly measurement of volume and temperature was carried out at Urualla, one of the ancient communities in the Eastern Part of Nigeria. The atmospheric temperature was measured using a copper/constantan thermocouple.

Figure-1
The rectangular water tank on top of RSWD stand

Figure-2
The glass roof on top of the rectangular water tank

Results and discussion

Characterization of the solar water distillation kit was done on January 2010 at Urualla, Imo State, Nigeria. Table 1 is the hourly volume of distilled water produced by the RSWD on Day 1. The highest condensate of 78.0ml was recorded at 5pm and the maximum temperature was 40.0^{0}C. The results obtained on the remaining five days (table 2 – table 6) show that the RSWD still usually produces the highest volume of distilled water towards evening. A relationship exists between volume of distilled water and daily temperature. A comparable high volume of condensate usually overflows as the atmospheric temperature reduces. Also, evaporation and condensation occurs overnight. Table 7 shows the relationship between the average daily temperature and total volume of distilled water collected for the day.

Table-1
Hourly volume and temperature measurement on Day 1

Time	Volume per hour x10^{-3}(m^3)	Atmospheric Temperature(^{0}C)
8am	0.0	25.5
9am	1.0	27.5
10am	1.0	31.0
11am	6.0	33.0
12noon	6.0	35.0
1pm	19.0	37.0
2pm	24.0	37.0
3pm	47.0	38.0
4pm	68.0	40.0
5pm	78.0	36.5
6pm	19.0	34.0
7pm	51.0	32.0

Table-2
Hourly volume and temperature measurement on Day 2

Time	Volume per hour x10^{-3}(m^3)	Atmospheric Temperature(^{0}C)
8am	4.0	28.0
9am	2.0	29.0
10am	8.0	31.0
11am	4.0	35.5
12noon	24.0	34.0
1pm	19.0	37.0
2pm	42.0	36.0
3pm	63.0	36.5
4pm	69.0	37.5
5pm	57.0	35.5
6pm	26.0	33.0
7pm	24.0	34.0

Table-3
Hourly volume and temperature measurement on Day 3

Time	Volume per hour x10^{-3}(m^3)	Atmospheric Temperature(^{0}C)
8am	0.5	26.5
9am	2.0	28.0
10am	3.5	29.0
11am	1.0	29.0
12noon	3.0	32.0
1pm	2.0	33.5
2pm	33.0	34.0
3pm	48.0	34.5
4pm	42.0	33.5
5pm	51.0	33.0
6pm	20.0	32.0
7pm	39.0	30.0

Table-4
Hourly volume and temprature measurement on Day 4

Time	Volume per hour x10^{-3}(m^3)	Atmospheric Temperature(^{0}C)
8am	2.0	26.5
9am	4.0	28.0
10am	0.5	30.0
11am	0.0	32.0
12noon	6.5	32.0
1pm	5.0	35.0
2pm	38.0	35.0
3pm	29.0	37.0
4pm	53.0	36.5
5pm	63.0	34.0
6pm	28.0	31.5
7pm	35.0	28.0

Table-5
Hourly volume and temperature measurement on Day 5

Time	Volume per hour x10^{-3}(m^3)	Atmospheric Temperature(^{0}C)
8am	1.0	23.0
9am	1.0	27.0
10am	0.0	30.0
11am	0.0	33.0
12noon	0.0	36.0
1pm	18.0	36.0
2pm	80.0	36.0
3pm	78.0	39.0
4pm	24.0	39.0
5pm	32.0	36.5
6pm	40.0	33.0
7pm	12.0	32.0

Table-6
Hourly volume and temperature measurement on Day 6

Time	Volume per hour x10^{-3}(m^3)	Atmospheric Temperature(^{0}C)
8am	7.0	27.5
9am	0.0	29.0
10am	8.0	31.0
11am	0.0	32.0
12noon	11.0	35.0
1pm	32.0	35.3
2pm	34.0	36.4
3pm	56.0	37.0
4pm	104.0	35.0
5pm	51.0	33.0
6pm	26.0	32.0
7pm	33.0	30.0

Table-7
The relationship between daily total volume and average temperature

Day	Total volume x10^{-3}(m^3)	Average Temperature(^{0}C)
1	385	33.9
2	429	33.6
3	298	31.2
4	382	32.1
5	365	33.4
6	471	32.8

Conclusion

A roof-type solar water distillation kit was successfully fabricated and characterized under actual environmental conditions in the Eastern part of Nigeria. The system includes four major components; a rectangular wooden basin, an absorber surface, a glass roof and a condensate channel. The RSWD of surface area 0.5m^2 was able to produce2.3m^3 of distilled water within six days. Though the quantity of water was small compared to daily need of potable water, the efficiency of the distillation kit can be increased by using large absorber surfaces. Any measure that can occasionally reduce the surface temperature of the glass roof will increase condensation process. Also, using solar concentrators to channel radiant heat to the absorber surface can increase the efficiency of the RSWD system. Meanwhile, since the RSWD can be fabricated with cheap and readily available local materials, somebody can fabricate a good number of it to meet daily demand of potable water.

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