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RESEARCH NOTE

Performance of a Double Slope Solar Water Distillation: A Case Study of Aiba Stream in Iwo

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P A P E R I N F O

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A B S T R A C T

Solar distiller was constructed and tested in this study. The purpose is to get a portable water from nearly any source available in a relatively cheaper means using a renewable solar energy. The result obtained clearly confirmed the reliability of this method to provide portable water especially in a rural area of developing country like Nigeria where the supply of fresh water is inadequate. A local dirty stream that is constantly throughout the year served as the source of the brackish water was used for this work. Sample taken from this stream was distilled using the constructed double slope solar distiller. The incoming solar radiation from the sun is focused and concentrated on to solar water distillation unit. Analyzing the sample of the distillate, the pH value of the brackish feed water was 9.20 ±1.10 while that of the distillate was 8.10 ±1.06, which falls within the WHO limits of 6.5-8.5 for drinkable water.

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INTRODUCTION

Solar distillation is quite an old technology that can be dated back to over five centuries. It came to use as far back as 1551 by Arab alchemists. Other Scientists reported in literature [1-4] also used stills. In 1872, Charles Wilson, a Swedish engineer of Northern Chile built the first solar plant. It was in operation for some 40years. Over the years many solar plants and individual stills have been built around the world. Nevertheless, the acute shortage of a good and clean portable water is still a major problem particularly in the rural areas of the developing countries like Nigeria. This make the efforts to improve on the old technology inevitable. This method (solar distillation) that utilizes solar energy to make drinkable water available for small communities where natural supply of fresh water is not sufficient or not available. Solar distillation is most suitable for locations where solar intensity is high, like in the tropics to ameliorate the scarcity of fresh water. The design and fabrication is easy, cost effective and efficient. As a supporting technique for water purification, various types of solar stills have been developed and are being applied worldwide. Generally, solar still systems have the advantage of low operating and maintenance cost and the shortcoming of low thermal efficiencies.

Detailed review of different designs of solar stills and the examination of different parameters that contribute to the performance of these solar have been carried out by Sampathkumar et al. [5]. Modeling of heat from these designs was focused by Reali and Modica [6] using desalination of sea water with a simple solar still using tubes. These solar distillations represents the most acceptable and easy technique, especially for small scale units. Conventional method of desalination, using high grade conventional energy have their negative impacts on the environment. Performance evaluation test conducted by varying the depth of water in the trough under the same climatic conditions showed that the productivity is dependent on the climatic, design and operational conditions [7]. The increased water productivity is inversely related to the depth of water and also strongly dependent on the solar radiation intensity. Medugu and Ndatuwong [8] also noticed the efficiency at any time increases with the increase of solar radiation and the increase of feed water (brackish) temperature.

METHODOLOGY

In this study a double-slope still was constructed by putting 2 sheets of 4mm thickness, transparent glass as the roof of the still and using Volvo gum to attach it to the side frames. The side wall was made of plain metal sheet painted black and in a rectangular shape of length 48 cm and breadth 42.5 cm. The

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Figure 1. Experimental setup of a double slope solar still with all the components label

height of the still is 24cm. The basin is made of galvanized metal plate 48 X 42.5 dimension and also painted black. The diagram of the solar water distillation unit discussed above is shown in Figure 1.

The basin was filled with brackish (feed water) to a marked level and was made to be exposed to irradiation from 7.00 a.m. till 6.00 p.m. (11hours) for ten days. The variation of feed water and ambient temperatures are illustrated in Figures 2-11.

COMPONENTS OF THE STILL

The various components of the solar still built are discussed below: Still basin; it is part of the system where the water to be distilled are kept. It is therefore essential that the material to be used should have high absorptivity, very less reflectivity and transmitivity. That is why a galvanized metal plate was used as the basin for this project and it was painted black for high absorptivity.

Side walls; provides rigidness for the still. Technically, it provides thermal resistance to the heat transfer that takes place from the system to the surrounding. So it must be made from the material that has low value of thermal conductivity and should be rigid enough to sustain its own weight and the weight of the top cover. Top cover: The surface of the top cover must be transparent to solar radiation, nonabsorbent of heat and nonabsorbent of water, clean and smooth. The material used was sheets of plain glass that is 4mm thick and Volvo gum was used to stick the glass to the still to prevent heat loss and to avoid leakage of water into the still.

Study area description and sample collection

Aiba stream was an outlet of Aiba reservoir in the ancient town of Iwo, Osun state, Nigeria. The stream runs through Kuti road, Oweyo, Oke-Afo and finally link into Oba River. Oweyo's location was considered in this study and this area lies between latitude 070 37' 41" N and longitude 040 11' 0.75" E with elevation of 226 m. This area is about 1 km away from Bowen University and notable activities around this area are car wash services, Motor Park, filling station and irrigation practices. The water sample was collected raw in a 5L keg from the stream and was taken down to the University in the solar research laboratory for the study.

RESULTS

Ambient and feed water temperature variation with respect to time for 10 consecutive days are shown in Figures 2-11.

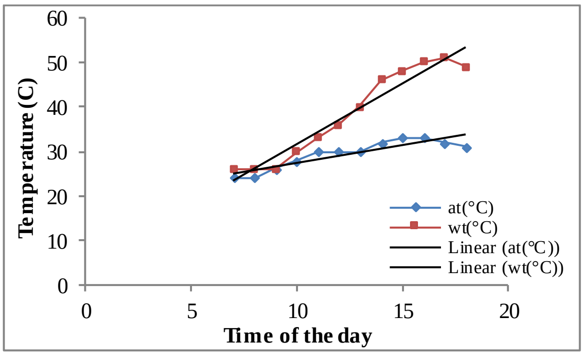

Figure 2. Temperature profiles from 7 a.m. to 6 p.m., 1st day

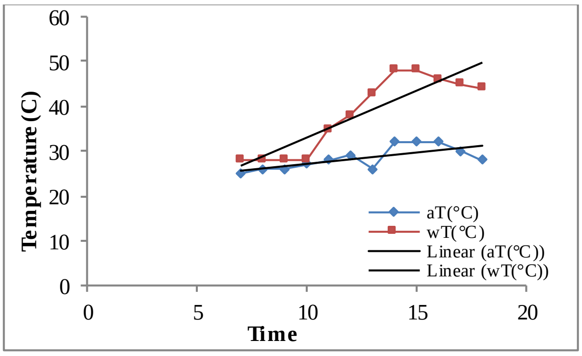

Figure 3. Temperature profiles, 2nd day

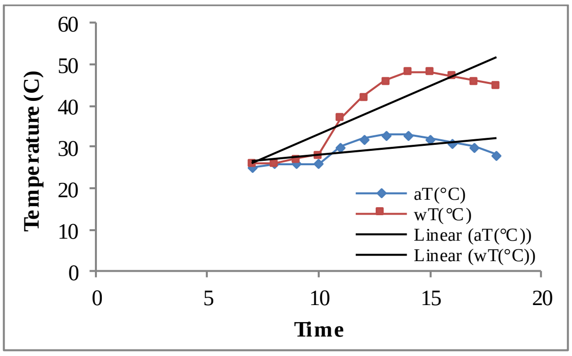

Figure 4. Temperature profiles, 3rd day

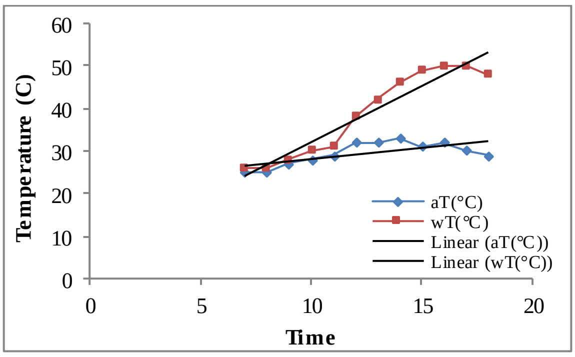

Figure 5. Temperature profiles, 4th day

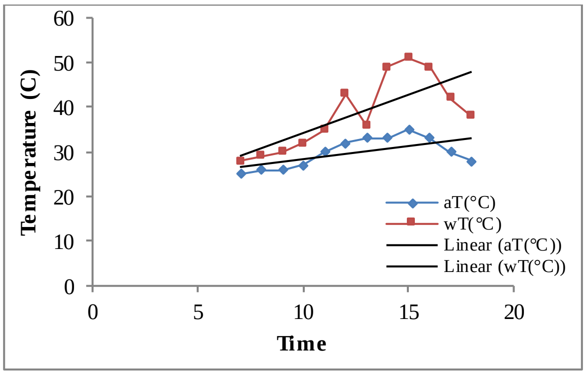

Figure 6. Temperature profiles, 5th day

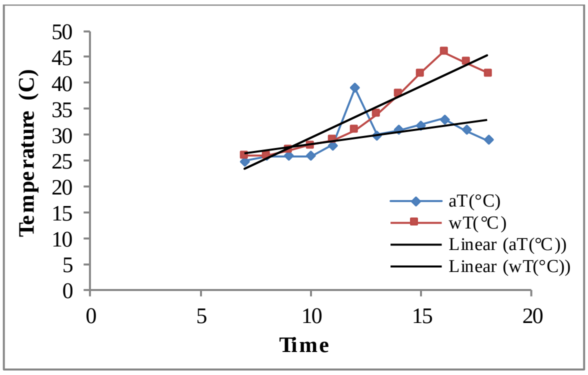

Figure 10. Temperature profiles, 9th day

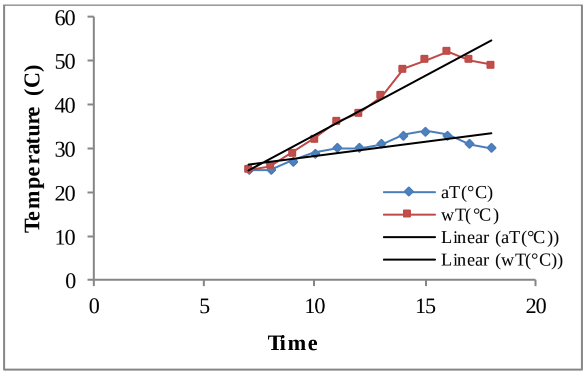

Figure 7. Temperature profiles, 6th day

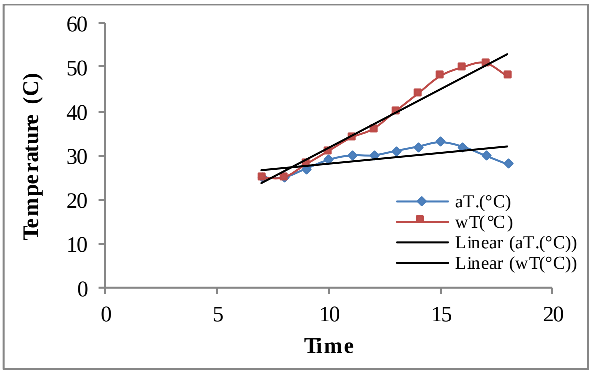

Figure 11. Temperature profiles, 10th day

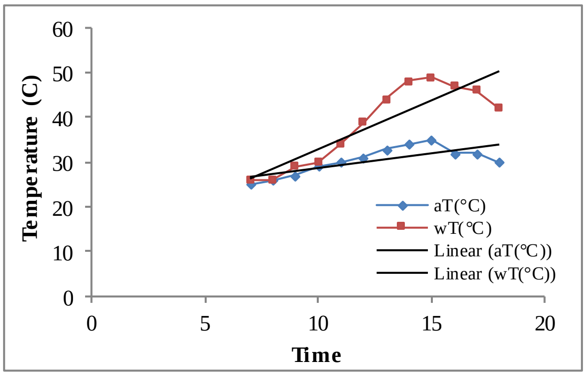

Figure 8. Temperature profiles, 7th day

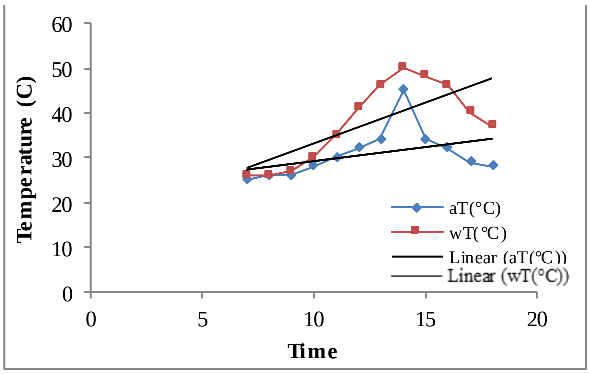

Figure 9. Temperature profiles, 8th day

DISCUSSION

Water temperature is observed to be generally increasing at all time, the highest occurring between the hours of 3-5 pm daily. The highest for the period of record was 51^{0}C while the highest ambient temperature was 35^{0}C. The quantity of distillate per day is shown by the histogram shown in Figure 12. The maximum volume of distillate in 1st, 2nd, and 4th day; that was correspond to the days the ambient temperatures were highest.

Considering Figures 2-11, it was observed that water temperature is higher and has a higher slope compared to ambient temperature, as the system was able to raise the temperature of the water as the intensity of irradiation increases. The temperature of the water in the tank reached to its maximum value between 1pm and 5pm when the ambient temperature was the highest (between 30-35°C). The temperature of the water in the tank then dropped as from 5.00 pm due to the drop in ambient temperature.

In Figure 3, at 1.00 pm on 2nd day, the weather was cloudy and it seemed to rain and this led to the drop in ambient temperature within the hours of 1pm and 2pm. Despite this, the water temperature still rose and this proved that the system can retain the heat trapped for a period of time before it starts to drop. In these graphs, it was observed that in the morning from 7am till 9am there is little or no change in water temperature during which the two temperature readings were close. But as the ambient temperature rose, the water temperature also rose and this occurs within the hours of 10am

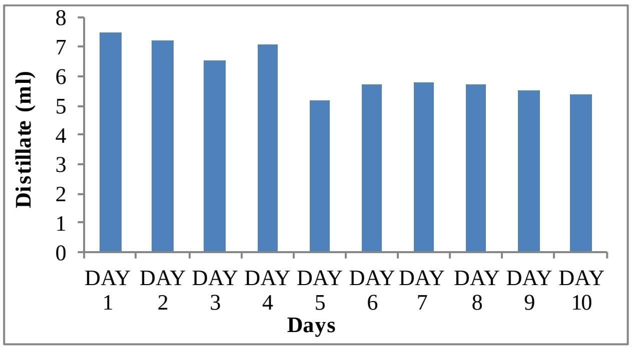

Figure 12. Bar chart for the volume of distilled water collected per day

till 4pm. At 4pm, the water temperature got to its peak, henceforth it began to drop after 5pm till 6pm due to the drop in ambient temperature.

All the graphs followed almost the same trend which is as the time increases, the temperatures also increased, later on in the day around 5pm, it starts to drop. The average volume of drinkable water produce by the still per day is 6.8-7 ml per hours. This system shows the following properties:

1) Higher retaining capacity of heat
2) Efficient utilization of absorbed temperature.

In the bar chart, day 1 has the highest distillate because the day was a very hot and sunny and same goes for 2nd day. Day 5th has the lowest distillate because the day was humid and it seemed it was going to rain.

CONCLUSION

Based on low amount of drinkable water collected, the system has very low performance due to low rate of vaporization. Any modification to enhance the rate of drinkable water production would require further research. With the test and analysis conducted on the distillate, it was found that the water has been purified to the level of usage for various purposes and with the addition of chlorine to the water to disinfect and remove any germs that may be present in the water it is therefore correct to state that the water is safe to drink and for cooking.

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Persian Abstract

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چکیده

در این مطالعه، واحد تقطیر خورشیدی ساخته و آزمایش شده است. هدف این است که آب قابل شرب را از نزدیکترین منبع موجود در یک سیستم نسبتاً ارزان تر با استفاده از انرژی تجدیدپذیر، انرژی خورشیدی تامین گردد. نتایج به دست آمده به وضوح اعتبار این روش را برای ارائه آب قابل شرب، به ویژه در یک منطقه روستایی کشور در حال توسعه مانند نیجریه که در آن منابع آب شیرین ناکافی است، تایید می‌کند. جریان آلوده محلی که در طول سال به طور مداوم جریان دارد به عنوان منبع آب شور برای این کار استفاده شده است. نمونه‌ای که از این جریان گرفته شده است با استفاده از واحد سازنده خورشید شیب دوگانه ساخته شده است. تابش خورشیدی متمرکز شده و به واحد تقطیر آب خورشیدی است. تجزیه و تحلیل نمونه تقطیر، مقدار pH آب خوراکی شور ۱/۱ ± ۹/۱ بود در حالی که میزان تقطیر ۱/۰۶ ± ۸/۱ بود که در محدوده WHO برای آب آشامیدنی ۶/۵-۸/۵ قرار دارد.