

Effects of Some Meteorological Variables on the Performance of Single Slope Solar Stills in Sokoto, North Western Nigeria

Kaisan Muhammad Usman and Sabi'u Bala Muhammad

Abstract- In this research, water sample was collected from Kwalkwalawa river, in Kwalkwalawa village, Sokoto State, North Western Nigeria. 25L of the water sample was used to fill a single slope solar still, and the whole set up exposed to the solar energy. The distillate yields of the sample were recorded at one hour intervals between the hours of 8.00am and 18.00pm. The corresponding values were measured for some meteorological variables like: solar radiation, ambient temperature, relative humidity and wind speed during each interval. The results were tabulated and picturesquely using bar charts. It was observed that the maximum yield recorded was obtained by 15.00pm. which also corresponds to the highest value of wind speed which accounts for condensation of the evaporated distillate. The relative humidity varied inversely with the yield. It has been observed that solar radiation varies parabolically with time, with its maximum value at 13.00pm. Solar radiation also varies linearly with yield only that, radiation reached its peak at around 13.00pm while the yield reached its maximum value around 15.00pm. Finally the yield of the distilled water increased as the ambient temperature increased, with the maximum yield recorded at the maximum value of the ambient temperature i.e. at 15.00pm. When the ambient temperature started to decline, the yield also started to decline equally.

Index Terms— Ambient temperature, relative humidity, solar radiation, solar still, wind speed

1 INTRODUCTION

Solar distillation is a process by which impure water is heated with solar energy, the evaporated water vapor is trapped and the condensed distillate collected as pure water (Garba et al, 2005). It is estimated that over two billion people are not connected to a power grid and will not be in the near future for a reason related to seclusion, low population density, poverty and inaccessibility. For these reasons, and to these people, autonomous solar systems can play a very important role in lighting, pumping, heating, drying etc (Alkama and Arkoub, 2009).

The use of solar distillation method in water purification is a very important method of solving day to day need of isolated villages for clean and healthy water. Distilled water is used for different purposes in institutions for laboratory experiments, health care centers, motor vehicle batteries, industrial and in commercial organisations (Garba et al, 2005).

Furthermore, the sun supplies more than enough energy to the entire system, its energy is replenishable, or in another term renewable. About 1.7×10^{17} watts per second of solar radiation is incident upon the earth. This is 30,000 times the global energy use by human beings (Garba et al, 2005). The solar distillation process is depended on different meteorological

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parameters, such as weather parameters like ambient air temperature, relative humidity, solar radiation and wind speed. This research work investigated the performance these meteorological variables on the distillate yield of solar still with time.

More so, clean water is an essential requisite for humankind and other living things to maintain their daily life. In many parts of the globe, fresh water demand of the people is fundamentally rising and this demand cannot be met by the obtainable natural water supply, in view of the fact that existing water sources are becoming limited and scarce, and also, they are being contaminated gradually with the large quantity of sewage and industrial waste. Conversely, abundant of solar energy is accessible with the large amount of rivers, lakes, sea water etc. Therefore, it is feasible to produce clean water from such water bodies using solar energy (i.e., solar distillation) economically. Consequently, increasing of clean and healthy water demand of the people can be solved partially by using solar distillation technologies (Yamali and Solmus, 2008).

According to Suleiman and Tarawneh (2007) major parameters which influence the solar still performance such as: dry spots and scale formation, air-tight conditions, glass cover inclination were investigated by different researchers; and good results were published (Boukar et al, 2004, Anil et al, 2005, El-Sebaai et al, 2005 and Aybar et al, 2005). The major handicaps that negatively influence the solar still productivity were taken in consideration, and some improvements on the design and operational conditions were made. In this research

work however, the variation of some meteorological variables such as ambient temperature, relative humidity, wind speed and solar radiation on the solar still were investigated.

2 METHODOLOGIES

A single slope insulated solar still was filled with 25L of water sample from Kwalkwalawa River, Sokoto State, North Wwestern Nigeria. The Kwalkwalaw river is the main source of water for drinking, cooking and other domestic and agricultural functions in the Kwalkwalawa village. However, during the previous reseach by same authors, it was observed that the water from such source has some contaminations and as such not healthy, and whence, the need for application of solar still distillation. The distillate output of the water sample was observed on hourly basis, between the hours of 8.00am. and 18.00pm.

Furthermore, at each hour interval, the solar radiation was measured using Pyranometer (Hioki 2005No. 951124222); the ambient temperature was measured using Digital Thermometer; the Wind speeds were measured using Anemometer and the relative humidities were measured using Hygrometer correspondingly. The results were tabulated in table 1 below, and analyses were carried out on the results.

3 RESULTS AND DISCUSSIONS

The experimental results of the effects of some meteorological variables: Solar radiation, ambient temperature, relative humidity and wind speed with distillte yields on hourly basis were tabulated in table 1 below.

TABLE 1
 EXPERIMENTAL RESULTS

Time Interval (hour)	Solar Radiation (W/m ²)	Ambient Temperature (°C)	Relative Humidity (%)	Wind Speed (m/s)	Yields in (ml)
8.00	260	23.30	15.20	0.4	0.40
9.00	455	35.00	3.70	1.3	16.70
10.00	650	41.50	2.60	1.5	35.00
11.00	780	43.30	1.20	0.5	50.00
12.00	858	43.00	0.45	1.7	120.00
13.00	871	43.40	0.00	0.6	170.00
14.00	793	45.20	0.00	2.0	190.00
15.00	624	43.50	0.30	6.0	210.00
16.00	338	38.70	2.70	0.9	140.00
17.00	143	32.70	6.00	0.5	100.00
18.00	13	27.10	11.60	0.0	0.40

3.1 Solar Radiation

It has been observed that solar radiation varies parabolically with time, with its maximum value at 13.00pm. Solar radiation also varies linearly with yield only that, radiation reached its peak at around 13.00pm while the yield reached its maximum value around 15.00pm

. Between the hours of 13.00 and 15.00, although the solar radiation had started declining, the yield was still increasing for the two hour interval. This was because, the solar still has trapped enough energy from the solar radiation, so that the water temperature increased significantly to

achieve maximum evaporation and condensation, and of cause the yield.

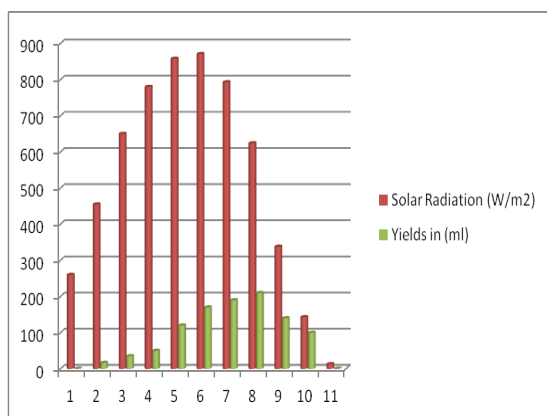


Figure 1 Variation of Solar Radiation with Distillate Yields

3.2 Ambient Temperature

From the experimental result and figure 2 below, the yield of the distilled water increased as the ambient temperature increased, with the maximum yield recorded at the maximum value of the ambient temperature ie at 15.00pm. When the ambient temperature started to decline, the yield also started to decline correspondingly. This was because, at higher values of the ambient temperature (afternoon), heat lost by the water content of the solar still due to conduction and convection was thereby reduced. At minimum values of the ambient temperature (Morning and Evening), more heat was lost from the single slope solar still to the surrounding, this is because, conduction rate is always proportional to the temperature gradient.

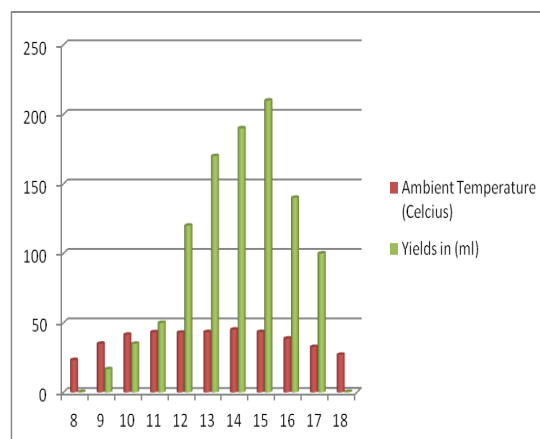


Figure 2 Variation of Ambient Temperature with Distillate Yields

3.3 Relative Humidity

Relative humidity as the only opposing parameter which can be observed from the experimental result and figure 3 below, had negative effect on the yield performance of single slope solar still. It was categorically clear that, minimum yield was recorded at maximum values of the relative humidity (During the hours of 8.00am and 18.00pm). Moreover, maximum yield was recorded at the minimum values of relative humidity (During the hours of 13.00pm and 15.00pm).

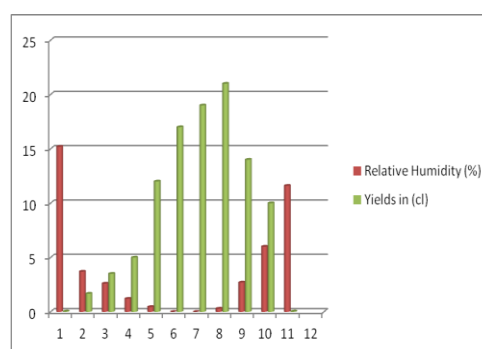


Figure 3 Variation of Relative Humidity with Distillate Yields

3.4 Wind Speed

From the experimental result and the figure 4 below, wind speed fluctuated at each hour reaching its peak at 15.00pm. corresponding to

the maximum yield, after which it began to decline. This shows that, more water vapour in the solar still was forced to condense for maximum yield to be achieved at higher values of wind speed. At lower speeds however, even though enough water vapour was formed less condensation and (of cause) yield was recorded. This is because, wind speed may be the only agent of cooling.

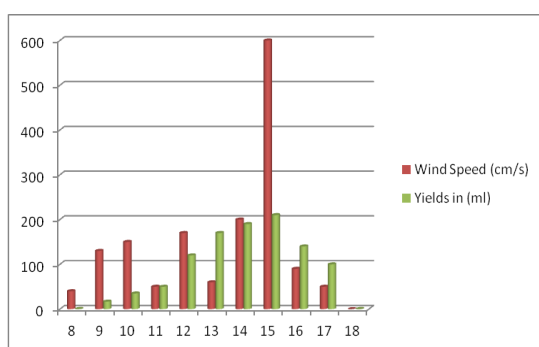


Figure 4 Variation of Wind Speed with Distillate Yields

4 CONCLUSIONS

Conclusively, going by the experimental findings presented abinitio, the solar radiation, the ambient temperature and the wind speed increase with a corresponding increase in distillate yield. While the relative humidity decreases with a corresponding increase in distillate yield. Hence, all the meteorological variables herein observed, have effects on the yield performance of single slope solar still with time.

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