

The Rate and Effect of Solar Radiation in Ebonyi, Nigeria

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ABSTRACT - Global solar radiation varies. And changes in the climatic conditions are worldwide environmental problems. This paper uses data consisting of weekly average of daily solar radiation for a period of one month. These data are obtained by using Daystar Solar Meter to measure the solar radiation at Ebonyi Local Government Area (Presco Campus) (8° N, 6° E). The clearness index is calculated. From the result, Ebonyi has enough solar radiation that will be utilized for photovoltaic applications. It also reveals its effect on farmers.

Index Terms – Solar Radiation, Clearness index, Sun, Earth, and Atmosphere

1 INTRODUCTION

The sun is an extremely powerful energy source, and sunlight is by far the largest source of energy received by the earth. Though its intensity at the earth's surface is actually low. This is essentially because of the enormous radial spreading of radiation from the distant sun. The radiation from the sun is capable of producing heat, causing chemical reactions, or generating electricity. The sun is Earth's principal and source of radiation energy. With a surface temperature of approximately 600k, the sun's electromagnetic radiation transmits some of this heat in the form of infrared radiation to our atmosphere and to varied surfaces on earth [1]. Earth's land surface, oceans and atmosphere absorbs solar radiation and this raise their temperature [2].

Solar radiation also known as insolation, is the electromagnetic radiation emitted by the sun. It is made up of radiation that comes directly from the sun. This direct radiation comes from the solar disc which has not suffered any deviation in its path before arriving to the earth's surface [3]. Solar radiation passes through the atmosphere and experiences absorption and scattering by various constituents of the atmosphere. Globally, solar radiation is divided into two, direct and diffuse solar radiation. Diffuse solar radiation is the type that results from scattering caused by gasses in the earth's atmosphere. More recently global solar radiation has been studied due to its importance in providing energy for earth's climatic system. Radiation is of economic importance as renewable energy alternatives. The amount of solar radiation reaching the surface of the earth

depends significantly on the concentration of airborne particulate matter gaseous pollutants and water in the sky, which can further attenuate the solar energy and change the diffuse and direct radiation ratio [4].

Solar energy is the energy that comes from the sun in the form of radiation which is received on the earth as light and heat [5]. It is the total frequency spectrum of electromagnetic radiation produced by the sun. The successful design and effective utilization of solar energy systems and devices for application in various facets of human needs, such as power and water supply for industrial, agricultural, domestic uses and photovoltaic cell largely depend on the availability of information on solar radiation characteristic of the location in which the system and devices are to be situated [6]. The utilization of solar energy, like any other natural resource, requires detailed information on availability. Since solar radiation reaching the Earth's surface depends on many factors which are not of global character, a study of solar radiation under local weather conditions is also essential. The geographical distribution of solar radiation over a region is normally different from other regions due to the position and atmospheric constituents of the local weather condition [7]. Cloudiness, atmospheric transmissivity, latitude and orientation of the Earth relative to the Sun, time of day, slope and aspect of the surface determine the spatial and temporal distribution of irradiance incident on a surface [8]. Clouds are the major cause of fluctuation in the solar radiation and sunshine hours on the ground surface. The variation, however, is not due to the angle of incidence of the sun's rays with ground surface and its azimuth [9]. Actually, mapping the solar radiant energy on the earth's surface is a requirement not only in the studies of climate change, effects on ecosystems, environmental pollution but also in agriculture, hydrology, food industry and non conventional energy development programs [10].

Furthermore, solar radiation that reaches the earth's surface has strong effect on the environment of the earth. Its effect can be directly or indirectly. This radiation which comes from the sun produces a vast range of wavelengths that approach the earth. It can be absorbed by animate or inanimate surface. All animals regulate their internal body temperature in order to maintain a relatively constant temperature within a small range; in effect the rate of heat gained or produced must be balanced with heat lost to the environment. Solar radiation

plays a large part in determining not only ambient and body temperatures but animal behavior as well. A wide variety of species have developed methods to reduce the cost of thermoregulation by behaving certain ways such as seeking shade, burrowing, etc.

Solar radiation is essential for life, transferring energy to plants from the basis of food webs. Organisms here evolved thermoregulatory behaviors and responses to concentrated periods of solar radiation as well as to changes in ambient temperature, which is also affected by solar intensity [11]. Behavioral responses to solar radiation and other environmental variable can be paired with changes in skin surface blood circulation. Humans are sensitive to solar radiation and may experience sunburn, heat strokes, eye diseases, and skin cancer when overexposed. Low doses of UV radiation are required for vitamin D synthesis and can be used to treat some illness [12]. Solar radiation has a significant effect on the circulatory physiology of some animals. Infrared thermal images show that certain areas of skin function as thermal windows, vasodilating the blood vessels and shunting warm blood directly to the skin surface, facilitating heat transfer to the air by convection or substrate by conduction. By increasing skin temperature in specific areas, such animals are able to increase the temperature gradient more so than if blood was perfused along the entire body surface [13]. All organisms regulate their internal body temperature to maintain a relatively constant temperature within a small range; in effect the rate of heat gained or produced must be balanced with heat lost to the environment.

Heat gained using solar radiation aids in digestion and increase growth rates in some animals at both extreme and moderate elevations. Solar radiation plays a large part in determining not only ambient and body temperatures but animal behavior as well. A wide variety of species have developed methods to reduce the cost of thermoregulations by behaving certain ways such as seeking shade, burrowing, etc.

2 METHODOLOGY

The main materials used in obtaining the data for this research work are; 1.Daystar solar meter, which was placed in an open horizontal surface. The global solar radiation was obtained from this instrument. 2.The GPS

global positioning instrument was used to obtain the latitude of the point of measurement. The value of clearness index K_T was calculated using the equation below;

$$K_T = \frac{\bar{H}}{H_o} \quad (1)$$

Where K_T is the average clearness index

\bar{H} is the monthly average radiation on horizontal surface at presco

H_o is the monthly average daily extraterrestrial radiation on a horizontal surface.

But

$$\frac{\bar{H}}{H_o} = a + b \left(\frac{\bar{n}}{\bar{N}} \right) \quad (2)$$

Where a and b are regression constants determined climatologically by Tiwari and Suleja [14] as

$$a = -0.110 + 0.235 \cos \phi + 0.323 \left(\frac{\bar{n}}{\bar{N}} \right) \quad (3)$$

$$b = 1.449 - 0.553 \cos \phi - 0.694 \left(\frac{\bar{n}}{\bar{N}} \right) \quad (4)$$

\bar{n} is the monthly average daily hours of observed sunshine

\bar{N} is the monthly average of the maximum possible daily hours of bright sunshine.

ϕ Latitude of the place of actual reading

3 RESULT AND DICUSSION

From the data obtained the graph below was plotted;

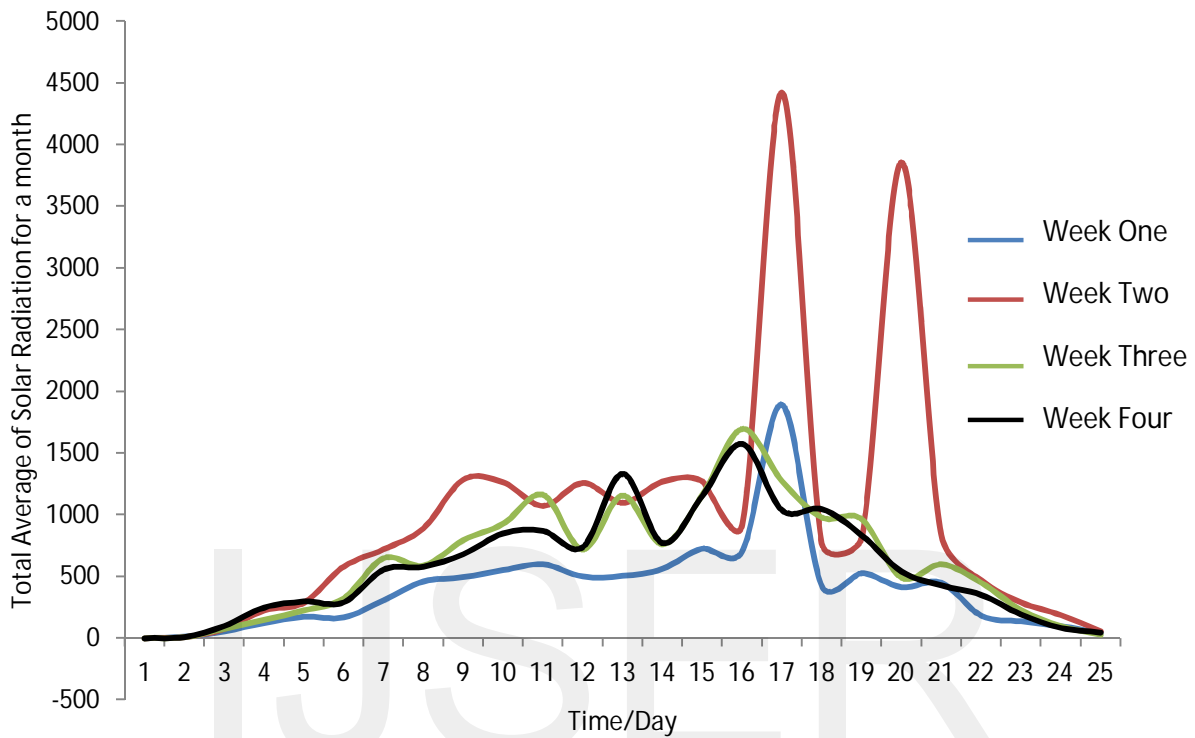


Figure 1; Graph showing the average solar radiation for four weeks

For the clearness index, using equation (3) and (4), the following were obtained from the data generated in this work:

$$a = 1.3311$$

$$b = -1.9358$$

$$\left(\frac{\bar{n}}{\bar{N}}\right) = 0.0964$$

And

$$\bar{H} = 333.28, \text{ (from the actual readings)}$$

Substituting these values into equation (2) and (1), we have;

$$\bar{K}_T = 1.1445.$$

From the figure 1 above, the highest average solar radiation occurred in the second week with the value of 3856.286 Wm^{-2} , and the lowest average solar radiation occurred in the third week with the value of 7.5 Wm^{-2} . The difference in the value of solar radiation could be due to variations in solar activity which took place within the period of observation. The clearness index was calculated in order to characterize the sky condition of Ebonyi (Presco campus). From the result, the clearness index is seen to be high with the value of 114.45%. The significant of this value is that the cloud is very clear and it enhanced direct radiation within the period and place of observation. This is in agreement with Ndilemeni et al, 2013 [15]. Hence there is a distinct clearness index between September/October 2014 (within period of observation). As such they can be high utilization of solar power in Ebonyi. The result further showed that Ebonyi receives enough solar radiation which can be used for photovoltaic applications. This implies that studying solar radiation will enhance the use of renewable energy as it promotes solar photovoltaic technology. This is in agreement with Khem et al, 2012 [16] and Basnyat 2004 [17].

In addition, solar radiation has effect on animal thermoregulation. Animals such as "cold-blooded" (example fish), regulate their body temperature externally through behavioral mechanism that alter heat exchange between their bodies and the environment. Although solar radiation is important to such animals as they bask to supplement heat gain. A high radiation can be critical to such animals as they try to remain active. As seen in the result above, the radiation is high and this may affect the animals negatively, thereby putting the farmers at great lost. This is in agreement with De Rensis and Scaramuzzi 2003 [18]. If these animals rely on external heat source then insulation would be detrimental to them. And they can only avoid direct solar radiation by moving to safe hiding places. But pond fishes may lack hiding places and as such die as a result of excess radiation. For poultry farmers, birds lack sweat glands, this make them to depend on other means for heat radiation. They change posture in relation to the sun which leads to huge impact in reduction of heat gain. This change in orientation helps in the conduction of excess heat away from the body. Hence poultry farmers faces less risk compare to fish farmers. Domestically, solar radiation affects animals such as cattle and goats which

are left in the pastures. These exposed animals have no shade and as such face great impact of radiation, enabling them to have much heat load. As they absorb excess heat from radiation their rate of productivity reduces, thereby creating decrease in productivity. This is in agreement with Schutz et al, 2009 [19]. Direct solar radiation causes high temperature on animals.

Conclusively, the rate of solar radiation can be estimated on the basis of clearness index. Solar radiation affects the earth's environment either directly or indirectly. It could serve as the driving force for meteorological activities.

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