Estimation of Mean Monthly Global Solar Radiation in Makurdi, Nigeria and its Environs Using Maximum Temperature Data

By

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Abstract: The mean monthly global solar radiation for Makurdi and its environs (Latitude 70 7'N and longitude 80 6'E) was estimated using the maximum temperature data taken at Air Force Base, Makurdi. The solar radiation (W/m2), hours of bright sunshine and maximum temperatures were measured hourly from 0600H to 1800H daily for Nine (9) years from 2003 to 2012. The mean global solar radiation, hours of bright sunshine and maximum temperature were 235.96 W/m2, 15.03 hours and 33.96 0C respectively. The highest solar radiation of 276.43 W/m2, highest bright sunshine hours of 7.0hrs and the highest maximum temperature of 38.50C was in the month of march while the lowest solar radiation of 193.18W/m2, lowest hours of bright sunshine of 3.4hrs and lowest maximum temperature of 30.40C was in August. The maximum temperature was measured with an instrument called zeal while the solar radiation was measured with an instrument called Gunn-Bellani in ml and later converted to Watts per meter squared. It is concluded among other things that the temperature increases as solar radiation intensity increases.

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INTRODUCTION

Solar energy is the most promising renewable energy source in view of its apparent limitation potentials (Sambo, 1995) and Ike, 2006). Solar energy is the most important energy source to man and it is essential factor to human life. Solar radiation is an environmentally benign and sustainable energy source, but it does not continue for long durations at a given location (Sen, 2004; Joshi, 2006; Joshi *et al;* 2009). Global solar radiation is the total amount of energy falling on a horizontal surface. It is measured in J/m^2 or W/m^2. The values are usually highest at clear sky conditions and lowest during very cloudy days. Solar energy, which is a radiation from the sun, is absorbed, scattered and reflected by the atmosphere. It reaches the ground as diffuse radiation, which comes from many directions or as beam radiation, which comes from direction of the sun (Pidwirny, 2006: Ojukwu and Chukwocha, 2006). About 1.2 kilowatts touches a squared meter of land

almost half this solar energy is visible light, about half is near infrared radiation and a very small percentage is in the form of ultra violet radiation (Goetz, 1990, Wikipedia, 2007 and Yohanna *et al.,* 2011). Solar energy is capable of producing heat, causing chemical reactions or directly generating electricity. Global solar radiation is the computed solar radiation from the extra-terrestrial direct and diffuse components of solar radiation putting consideration the sun shine duration data, temperature and humidity (Polo *et al.,* 2009; Zarzalejo *et al.,* 2009). The comprehensive deign and effective utilization of solar energy systems depend largely on adequate information of the solar radiation characteristics of the region or location in which the systems are located (Moradi *et al.,* 2009; Polo *et al.,* 2009).

Solar radiation affects the earth's weather processes, which determine the natural environment. Its presence at the earth's surface is necessary for the provision of food for mankind. The growth of all things on the earth depends on the sun. The radiation from the

sun (solar radiation) can be regarded as the only heat source for the seas and atmosphere of the earth and thus the world weather and climate (Onwualu *et al.,* 2006).

Makurdi, Nigeria is a tropical location with abundant solar radiation that can be harnessed for everyday use and to do this there is need to know the amount of solar radiation in the location to facilitate the design of solar devices.

The objective of this study is to estimate the mean monthly global solar radiation in Makurdi and its environs using maximum temperature data obtained from the experimental measurements/meteorological unit at the Air force base, Makurdi.

radiation was measured from an instrument called Gunn-Bellani in milliliter (ml) at the Air force Base, Makurdi, Nigeria and the readings were converted to the standard solar radiation in W/m^2 using the formula :1ml= (1.357 $\pm$0.176)MJ/day or 15.706 W/m^2 (Okonkwo and Akubuo 2001). The monthly records of meteorological observations for Makurdi location were taken from 2003 to 2012 (9 years). At the end of the ninth year the mean solar radiation parameters for the nine (9) years was computed to get the estimated mean monthly global solar radiation in Makurdi and its environs-using the maximum temperature data taken during the visible sunshine hours.

MATERIALS AND METHODS

Makurdi, Nigeria is located on latitude 7^07'N and an altitude of 106.4m above mean sea level. The global solar radiation, maximum temperature and sunshine duration were measured daily from 0600H to 1800H. The maximum temperature was taken with an instrument called zeal in ^0c while the minimum temperature was taken with an instrument called cassela. The solar

RESULTS AND DISCUSSION

Table1: Mean Monthly Records of Meteorological Observations of solar radiation   Parameters   for Makurdi Location from 2003-2012

Moths/years 2003-2012	Average max. Temp.(c)	Mean sunshine (hr)	Mean Solar Ml	Radiation W/m²
January	35.7	6.7	15.4	241.87
February	37.7	6.4	16.6	260.72
March	38.5	7.0	17.6	276.43
April	35.7	6.2	15.5	243.44
May	35.5	4.9	15.4	241.87
June	31.4	3.6	14.2	223.03
July	30.7	3.8	12.4	194.75
August	30.4	3.4	12.3	193.18
September	31.1	3.7	13.4	201.47
October	32.2	3.6	14.3	224.60
November	33.7	6.2	16.2	254.44
December	34.9	6.3	17.0	267.00
Total	407.5	61.8	180.3	2831.46
Mean	33.96	5.15	15.03	235.96

Values indicated are extrapolated from the monthly mean values obtained from Air force Base, Makurdi
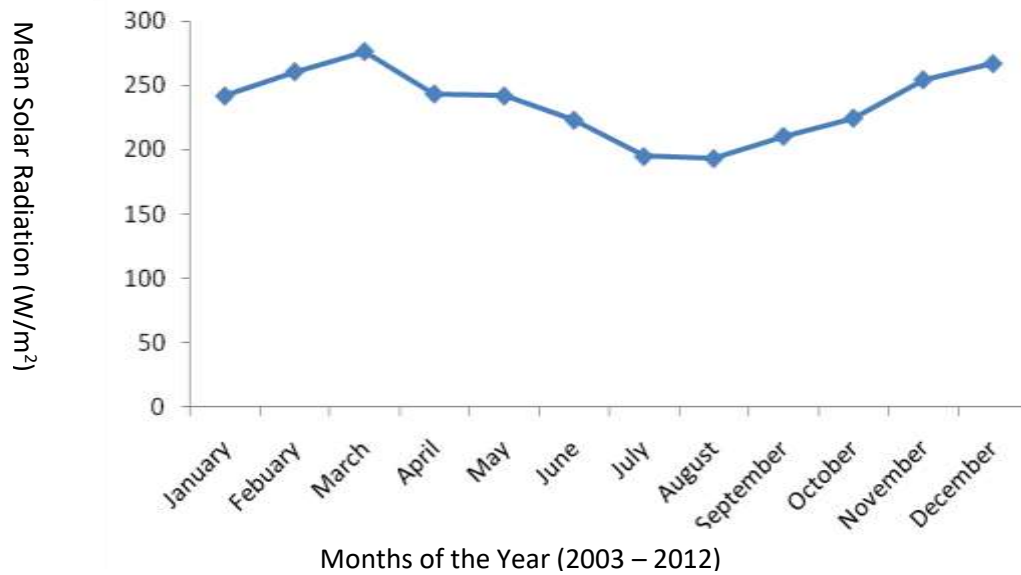
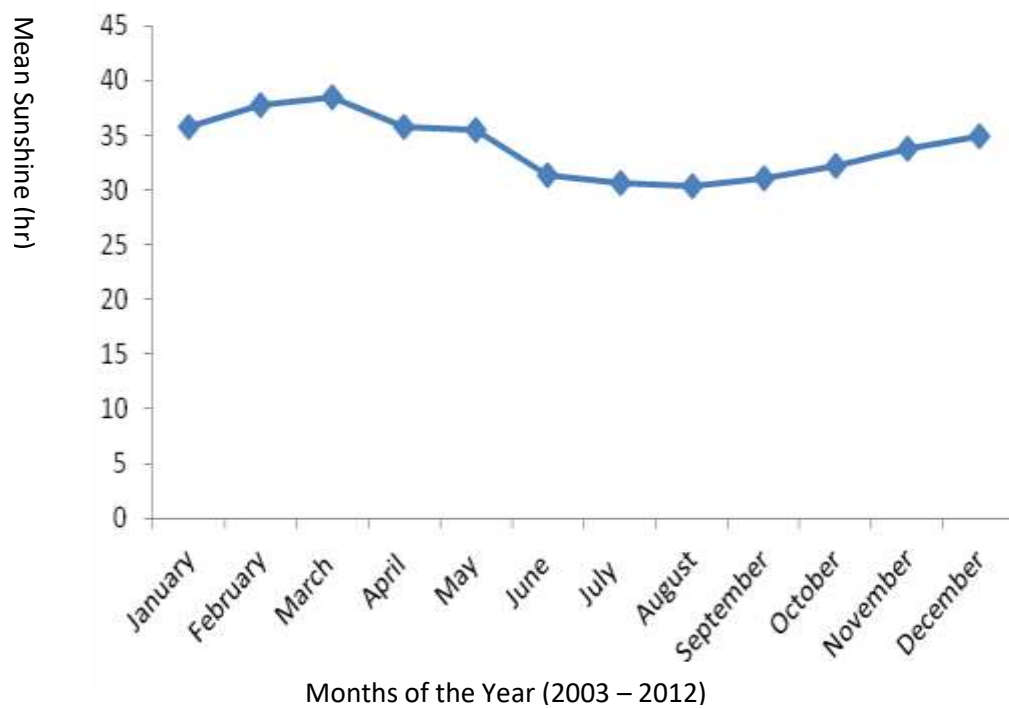**Figure 1**: Monthly Variation of Mean Solar Radiation for Makurdi location and its environs

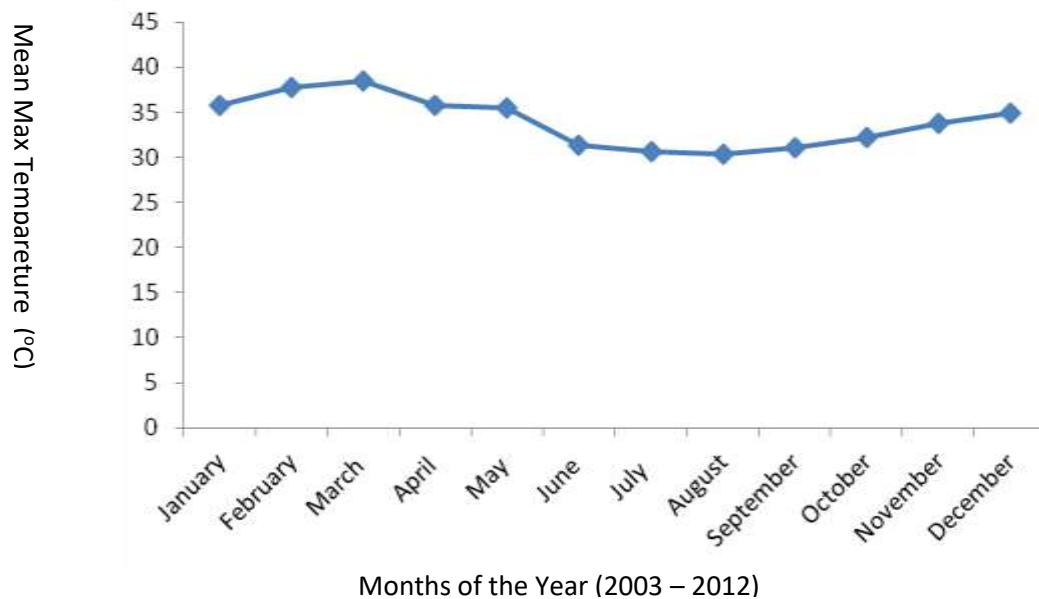**Figure 2**: Monthly Variation of Mean Sunshine hours for Makurdi location and its environs

Figure 3: Monthly Variation of Mean Maximum Temperature for Makurdi location and its environs

Table 1 is a summary of measured monthly mean global solar radiation parameters. The location has a mean global solar radiation of 235.96 W/m^2, mean sunshine hours of 5.15 hours and mean maximum temperature of 33.96 °C. The month of March, which had the highest measured mean solar radiation of 276.43W/m^2 also had the highest hours of bright sunshine of 7.0hrs as well as the highest ambient or air temperature of 38.5°C (Fig1, 2, 3). This implies that temperature increases as solar radiation intensity increases (Sanusi and Aliyu, 2005). This is expected because the yearly rotation of the earth about the sun shows that the sun is at the equator in March nearly to cross into the northern hemisphere. Also the amount of solar radiation on a flat surface depends on the weather, latitude of the location, surface orientation and tilt angle of the horizontal (Arinze and Obi, 1994) and Makurdi location (latitude 7° 7'N) is within the equatorial belt.

The lowest measured solar radiation of 193.18W/m^2 in August also had the lowest hours of bright sunshine of 3.4 hours due to the dusty cloud cover and interruption by the cloud at that period since solar energy is available only when the sun shines (Foster and Mickenzie 1981, Burari and Sambo, 2003). Also under heavy cloud condition, no direct (beam) radiation reaches the horizontal (Joel & Roy, 1998: Montero et al., 2009). Cloud reflects some incoming radiation back to space thereby reducing the amount of radiation that reaches the earth's surface (Suri & Hoefrerka, 2002&2004, Dupont & Mastegar, 2006; Onwualu, 2006). This result agrees with the work of Zarzalejo (2006) and

Zarzalejo *et al.,* (2009), which showed that solar radiation increases with the duration of sunshine hours.

CONCLUSION

It is concluded that
 I. The estimated mean global solar radiation; mean hours of bright sunshine and mean maximum temperature were 235.96W/m^2, 5.15hours and 33.96°C respectively for the Makurdi and its environs.
 II. The highest solar radiation of 276.43W/m^2 and bright sunshine hours of 7.0hours was in March while the lowest solar radiation of 193.18W/m^2 and lowest hours of bright sunshine of 3.4hours was in August.
 III. Ambient temperature increases as solar radiation intensity increases.

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