AN ANALYSIS OF SOLAR RADIATION LEVEL IN MAIDUGURI TOWN OF BORNO STATE, NIGERIA.

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ABSTRACT
In this paper the daily sunshine duration is used to estimate average global solar radiation for Maiduguri, Borno State, Nigeria. The daily sunshine hour were measured for five years from which the monthly mean values were determined. Angstrom model was then used to estimate the global solar radiation based on the monthly mean sunshine hour. The value of solar radiation for Maiduguri town vary from the range of $16.8040\ Mjm^{-2}day^{-1}\ to\ 25.0376\ Mjm^{-2}\ day^{-1}$ under the period of this research with the mean value of $23.2044\ Mjm^{-2}\ day^{-1}$.

Keywords: Visible light Radiation, Infrared Radiation, Ultraviolet Radiation, Pyrheliometer and Pyronometer.
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INTRODUCTION
Solar radiation occupies one of the most important places among the various possible alternative energy sources. An accurate knowledge of solar radiation distribution at a particular geographical location is of vital importance of the development many solar energy devices. Unfortunately, for many developing countries solar radiation measurements are not easily available due to the shortage of measurement equipment's. it is therefore

important to consider methods of estimating the solar radiation based on the readily available meteorological parameters (Augustine et al., 2010). Solar radiation is the radiation or energy we get from the sun, it is also known as short-wave radiation. Solar radiation consists of visible light, infrared and ultraviolet radiation.

The sun is a mysterious and powerful source of energy, the history of solar energy data as many years back, Greek and Roman Empires during a time when myth and reality were intervened. To the Greek, Romans, Egyptians of that time, nature and the environment around them was seen as the home of goals. The Egyptians followed the rising sun for guidance to be tombs of their Kings and Queens. Both the Greeks and Egyptians used the sun as part of mummification process in drying the dead bodies and also used passive solar to help them in their daily lives. The Greeks use a technique that incorporated mirrors reflecting the sun's light towards Roman ships prepared for war. The Greek won that war due to the sun resilient power.

MATERIALS AND METHODS

Visible light Radiation

All electromagnetic radiation is light, but we can only see a small portion of this radiation, the portion we call visible light. Cone shaped cells in our eyes act as receivers turned to the wave lengths in this narrow band of the spectrum have wavelengths too large or too small and energetic for the biological limitation of our perception.

Infrared Radiation

In invisible radiant energy, electromagnetic radiation with longer wave lengths than those of visible light; extending from the normal red edge of the visible spectrum at 700 nanometers (frequency 430 THz to 300 GHz) although people can see infrared up to at least 1050nm in experiments (Apparao et al., 1975).

Ultraviolet Radiation

Ultraviolet is electromagnetic radiation with wave length shorter than that of visible light than x-ray from 400nm to 10nm in wave length. Though usually invisible, under some conditions children and young adults can see ultraviolet down to wavelengths of about 310nm and people with missing lens can also see some ultraviolet wavelengths.

Instrument used in measuring Solar Radiation

The instruments used are;

i. **Pyrheliometer:** an instrument for measuring the intensity of direct solar radiation at normal incidence.
ii. **Pyronometer:** an instrument for measuring the global solar radiation received from the entire hemisphere when fitted with a shading ring it measure the diffuse radiation and when routed with its sensor facing the downward it measure reflected solar radiation.

Method of Computation

The most convenient and widely used correlation for predicting solar radiation was developed by angstrom and later modified by Prescott. The angstrom formula is given by estimation of mean monthly global solar radiation.

$$\frac{\bar{H}}{\bar{H}_O} = a + b\,\frac{\bar{S}}{\bar{S}_O} \qquad 1$$

Where $\bar{H}$ (Mjm^{-2} day -1) is the monthly mean daily global Solar radiation on a horizontal surface, $\bar{S}$ (hours) is the monthly mean daily bright sunshine hours, $\bar{S}_O$ (hours) is the maximum possible monthly mean daily sunshine hours, $\bar{H}_O$ (Mjm^{-2} day -1) is the monthly mean extraterrestrial solar radiation on horizontal surface and a and b are regression constant given (Medugu et al., 2012).

Result

The data obtained are the monthly daily data for sunshine hours were obtained from the Nigeria meteorological services, Maiduguri Borno state Nigeria. The data obtained covered a period of five years (2008 - 2012) for Maiduguri, Nigeria located on latitude 11.846464ºN and 13.1603ºE.

Table 1: Monthly mean values of daily solar radiation and the required meteorological parameters for Maiduguri in the year 2008

YEAR 2008							
Month	$\bar{S}$	$\bar{S}_O$	$\frac{\bar{S}}{\bar{S}_O}$	a	b	$\bar{H}_O$	$\bar{H}$
JAN	9.0	12.0162	0.7490	0.3620	0.3880	37.6131	24.5428
FEB	9.0	11.9580	0.7526	0.3631	0.3854	37.6165	24.5709
MAR	9.0	12.0211	0.7487	0.3618	0.3854	37.6114	24.5395
APR	9.0	12.0357	0.7478	0.3615	0.3882	37.6169	24.5365
MAY	7.4	11.9982	0.6168	0.3192	0.3888	37.6154	23.1370
JUN	7.0	11.9686	0.5849	0.3089	0.4797	37.6135	22.6598
JUL	7.0	12.0055	0.5831	0.3083	0.5019	37.6150	22.6323
AUG	7.0	12.0197	0.5824	0.3081	0.5031	37.6129	22.6201
SEP	7.0	12.0382	0.5815	0.3078	0.5036	37.6177	22.6087
OCT	7.0	12.0001	0.5833	0.3084	0.5042	37.6121	22.6347
NOV	7.0	11.9680	0.5849	0.3089	0.5018	37.6179	22.6629
DEC	7.0	12.0036	0.5832	0.3083	0.5031	37.6104	22.6310

Table 2: Monthly mean values of daily solar radiation and the required meteorological parameters for Maiduguri in the year 2009

YEAR 2009							
Month	$\bar{S}$	$\bar{S}_O$	$\frac{\bar{\bar{S}}}{\bar{S}_O}$	a	b	$\bar{H}_O$	$\bar{H}$
JAN	9.0	12.0162	0.7490	0.3619	0.3880	37.6131	24.5428
FEB	9.0	11.9580	0.7526	0.3631	0.3854	37.6165	24.5709
MAR	9.0	12.0211	0.7487	0.3618	0.3882	37.6114	24.5395
APR	9.0	12.0357	0.7478	0.3615	0.3888	37.6169	24.5365
MAY	7.4	11.9982	0.6168	0.3192	0.4797	37.6154	23.1370
JUN	7.0	11.9686	0.5848	0.3089	0.5019	37.6135	22.6598
JUL	7.0	12.0055	0.5831	0.3083	0.5031	37.6150	22.6323
AUG	7.0	12.0197	0.5824	0.3081	0.5036	37.6129	22.6201
SEP	7.0	12.0382	0.5815	0.3078	0.5042	37.6177	22.6087
OCT	7.0	12.0001	0.5833	0.3084	0.5029	37.6121	22.6347
NOV	7.0	11.9680	0.5849	0.3089	0.5019	37.6179	22.6629
DEC	8.5	12.0036	0.7081	0.3487	0.4163	37.6104	24.2036

Table 3: Monthly mean values of daily solar radiation and the required meteorological parameters for Maiduguri in the year 2010

YEAR 2010							
Month	$\bar{S}$	$\bar{S}_O$	$\frac{\bar{\bar{S}}}{\bar{S}_O}$	a	b	$\bar{H}_O$	$\bar{H}$
JAN	9.7	12.0162	0.8072	0.3807	0.3475	37.6131	24.8731
FEB	9.2	11.9596	0.7693	0.3685	0.3739	37.6155	24.6794
MAR	9.4	12.0048	0.7830	0.3729	0.3644	37.6122	24.7567
APR	7.8	12.0426	0.6477	0.3292	0.4583	37.6168	23.5490
MAY	7.4	12.0156	0.6159	0.3189	0.4804	37.6152	23.1243
JUN	7.8	11.9790	0.6511	0.3303	0.4559	37.6128	23.5891
JUL	7.6	11.9899	0.6339	0.3247	0.4679	37.6167	23.3713
AUG	5.6	12.0029	0.4666	0.2707	0.5840	37.6126	20.4294
SEP	6.8	12.0411	0.5647	0.3024	0.5158	37.6184	22.3348
OCT	8.9	12.0173	0.7406	0.3592	0.3938	37.6119	24.4798
NOV	10.5	11.9821	0.8763	0.4031	0.2996	37.6168	25.0376
DEC	9.5	11.5971	0.8192	0.3846	0.3393	36.3973	24.1134

Table 4: Monthly mean values of daily solar radiation and the required meteorological parameters for Maiduguri in the year 2011

YEAR 2011							
Month	$\bar{S}$	$\bar{S}_O$	$\frac{\bar{\bar{S}}}{\bar{S}_O}$	a	b	$\bar{H}_O$	$\bar{H}$
JAN	9.3	12.0162	0.7740	0.3700	0.3706	37.6131	24.7061
FEB	8.7	11.9580	0.7276	0.3550	0.4029	37.6165	24.3788
MAR	8.5	12.0211	0.7071	0.3484	0.4171	37.6114	24.1946
APR	7.8	12.0357	0.6481	0.3293	0.4580	37.6154	23.5536
MAY	6.8	11.9982	0.5668	0.3031	0.5144	37.6154	22.3669
JUN	6.5	11.9686	0.5431	0.2954	0.5309	37.6135	21.9559
JUL	7.4	12.0055	0.6164	0.3191	0.4800	37.6150	23.1315
AUG	6.8	12.0197	0.5657	0.3027	0.5151	37.6129	22.3485
SEP	8.3	12.0382	0.6895	0.3427	0.4293	37.6177	24.0254
OCT	8.3	12.0001	0.6917	0.3434	0.4278	37.6121	24.0442
NOV	8.3	11.9680	0.6935	0.3440	0.4265	37.6179	24.0667
DEC	4.9	12.0036	0.4082	0.2519	0.6345	37.6104	19.0597

Table 5: Monthly mean values of daily solar radiation and the required meteorological parameters for Maiduguri in the year 2012

YEAR 2012							
Month	$\bar{S}$	$\bar{S}_O$	$\frac{\bar{\bar{S}}}{\bar{S}_O}$	a	b	$\bar{H}_O$	$\bar{H}$
JAN	9.5	12.0162	0.7906	0.3754	0.3591	37.6131	24.7968
FEB	8.9	11.9580	0.7443	0.3604	0.3912	37.6165	24.5105
MAR	8.9	12.0211	0.7404	0.3591	0.3940	37.6114	24.4777
APR	7.2	12.0357	0.5982	0.3132	0.4926	37.6154	22.8676
MAY	3.9	11.9982	0.3251	0.2250	0.6822	37.6154	16.8040
JUN	6.4	11.9686	0.5347	0.2927	0.5367	37.6135	21.8041
JUL	5.0	12.0055	0.4165	0.2545	0.6187	37.6150	19.2667
AUG	5.0	12.0197	0.4160	0.2544	0.6191	37.6129	19.2536
SEP	5.0	12.0382	0.4154	0.2542	0.6195	37.6177	19.2403
OCT	5.0	12.0001	0.4167	0.2546	0.6186	37.6121	19.2699
NOV	5.0	11.9680	0.4179	0.2549	0.6178	37.6179	19.3002
DEC	5.0	12.0036	0.4165	0.2545	0.6187	37.6104	19.2660

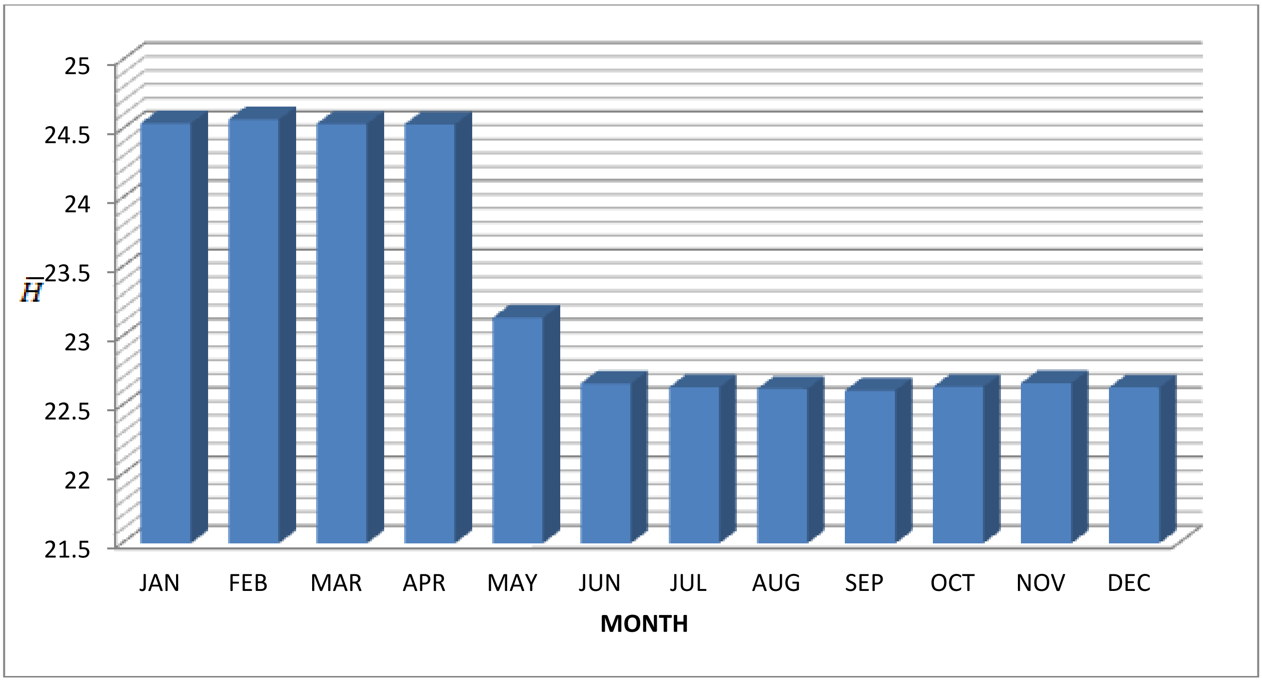

Fig. 1: Months against Peak Radiation ($\overline{H}$)of Solar Radiation for the Year 2008

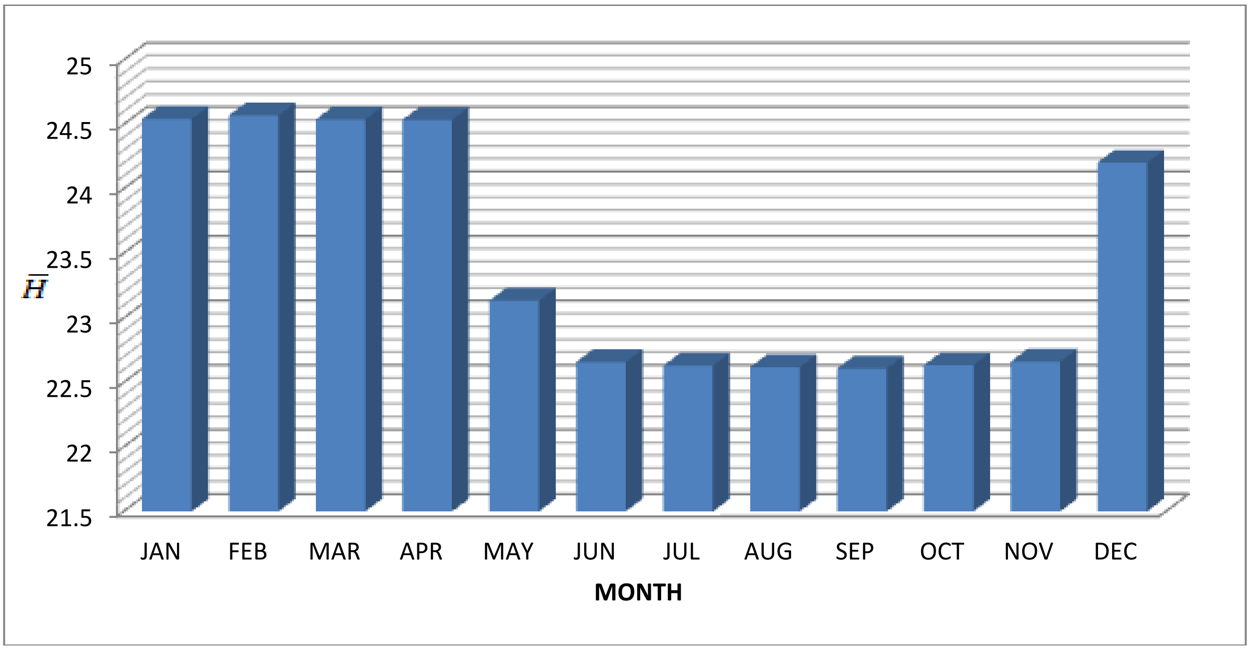

Fig. 2: Months against Peak Radiation ($\overline{H}$) of Solar Radiation for the Year 2009

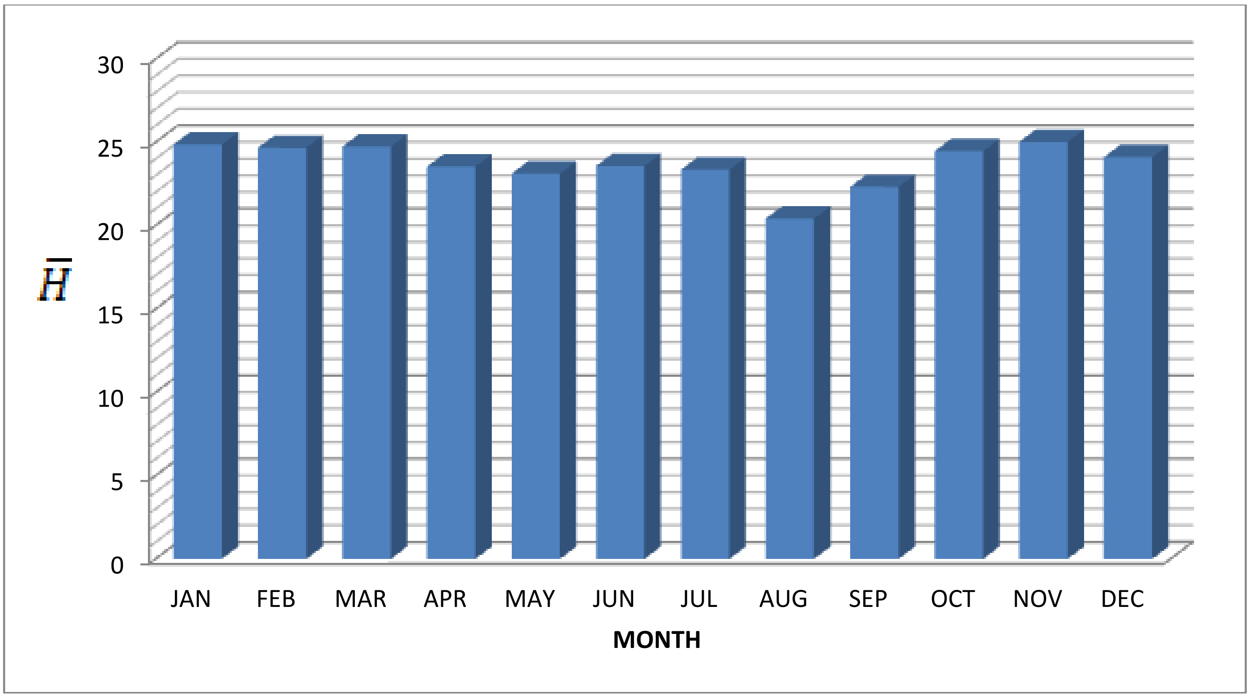

Fig. 3: Months against Peak Radiation ($\overline{H}$) of Solar Radiation for the Year 2010

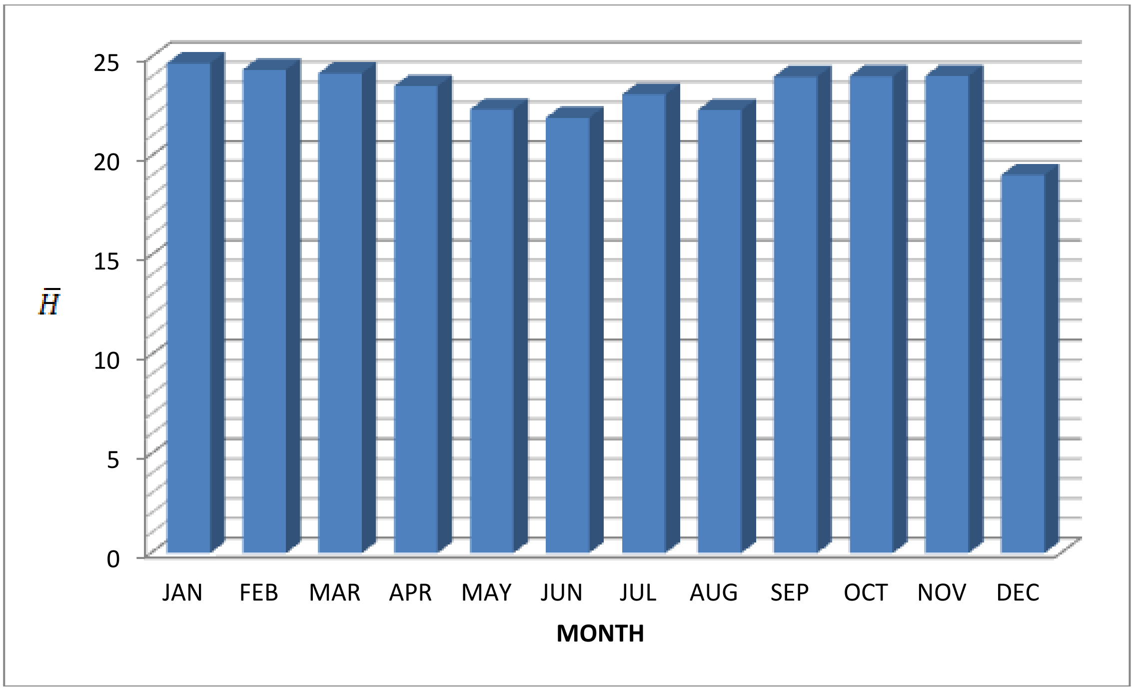

Fig. 4: Months against Peak Radiation ($\overline{H}$) of Solar Radiation for the Year 2011

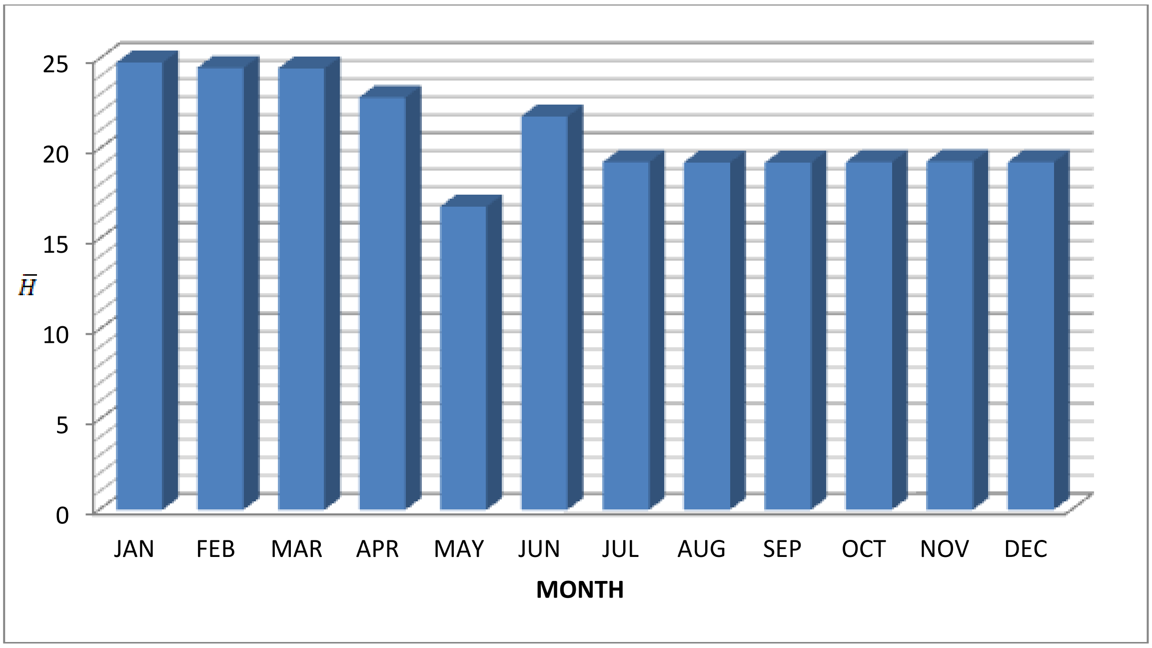

Fig. 5: Months against Peak Radiation ($\bar{H}$) of Solar Radiation for the Year 2012

DISCUSSION

The relevant meteorological and solar radiation data calculated using angstrom formulae which was later modified by Precott ; presented for whole period are shown in table 1 to 6.

Fig. 1: shows that the month of February has the highest Peak radiation but for January, March and April are least than February while for May, June, July, August, September, October, November, December have low Peak radiation.

Fig. 2: shows that the month of February has the highest Peak radiation but for January, March, April and December are least than February while for May, June, July, August, September, October and November have low Peak radiation.

Fig. 3: indicate that the month of November has the highest Peak radiation but for January, February, March, October, December are least than November while for April, May,

June, July, August and September have low Peak radiation.

Fig. 4: indicate that the month of January has the highest Peak radiation but for February, March, September, October, November are least than January while for April, May, June, July, August and December have low Peak radiation.

Fig. 5: shows that the month of January has the highest Peak radiation but for February, March, April, June are least than January while for May, July, August, September, October, November and December have low Peak radiation.

In general Fig. 3 to 5 reveals that it have much months with high radiation while Fig. 1 to 2 has least month. The higher value is obtained in dry season than wet season and the value of solar radiation for Maiduguri town over the period of the research is estimated to be using $23.2044\ Mjm^{-2}\ day^{-1}$ Angstrom, also observed from table 1 to 5 shows that solar radiation vary from the range of $16.8040\ Mjm^{-2}day^{-1}\ \ to\ 25.0376\ Mjm^{-2}\ day$ for Maiduguri.

SUMMARY

The results of this article clearly indicate that the developing empirical models for estimating global solar radiation on horizontal surface reaching the earth. There is need to consider solar electricity generation as an alternative option considering the power problem which is still deteriorating in Maiduguri.

CONCLUSION

The data obtained in this article can be utilized in design, analysis and performance estimation of solar energy system which is gaining attention in Nigeria in particular and World at large. From the observation obtained Maiduguri can have a constant power supply using solar energy.

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First and foremost, I must show my appreciation to almighty God for all he has done for me. Also, my heartfelt appreciation goes to my brother and sisters for their love, they are in person of Maryam, Madu, Sarah, Blessing, Rejoice and the memory of my late Sister Rebecca.

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