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APPLICATION OF REGRESSION AND MULTIPLE CORRELATION ANALYSIS TO MORNING HOURS SOLAR RADIATION IN LAPAI

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ABSTRACT

Solar radiation in Lapai within the morning hours has been estimated by correlating meteorological parameters. This was achieved by applying the first and second order regression and multiple correlation analysis method. The correlation coefficient based on the first and second order equations in temperature and relative humidity were 0.828, 0.692, 0.860 and 0.622 while the correlation coefficient based on the multiple correlations between solar radiations, temperature and relative humidity were 0.351. Validity tests were carried our using mean bias error (MBE), root mean square error (RMSE) and mean percentage error (MPE). The tests show that the errors were minimal in the first order equations in temperature and relative humidity. Comparison of the measured and predicted values of solar radiation based on the relative humidity and average temperature first order equations show a close agreement, and suggests the best equations to be used in estimating solar radiation in Lapai and its similar climatic condition.

Keywords: *Solar radiation, multiple regression, correlation coefficient, meteorological parameter-temperature and relative humidity.*

INTRODUCTION

Solar radiation is the energy from the sun reaching the earth. It is the driving force of both the physical and biological cycles on the earth [1, 4]. As a result it becomes pertinent to have very good knowledge of past records of solar radiation at a location so as to aid in the estimation of the performance of any solar energy system. Pyrheliometer and Pyranometer can be used readily to obtain the diffuse component of the radiation and the global solar radiation respectively. Meteorological stations have been used mostly for this purpose. However, there are a few of such stations across the globe and worse still in the developing countries. In order to develop solar radiation data, researchers had extrapolated values from one location for application in a different location. Hence solar radiation prediction from estimation models has been widely utilized globally to generate solar radiation database for various location of the world. There are numerous statistical techniques of estimating solar radiation and each method is based on different principles [2, 3]. Due to the present economic hardship in Nigeria, there is every tendency for having problems of maintaining and purchasing the used in measuring the meteorological parameters in the meteorological stations. The solution of this problem has motivated one into the need for an empirical modeling for estimation of solar radiation that will be affordable and easily maintained as it uses mathematical, statistical correlation and regression analysis for computation. The aim of this work is therefore to develop a relation between solar radiation with temperature and relative humidity for morning hours in Lapai.

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Materials and Method of analysis

The data (maximum and minimum temperatures, relative humidity and solar radiation) used in this study were obtained from the weather station located at Geography Department of Ibrahim Badamasi Babangida University, Lapai (IBBUL), Niger State, Nigeria. The data were collected at 5-minute interval in the year 2010 and cover a time period of 7.30 -11.30 am. The minimum and maximum temperatures were averaged to obtain the average temperature at each time interval. Table 1 shows the climatic parameters obtained with their units.

Table 1: Climate parameters

S/N	Parameter	Unit
1.	Average Temperature (T_{av})	^oC
2.	Relative Humidity (R)	%
3.	Solar Radiation (H)	W/m^2

In the analysis we employ the first and second order regression equations

$$a + bx = Y \quad (1)$$

$$a + bx + cx^2 = Y \quad (2)$$

where *a* and *b* are constants which will be determined . Y is the same as solar radiation (H) and it is the dependent variable. *x* is the independent variable which can be replaced by any of the meteorological data such as average temperature and relative humidity.

Results and Discussions

Figs. 1 and 2 show the scatter plot of solar radiation against average temperature, and solar radiation against relative humidity respectively. Despite the large amount of scattered points, a definite correlation between them does exist. The large amount of scattered data is partly attributable to errors in estimation the solar radiation at 5-minute intervals.

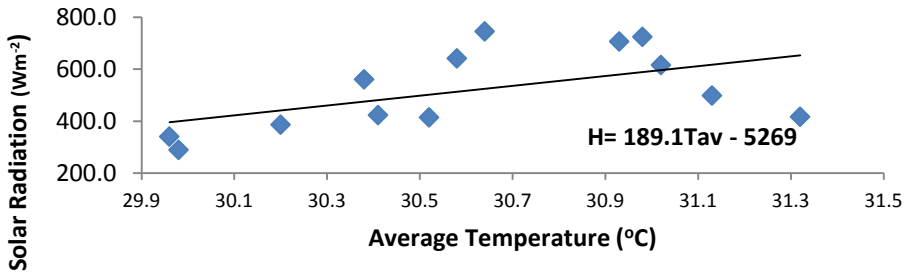

Fig. 1: Solar radiation against average temperature

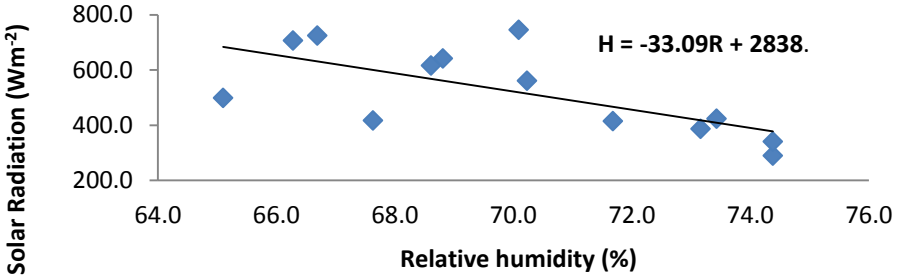

Fig. 2: Solar radiation against relative humidity.

The first and second order regression equations obtained in this work using the average temperature and relative humidity are as follows:

$$H_1 = -2715.96 + 105.72T_{av} \quad (3)$$

$$H_2 = 2883.77 - 33.094R \quad (4)$$

$$H_3 = -5011.04 + 175.08T_{av} + 0.81T_{av}^2 \quad (5)$$

$$H_4 = 698.60 - 1.70R - 0.012R^2 \quad (6)$$

The multiple regression of solar radiation with average temperature and relative humidity were obtained as

$$H_5 = -20.89R - 64.77T_{av} \quad (7)$$

The correlation based on the average temperature alone is obtained as 0.828 and relative humidity alone is 0.860. The estimated results from each of the average temperature and relative humidity show a closer agreement to the measured data than that predicted from the correlation based on the average temperature and relative humidity taken together. A comparison of the result of equation (3), (4), (5), (6) and (7) indicates that the correlation of equation (4) based on the relative humidity alone and equation (3) based on average temperature alone should be employed for computing solar radiation in the morning hours in Lapai. The deviations between the measured and estimated values of the solar radiation have been evaluated. This is in an effort to test the validity of the equations for the solar radiation. As seen from table 2, the percentage errors are very small and the equations may be taken as valid equations for estimating solar radiation in the morning hours in Lapai.

Table 2: Summary of calculations.

S/N	Equations	CC	CD	MBE	RMSE	MPE
1.	$H_1 = -2715.96 + 105.72T_{av}$	0.828	0.686	-0.189	0.682	0.003
2.	$H_2 = 2883.77 - 33.094R$	0.860	0.740	0.004	0.016	-0.001
3.	$H_3 = -5011.04 + 175.08T_{av} + 0.81T_{av}^2$	0.692	0.479	0.419	1.152	-0.006
4.	$H_4 = 698.60 - 1.70R - 0.012R^2$	0.622	0.387	-0.217	0.782	0.003
5.	$H_5 = -20.89R - 64.77T_{av}$	0.351	0.123	0.538	1.939	0.008

The validity of the equations were also tested using mean bias error (MBE), root mean square error (RMSE) and correlation coefficient (CC) which gave good results as seen in Table 2.

CONCLUSION

In this study, an attempt has been made at estimating solar radiation based on meteorological data at IBBUL. The results of the estimated values show a closer agreement to the measured data. The results were obtained using first and second order regression and multiple regression analysis which portrays a good correlation. The deviations between the measured and estimated values were minimal. These results from this analysis will greatly reduce the problem associated with waste of time and lack of efficient instruments. It will also be an easy way to present data and ensure that data never runs out. This will also allow user of the data to track information of solar radiation data in Lapai.

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