Research Journal of Applied Sciences 2 (12): 1266-1269, 2007
ISSN: 1815-932X

Characteristic Variation of Relative Humidity and Solar Radiation over a Tropical Station Ibadan, Nigeria

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Abstract: Characteristic variation of relative humidity and solar radiation enhances the understanding of the significance of indicated trends of variability to everyday life and the factors that might be responsible for such variations. This study critically analyses the seasonal trends and the existing relationship between solar radiation and relative humidity of Ibadan, Nigeria. The data used for the study were extracted from a 48 months (1999-2001) daily radiation data estimated from Gunn-Bellani distillate and relative humidity obtained from International Institute for Tropical Agriculture (IITA) Ibadan (7.3°N, 3.3°E), Oyo State. Simple graphical methods were adopted to analyze the trends of variation, using average monthly values for each parameter. The monsoon depression usually occurs annually during the month of August. The minimum value of solar radiation and a high value of relative humidity of 10.3MJ/m^2/day and 87.8%, respectively were recorded during this month. The curves on the mean relative humidity are inversely proportional to observed curves on solar radiations.

Key words: Solar radiation, relative humidity, monsoon depression, dew temperature, vapour pressure

INTRODUCTION

A seasonal and spatial variation in energy exchange experienced in climate depends on the variations in the interaction between the earth and the atmosphere (Stone, 1955; Sutchliffe, 1956). Though all aspects of the Earth's climatic indices such as winds, rain, clouds and temperature are the results of energy transfers and transformations within the earth (Green, 1956). The seasonal variation of the solar radiation and how the axis of the earth is titled to the plane of its angle at which the solar radiation strikes the earth surface varies from season to season (Frohlish and Londan, 1985; Battan, 1979).

The Northern Hemisphere receives more solar energy in June, July and August and is therefore warmer than in December, January and February when it receives less (Budgko, 1963). Humidity is an attribute of human environment most generally recognized by its important role as a determinant in climate, weather and personal comforts (Wildhack, 1963). The ratio between the actual weight of moisture and the total amount that can be held by a unit volume of air at a specified temperature and pressure expressed as a percentage. Relative humidity of air is how close to saturation the air is; the lower the relative humidity of the air the greater is the capacity of the air to absorb more moisture (Keith, 2003). Steve (2003) gave an instance of an area having a relative humidity of 45%; if half the thermal energy were removed, the relative humidity would rise to 90% without changing the amount of moisture in the air. When dew point temperature is used as a measure of humidity, any change is strictly due to moisture change. When dew point temperature is used as a measure of humidity, any change is strictly due to moisture change (Bannon and Steele, 1960). The dew point Temperature (T_{dew}) can be calculated using the relation given by Penman-Montieth Equations.

$$\ell_a = \ell^\circ \left(T_{dew}\right) \quad (1)$$

Where:

ℓ_a = The actual vapour pressure in (KPa).
ℓ° = The saturation vapour pressure (KPa).
T_{dew} = The dew point temperature.

Expression (1) can be written as

$$\ell_a = \ell^\circ \left(T_{dew}\right) = 0.6108 \exp\left[\frac{17.27T_{dew}}{T_{dew} + 273.3}\right] \quad (2)$$

$$\ell^\circ = 0.6108 \exp\left[\frac{17.27T_{dew}}{T_{dew} + 273.3}\right] \quad (3)$$

Where, T = Air Temperature.

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The Relative Humidity (RH) expresses the degree of saturation of air as a ratio of the actual vapour pressure to the saturation vapour pressure at the same temperature.

$$RH = \frac{100\ell_a}{\ell^\circ(T)} \quad (4)$$

The actual vapour pressure (e_a) can be also be calculated from the relative humidity.

$$\ell_a = \frac{\ell_a(T_{min})\frac{RH_{max}}{100} + \ell^\circ(T_{max})\frac{RH_{min}}{100}}{2} \quad (5)$$

Whenever the equipment estimating RH_{min} has an error, RH data integrity is in doubt and then one should use only Rh_{max}.

$$\ell_a = \ell^\circ(T_{dew})\frac{RH_{max}}{100} \quad (6)$$

or RH_{mean}. In the absence of RH_{max} and RH_{min}, another equation that can be used for the estimate is;

$$\ell_a = \frac{RH_{min}}{100}\left[\frac{\ell^\circ(T_{max}) + \ell^\circ(T_{min})}{2}\right] \quad (7)$$

When RH_{mean} is the mean relative humidity defined as the average between RH_{max} and RH_{min}.The expression 1-7 are called the Penman-Monteith equations.

This research aims at the following: To undertake a precise study of the seasonal variation trends of solar radiation and associated parameter; to enhance the understanding of the significance of indicated trends of variability to our everyday lives and the factor that might be responsible for such variations and To carry out a critical analysis of the existing relationship between solar radiation and associated parameter. The recent related research works includes that of Wade (1994). In essence, this research assesses the characteristic variation of solar radiation and relative humidity for a full appraisal of the seasonal variations on the average monthly, seasonal and daily pattern of the associated parameters.

MATERIALS AND METHODS

The data used for this study, were extracted from the record of 48 months (1999-2001) of the weather description of daily data file from International Institute for Tropical Agriculture (IITA) Ibadan, Oyo state. The data include daily information on Rainfall, Pan-evaporation, wind speed, solar radiation, temperature and maximum and minimum relative humidity. The solar radiation and relative humidity were extracted from the file. Then the monthly mean relative humidity was computed. Also, the solar radiation was determined from the equation (Allen and Smith, 1994):

$$R_n = 0.77R_s - R_{nL}$$

Where:

R_s = Incident Solar Radiation ($MJm^{-2}day^{-1}$).
R_{nL} = Net longwave radiation ($MJm^{-2}day^{-1}$).
R_n = Net Radiation ($MJm^{-2}day^{-1}$).

Annual patterns of the monthly means of these parameters are presented. Simple graphical method was adopted to analyze the results and comparative studies in variations of monthly relative humidity and radiation flux are carried out.

RESULTS AND DISCUSSION

For the station under consideration, the monthly mean relative humidity and solar radiation were calculated from the daily records obtained from the instruments. Also, the annual mean distributions of the associated parameters are determined. These were shown in Table 1 and 2.

From Table 1 and 2, it was observed that for the period considered, 1999 had the highest value of radiation flux of $18.9MJm^{-2}day^{-1}$. Also the highest value of relative

Table 1: Calculated monthly mean relative humidity (%) and solar radiation ($MJm^{-2}day^{-1}$)

	Mean solar radiation ($MJm^{-2}day^{-1}$)			Mean relative humidity (%)		
Months	1999	2000	2001	1999	2000	2001
January	13.6	12.0	12.6	67.9	70.9	67.1
February	16.2	15.6	16.5	68.2	53.1	59.2
March	18.6	17.1	18.3	78.9	65.2	70.4
April	18.9	16.2	17.9	78.1	79.6	78.0
May	17.0	16.8	17.3	79.0	81.2	81.6
June	14.8	15.9	15.9	83.4	83.4	84.0
July	13.2	12.9	12.9	85.7	86.3	.3
August	11.4	10.3	8.3	85.7	87.8	87.4
September	11.8	13.1	8.3	85.5	85.4	83.6
October	12.7	15.3	13.8	83.5	81.4	81.9
November	14.8	16.5	14.9	77.5	74.2	73.1
December	13.4	14.1	12.9	64.8	67.3	72.8

Table 2: Calculated annual mean distribution of solar radiation ($MJm^{-2}day^{-1}$) and relative humidity (%)

Years	Solar radiation ($MJm^{-2}day^{-1}$)	Relative humidity (%)
1999	14.7	78.4
2000	14.6	76.3
2001	14.4	76.3

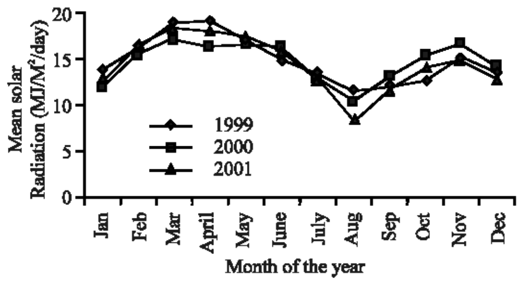

Fig. 1: Graph of solar radiation ($MJm^{-2}day^{-1}$) for three years in Ibadan, Nigeria

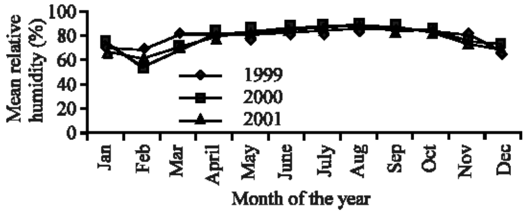

Fig. 2: Graph of mean relative humidity (%) for three years in Ibadan, Nigeria

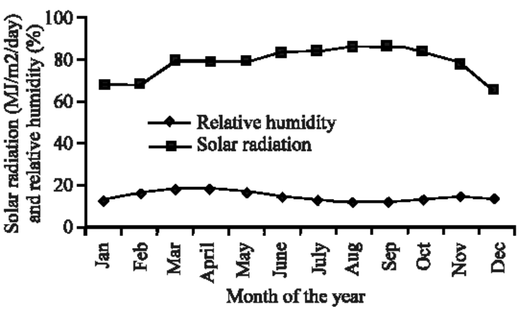

Fig. 3: Graph showing the variation of solar radiation ($MJm^{-2}day^{-1}$) relative humidity(%) for the year 1999

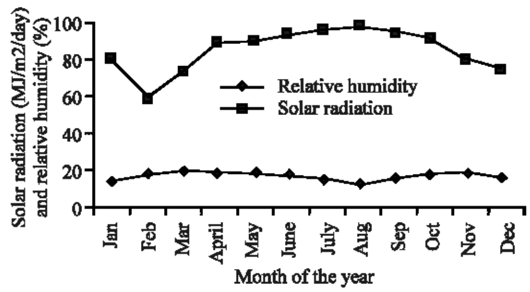

Fig. 4: Graph showing the variation of solar radiation ($MJm^{-2}day^{-1}$) relative humidity(%) for the year 2000

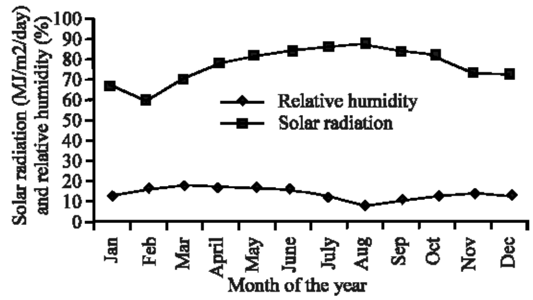

Fig. 5: Graph showing the variation of solar radiation ($MJm^{-2}day^{-1}$) relative humidity(%) for the year 2001

humidity of 87.8% was noted for the year 2000. It was observed in Fig. 1 and 2, that the average Solar radiation showed the same values in the months of June and July for the year 2000 and 2001. Also the average solar radiation showed the same values in the months of September and November for the year 1999 and 2001. The month of April has the highest radiation flux of $18.9MJm^{-2}day^{-1}$. A wide depression in the flux occurrence was shown in June and this continued through July and August. This is referred to as Monsoon depression (Roger and Richard, 1987). The monsoon depression is attributed to high Relative Humidity and low radiation flux.

The slight drop in the value of relative humidity in the month of May 2001 can be explained by the earth revolution, because of high intensity of sunlight during this month. The temporal fluctuation in the relative humidity over the region tends to suggest the effect of the Dry Adiabatic Lapse Rate (DALR) over the atmosphere (Ransom, 1963). Figure 3-5 showed that the month of August has the minimum value of Solar Radiation and high value of relative humidity, respectively for the period considered. The 2 curves on the graph were not linearly correlated. The curve for solar radiation showed a uniform pattern for the values, while the relative humidity formed irregular ones. Within the month of May to December, the radiation flux is inversely proportional to the relative humidity for the period under consideration. The trends of variation may be clearly due to Sun's elevation, moisture condition of the atmosphere, variation in the cloud cover, the angle of inclination on which the intensity of direct solar radiation depends (Barry and Chorley, 1976; Durbin, 1961).

The trends and patterns of variation in the parameter studied may provide helpful information in the prediction of natural processes that occur in the atmosphere. This relationship can be used to explain the effect of relative humidity on the solar system and can also serve as information in green house crop management, especially in the prediction of the factors that are useful for controlling the environment especially the domestic air conditioner and dehumidifier.

CONCLUSION

The research examines the relationship between solar radiation and relative humidity over Ibadan, Nigeria. The lowest values of radiation fluxes are recorded during the monsoon period. The harmattan period showed high values of radiation fluxes and low values of relative humidity. These findings correlate with those of Roger and Richard (1987), Ransom (1963), Barry and Chorley (1976) and Durbin (1961). This is used to explain the effect of relative humidity on solar potential system and in the control of the environment. The periodic assessments of the associated parameters have positive effect on the environment as it is shown from the data. Mean relative humidity decreases with increase in the amount of radiation for each month of the year.

ACKNOWLEDGEMENT

The authors are grateful to the International Institute of Tropical Agriculture (IITA) Ibadan for providing relevant data used in this research.

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