Multistrand Investigations of the Integral Influence of Rainfall and Relative Humidity on Solar Radiation Intensity during Dry Season in Port Harcourt Metropolis

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Abstract

This work investigates how the amount of rainfall (mm) and relative humidity (%rh) influence the solar radiation intensity (W/m^2) in Port Harcourt Metropolis. The data were collected in three months of dry season from November, 2016 to January, 2007 on daily basis at 5 minutes interval using appropriate instrumentations in Rivers State University NECOP Weather Station and analyzed using SPSS software, version 20.0 with respect to their daily and weekly averages in terms of measure of central tendencies and Anova (two-tail) at significance level (α) of 0.05 at sample points (n) of 92. The independent weather variables are the relative humidity (%rh) and the rainfall (mm) while the dependent weather variable is solar radiation intensity (W/m^2). The results showed that changes in amount of rainfall (mm) and relative humidity (%) negatively influence the magnitude of solar radiation intensity (W/m^2) during dry season. The variations in the amount of rainfall (mm) significantly influenced the solar radiation intensity (W/m^2) while that of the relative humidity is not obvious, which might have been caused by the dryness of air during the dry season. Solar radiation intensity ranges from 40.8W/m^2 to 155.0W/m^2 with a mean average of 106.2W/m^2. The amount of rainfall (mm) has its minimum and maximum values as 0.00mm and 0.264mm respectively with a mean average of 0.06513mm. The relative humidity from measurements ranges from 32.27% to 77.06% with a mean average of 68.0466%. It was also observed there was no significant difference in solar radiation intensity(W/m^2) for the different weeks during the dry season since F (= 1.480) is less than the critical value (= 1.848), and the p-value (= 0.144) is greater than α (= 0.05).The essential of this study can be employed in the aviation industries, agricultural sector, manufacturing industries, meteorological institutions and governmental environmental ministries and agencies for effective planning and implementation of policies for sustainable developments.

Key Words: Solar radiation intensity, Relative humidity, Rainfall, , Dry season

Introduction

Majority of human activities centers on the power of the sun. The sun is regarded as the most important source of energy referred to as “the life giver” of every living thing on earth. Without the sun, there would not have been living things or organisms on earth. Though, there are some problems that are created by the sun for example, the production of excess heat that may lead to an increase in the human body temperature (Seo, 2010).The energy which comes from the suns light that falls to the earth is known as solar radiation. The solar radiation incident on the earth has strength of about 175x10^{9}MW equivalent to 10^5 times the strength of all existing power plants on earth during full scale working (Jasmina and Amelija, 2001). The quantity of this solar radiation reaching a given surface area in a given time is called the solar radiation intensity measured in watts per metre square (W/m^2) by pyranometer and pyheliometer.

The solar radiation which strikes a surface changes from time to time. These changes depend on the geographical location; season, atmospheric conditions and time of the day (Gueymard, 2004).The atmospheric conditions are the weather variables such as relative humidity, rainfall, air pressure, wind, air temperature etc. and it is partially reflected, absorbed and transmitted when it falls on a transparent medium or object. Thirty percent (30%) of the sun's energy is either reflected or absorbed by clouds, ocean and land masses, when it strikes a surface (Seith *et al*, 2012).

Nigeria is a country that is endowed with annual average sunshine hours of about 6.25 hours; out of which 3.50 hours is at coastal area (Niger delta and Lagos) and 9.00 hours at the Northern regions (Olayinka *et al*, 2015). Solar radiation is one of the most essential weather variables which determine the condition of a place (it determines if a place is cold or has high temperature). The influence of other weather variables on solar radiation intensity in a place is critical for technological innovation, forecasting and planning for natural disasters that may arise from climatic change. In addition, it is of great importance in providing information on climatic risks information for local and national planning and decision making for sustainable development in the areas of aviation, agriculture and health. Furthermore, evaluate the potential of renewable energy of a place and provides platforms on optimization of time for higher productivity of firms.

In this research, we investigate the integral influence of rainfall and relative humidity as independent weather variables on solar radiation intensity which is the dependent weather variable in Port Harcourt. This can be achieved by measuring the magnitudes of the solar radiation intensity, rainfall and relative humidity with their appropriate instrumentations and employing a Multistrand approach of data analysis to determine their relationship and to evaluate the integral influence of the independent variables on the dependent variable. However, a bit of literatures were also reviewed on the study area; sun, solar radiation and solar radiation intensity; and the independent weather variables (rainfall and relative humidity) in the course of this study.

The Study Area

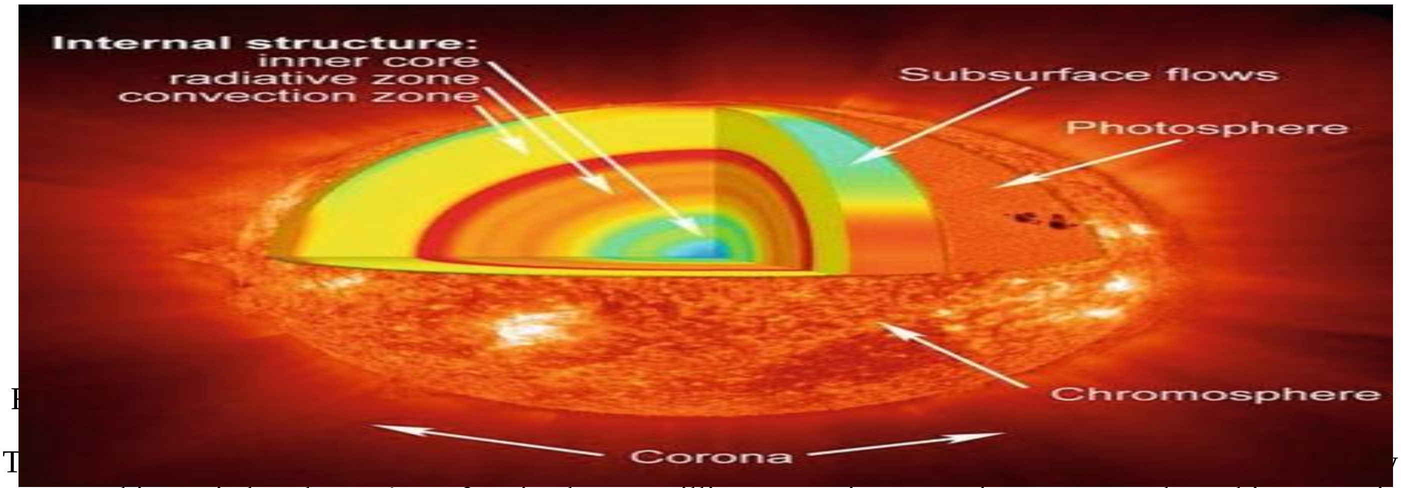
This research is carried out in Rivers State University, which is located in Port Harcourt city local government Area. Port Harcourt city is a coastal part of Nigeria which is located in the Niger Delta region of Nigeria and it is located within the Latitude of $6^o.58'$ to $8^o.00'S$ and a longitude of $4^o.4$ to $4^o.5$ E and surrounded by other towns namely Oyigbo, Rumuokini, Choba, Ogbogoro, Old Bakana and Isaka, Okrika, Eleme and the Ogonis as shown in Figure 1(Chukwuemeka and Nnabuchi, 2001)

Figure 1: Map of Port Harcourt (Map data at Google, 2017)

It features a tropical wet climate with lengthy and heavy rainy seasons and very short dry seasons. The monthly rainfall increase from March to October, it reduces in the dry season which last from November to February. The populace experience two weeks of no rain or little rain within the month of July and August. This is sometimes regarded as “August brake” and this varies from time to time depending on the weather. It has low temperature at night and a high temperature during the day condition (Uko *et al*, 2016).

The Sun, Solar Radiation and Solar Radiation Intensity

In the solar system, the sun is regarded as the brightest star and the source of solar radiations. Figure 2 shows the internal structure of the sun. The photosphere emits solar radiation to space with an average temperature of about 5777K. It has a cool area known as the sun spots. The chromosphere contains solar flares which are composed of gas, electrons and from it radiations erupt. It has an average temperature of $10x10^3$K (Salcedo *et al*, 2014).



generated is carried to the sun’s surface in about a million years via convection process, where this energy is then released as light and heat. The temperature of the core of the sun which has 20% extension from the centre of the solar radius is about $15.7x10^6$K, this shows how extreme the temperature of the sun is (Alejandro, 2012).

Solar radiations are electromagnetic radiations that range from 0.25 to 4.5µm in wavelength. These radiations include the visible light, ultraviolet and near infrared (IR) radiation as shown in Figure 3 of the electromagnetic spectrum. The energy quantum from the solar radiations is called the photon. The total amount of quantum energy produced by incident photons per unit of area is defined as the solar radiation intensity measured in Watts per square metre (W/m^2). The solar radiation intensity on the earth’s surface depends on factors such as location, topography, air pollution, weather variables and cloud cover. In the atmosphere, solar radiation is scattered, absorbed and also reflected by the component of the atmosphere, this process of phenomena is called atmospheric effect (Rod, 2016).

The solar radiation is composed of the direct beam, diffuse and ground reflected radiations. Direct beams are regarded as the solar radiations that reach the earth without scattering. This means that their insolation are neither interrupted by the earth’s surface nor influenced by atmospheric effects. Diffuse radiations are the solar radiations whose insolation are scattered by the cloud and influenced by atmosphere effects. The Reflected radiations are those solar radiations that are reflected from surrounding surface and terrain (Seo, 2010). The sum of these radiations (direct, diffuse and reflected radiation) made up the total or global radiation that reaches the earth surface.

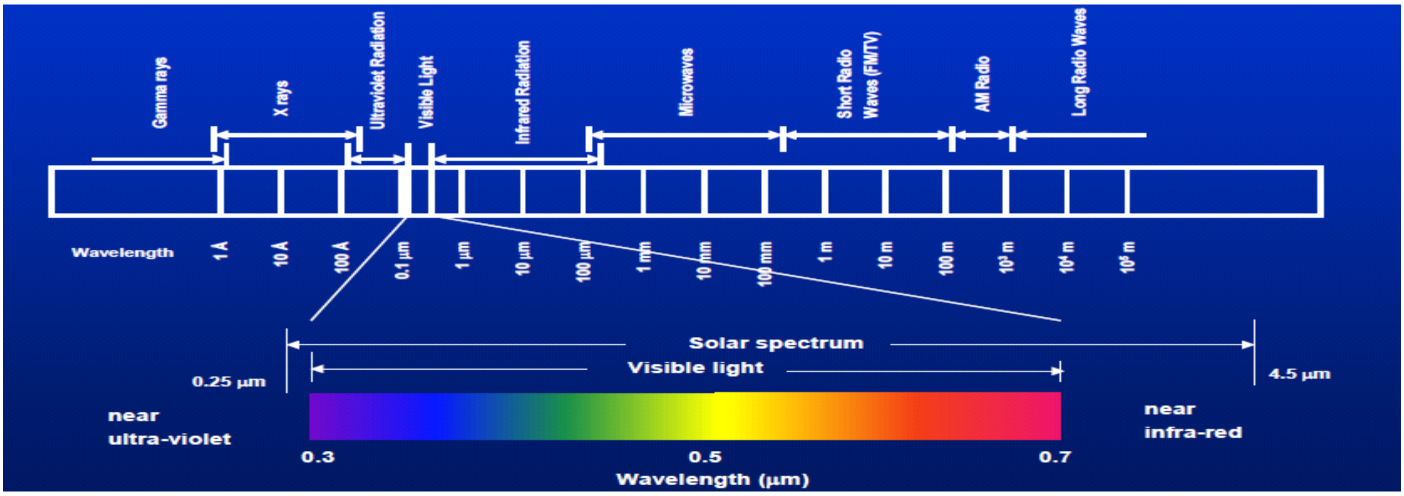


Figure 3: The solar spectrum from the electromagnetic spectrum (Seo, 2010)

The Independent Weather Variables (Rainfall and Relative Humidity)

When precipitation takes the form of water and measured in millimetre (mm), it is referred as rainfall (Wilfried, 2008).When raindrops leave a warmer air and then encounters a colder air below, this raindrop solidify and it reaches the ground as a small pellets of ice which is not bigger than the raindrops that formed it (Joseph, 2012).Rainfall can be classified as conventional rain, cyclonic or frontal and orographic or relief rain. The convectional rain occur when air is heated by the sun to become light in weight, then rises up in convention currents and during its rising period, it expands and loses heat thereafter, condensation occurs thereby leading to the formation of cumulous cloud that does not last long. This type of rain is characterised by thunderstorm and lightening. It is some of common in the interior parts of the continents especially in the northern hemisphere (Minghu and Yanjan, 2001).

The cyclonic or frontal rainfall occur when the leading edge of moist, warm air mass collide with a cool and dry air mass. The cool air mass molecules are tightly packed together, meaning that they are denser, in other words, the warm air is lighter than the cool air. This warm air mass is then forced up over the cool air, as the warm air rises towards the cool air; it cools and condenses, then precipitates as rainfall (Salcedo *et al*, 2014). The orographic rainfall occurs when air mass that is saturated comes across a mountain and forced to rise and expand due to buoyancy which led a drop in temperature and condensation of the moisture. In other words, orographic rainfall can be produced by the lifting of moist air around a mountain where it rises, cools forming orographic clouds and thunder lightening ,then condenses as rain (Wilfried,2008).

Relative humidity (RH) is the ratio of the partial pressure of water vapour to the equilibrium vapour pressure of water at a given temperature. Relative humidity depends on temperature and the pressure of the system of interest. The same amount of water vapour results in higher relative humidity in cool air than warm air. A related parameter is that of dew point. Climate control refers to the control of temperature and relative humidity in buildings, vehicles and other enclosed spaces for the purpose of providing for human comfort, health and safety, and of meeting environmental requirements of machines, sensitive materials and technical processes (Hukseflux, 2012).

Materials and Methods

The instrument used in this research work is mounted at the Rivers State University (RSU) meteorological gardens, Port Harcourt, Nigeria. The station is computerised and built up with weather resistant efficient and low power consumption hardwares and softwares. The hardwares and softwares are: the sensors, measurements and control system, solar power system for charging of the rechargeable battery (12V) powering the system and for uninterrupted power supply and the data logging system. This weather station is programmed to automatically record data in every 5 minutes on a daily basis with CR 1000 model number of the data logger. The data logger is the central processing unit of the weather station. We use the pyranometer shown in Figure 4 to take the measurement of the solar radiation intensity within its hemispherical field of view.

Figure 4: Pyranometer (RSU Metrological Station, 2017).

The Rainguage is used to measure the amount of rainfall within the study period as shown as Figure 5 .while Hygrometer is used for the measurement of relative humidity.

Figure 5: The Rainguage (RSU Meteorological Station, 2017)

The collection of data is made with the aid of Logger net software (Logger net 4.0). A USB to serial (DB-9) adapter data cord is connected from port RS-232 of the programmable data logger of the Cambell Scientific Weather Station to a laptop that is specifically programmed to the weather station as shown in Figure 6. The data were collected on 5 seconds interval within a day for three months of dry season that ranges from November 2016 to January 2017. Afterward split into daily, weekly and monthly averages. The data were analyzed with Statistic Package for Social Sciences (SPSS) version 20.0 with respect to their appropriate statistics to have the central tendencies of the weather variables. Multistrand analysis that involved cross plots and Anova analysis was employed to investigate and evaluate the integral influences of the independent weather variables(Relative humidity (%) and the rainfall (mm)) as implied in their relationship with the dependent weather variable(solar radiation intensity (W/m^2)).

Figure 6: A view showing the connection between a laptop and the Electronics Box in the weather station

Results and Discussions

Results

The Daily averages of the weather variables for dry season from November, 2016- January, 2017 as recorded by the instrumentations in the Rivers State University meteorological stations are presented in Table 1.

Table 1: Daily Averages for Dry Season (November, 2016-January, 2017)

S/n	Date	Solar radiation intensity (W/m^2)	Relative humidity (%)	Rain fall (mm)
1	Tue 01 Nov 2016	70.266	73.761	0.060
2	Wed 02 Nov 2016	113.879	70.268	0.229
3	Thu 03 Nov 2016	75.962	72.412	0.040
4	Fri 04 Nov 2016	122.316	71.620	0.108
5	Sat 05 Nov 2016	57.398	75.790	0.000
6	Sun 06 Nov 2016	115.133	72.309	0.000
7	Mon 07 Nov 2016	59.870	74.061	0.043
8	Tue 08 Nov 2016	83.235	74.930	0.019
9	Wed 09 Nov 2016	140.509	70.041	0.132
10	Thu 10 Nov 2016	144.049	65.499	0.157
11	Fri 11 Nov 2016	75.377	73.362	0.090
12	Sat 12 Nov 2016	94.571	71.182	0.058
13	Sun 13 Nov 2016	117.602	69.093	0.000
14	Mon 14 Nov 2016	141.810	70.297	0.000
15	Tue 15 Nov 2016	111.586	75.338	0.056
16	Wed 16 Nov 2016	136.340	70.992	0.006
17	Thu 17 Nov 2016	65.697	73.130	0.264
18	Fri 18 Nov 2016	108.721	76.369	0.065
19	Sat 19 Nov 2016	109.520	72.568	0.108
20	Sun 20 Nov 2016	83.105	74.884	0.000
21	Mon 21 Nov 2016	40.791	76.008	0.000
22	Tue 22 Nov 2016	151.639	68.429	0.000
23	Wed 23 Nov 2016	144.638	69.680	0.063
24	Thu 24 Nov 2016	104.752	74.172	0.060
25	Fri 25 Nov 2016	135.111	73.511	0.229

26	Sat 26 Nov 2016	100.346	73.657	0.040
27	Sun 27 Nov 2016	95.792	73.331	0.108
28	Mon 28 Nov 2016	55.663	75.883	0.000
29	Tue 29 Nov 2016	98.793	72.661	0.000
30	Wed 30 Nov 2016	124.392	71.393	0.043
31	Thu 01 Dec 2016	132.577	72.299	0.019
32	Fri 02 Dec 2016	90.524	75.075	0.132
33	Sat 03 Dec 2016	63.414	76.551	0.157
34	Sun 04 Dec 2016	94.430	69.390	0.090
35	Mon 05 Dec 2016	86.568	74.052	0.058
36	Tue 06 Dec 2016	114.630	70.261	0.000
37	Wed 07 Dec 2016	144.289	68.553	0.000
38	Thu 08 Dec 2016	78.700	70.903	0.056
40	Sat 10 Dec 2016	76.997	72.711	0.264
41	Sun 11 Dec 2016	100.957	76.807	0.065
42	Mon 12 Dec 2016	104.205	73.295	0.108
43	Tue 13 Dec 2016	119.117	69.967	0.000
44	Wed 14 Dec 2016	100.895	70.549	0.000
45	Thu 15 Dec 2016	71.526	74.086	0.000
S/n	**Date**	**Solar radiation intensity (W/m^2)**	**Relative humidity (%)**	**Rain fall (mm)**
46	Fri 16 Dec 2016	93.781	72.978	0.063
47	Sat 17 Dec 2016	94.596	70.009	0.060
48	Sun 18 Dec 2016	120.169	69.458	0.229
49	Mon 19 Dec 2016	127.033	72.112	0.040
50	Tue 20 Dec 2016	102.842	71.410	0.108
51	Wed 21 Dec 2016	78.861	69.948	0.000
52	Thu 22 Dec 2016	107.994	68.578	0.000
53	Fri 23 Dec 2016	107.535	66.650	0.043
54	Sat 24 Dec 2016	86.674	70.453	0.019
55	Sun 25 Dec 2016	155.657	55.835	0.132
56	Mon 26 Dec 2016	124.823	32.273	0.157
57	Tue 27 Dec 2016	117.066	37.140	0.090
58	Wed 28 Dec 2016	130.725	42.749	0.058
59	Thu 29 Dec 2016	119.538	45.488	0.000
60	Fri 30 Dec 2016	129.458	45.966	0.000
61	Sat 31 Dec 2016	126.034	55.865	0.056
62	Sun 01 Jan 2017	144.603	48.467	0.006
63	Mon 02 Jan 2017	148.434	40.708	0.264
64	Tue 03 Jan 2017	142.278	47.485	0.065
65	Wed 04 Jan 2017	142.021	45.231	0.108
66	Thu 05 Jan 2017	123.294	62.581	0.000
67	Fri 06 Jan 2017	116.805	67.151	0.000
68	Sat 07 Jan 2017	125.632	67.998	0.000
69	Sun 08 Jan 2017	78.491	69.280	0.063
70	Mon 09 Jan 2017	155.554	45.252	0.060
71	Tue 10 Jan 2017	126.539	68.078	0.229

72	Wed 11 Jan 2017	130.450	67.108	0.040
73	Thu 12 Jan 2017	55.800	71.435	0.108
74	Fri 13 Jan 2017	103.979	70.195	0.000
75	Sat 14 Jan 2017	96.780	71.954	0.000
76	Sun 15 Jan 2017	63.908	74.243	0.043
77	Mon 16 Jan 2017	136.430	68.255	0.019
78	Tue 17 Jan 2017	123.298	69.120	0.132
79	Wed 18 Jan 2017	62.013	73.885	0.157
80	Thu 19 Jan 2017	100.768	71.686	0.090
81	Fri 20 Jan 2017	99.843	71.865	0.058
82	Sat 21 Jan 2017	103.946	69.568	0.000
83	Sun 22 Jan 2017	65.341	73.808	0.000
84	Mon 23 Jan 2017	111.043	71.801	0.056
85	Tue 24 Jan 2017	114.688	68.094	0.006
86	Wed 25 Jan 2017	105.424	70.188	0.264
87	Thu 26 Jan 2017	48.077	77.055	0.065
88	Fri 27 Jan 2017	125.753	68.691	0.108
89	Sat 28 Jan 2017	117.497	70.294	0.000
90	Sun 29 Jan 2017	143.526	67.941	0.000
91	Mon 30 Jan 2017	128.883	69.222	0.000
92	Tue 31 Jan 2017	48.321	72.930	0.063

Table 2: Weekly Average for Dry Season (November, 2016-January, 2017)

S/N	Week	Solar intensity(W/m^2)	Relative humidity (%)	Rainfall(mm)
1	1	87.964	72.765	0.087
2	2	101.821	71.616	0.071
3	3	113.039	72.549	0.071
4	4	108.626	72.904	0.056
5	5	94.451	73.850	0.066
6	6	99.318	70.916	0.068
7	7	97.868	72.569	0.042
8	8	104.444	69.822	0.063
9	9	129.043	44.938	0.070
10	10	134.724	54.281	0.063
11	11	106.799	66.281	0.071
12	12	98.601	71.115	0.071
13	13	98.260	71.440	0.071
14	14	106.910	70.884	0.021

Table 3: Descriptive Statistics of the Weather Variables for Dry Season (November, 2016-January, 2017)

		Solar radiation (w/m^2)	Relative humidity (mm)	Rain fall (mm)
N	Valid	92	92	92
	Missing	0	0	0
Mean		106.1903	68.0466	.06513
Std. Error of Mean		2.92458	.99757	.007579
Median		108.3575	70.6140	.05600
Std. Deviation		28.05163	9.56840	.072692
Minimum		40.79	32.27	.000
Maximum		155.66	77.06	.264

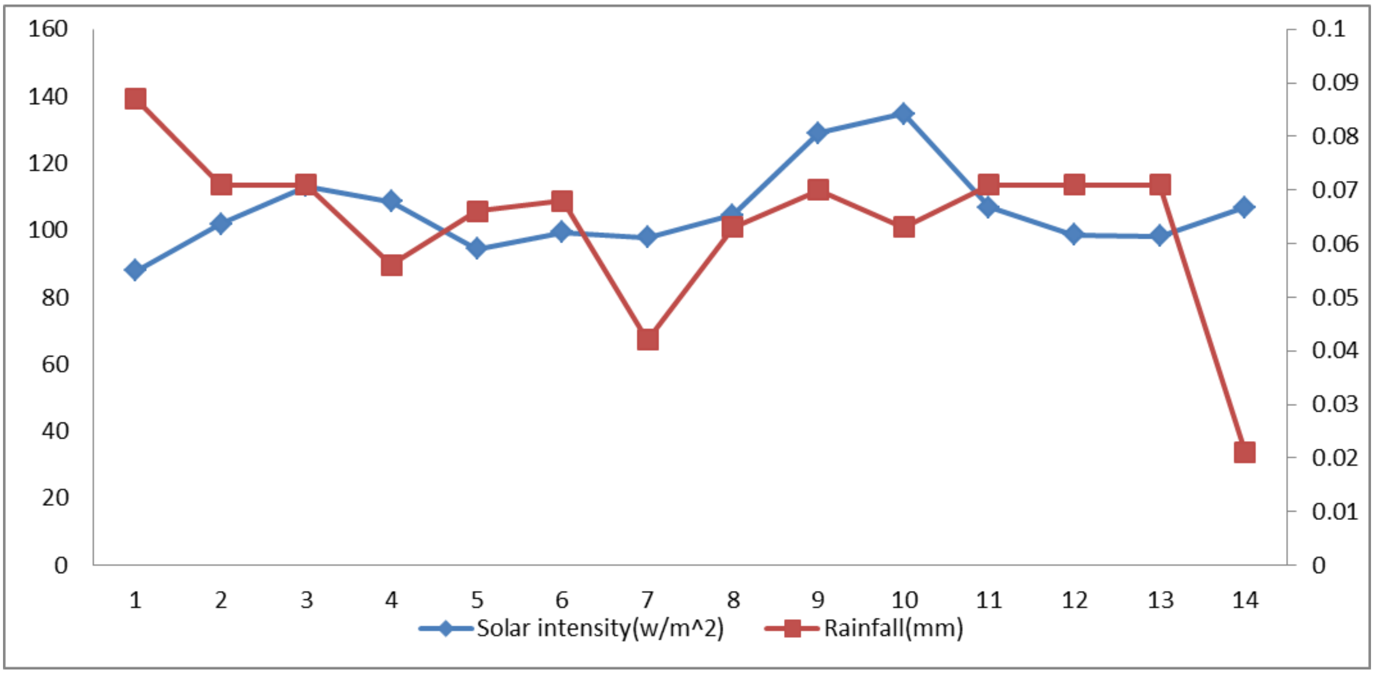


Figure 7: Cross Plots of Solar Radiation Intensity (W/m^2) and Rainfall (mm)

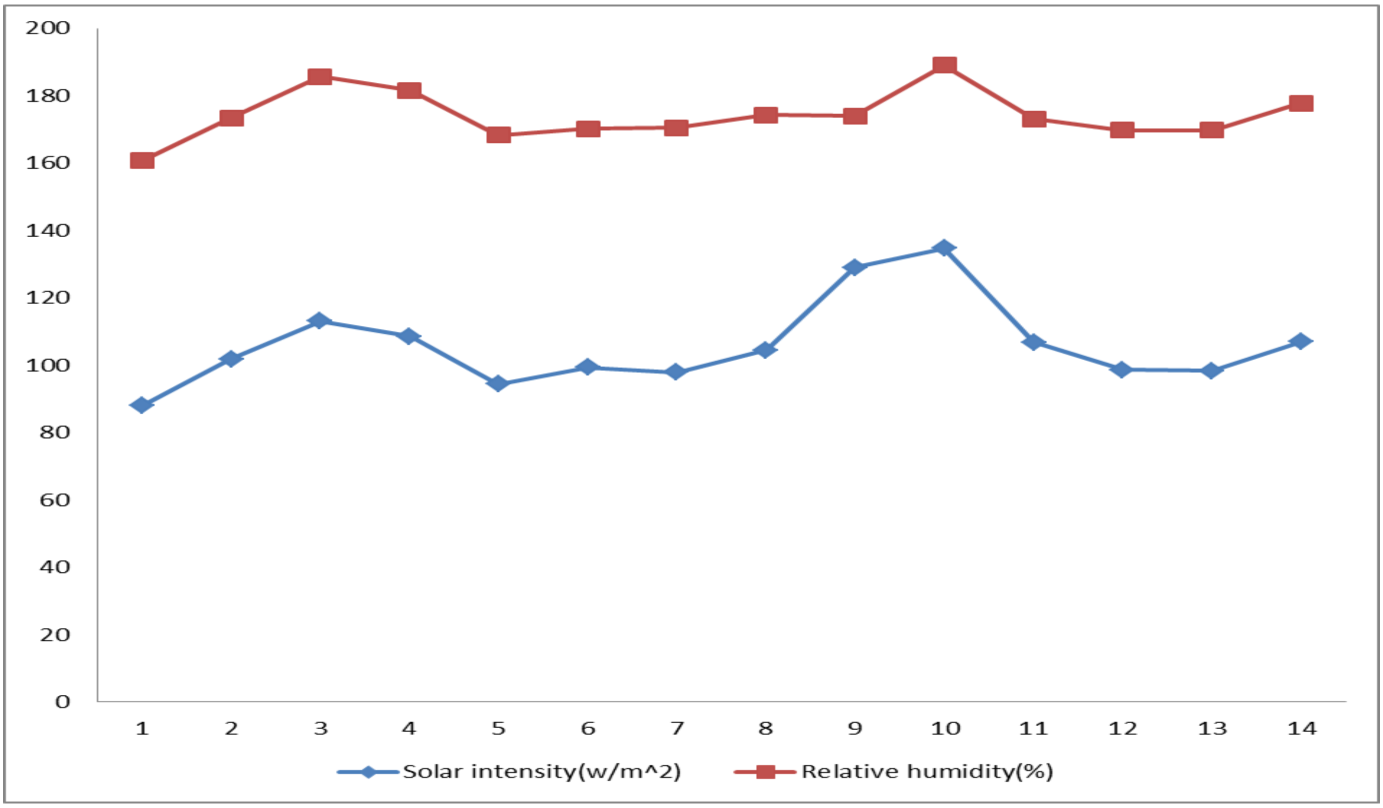


Figure 8: Cross Plots of Solar Radiation Intensity (W/m^2) and Relative Humidity (%)

Anova of Weekly Variations for Solar Radiation Intensity (W/m^2)

Hypothesis:

H_0: There is no significant influence on in solar radiation intensity by relative humidity for the different weeks during the dry season.i.e. $\mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5 = \mu_6 = \mu_7 = \mu_8 = \mu_9 = \mu_{10} = \mu_{11} = \mu_{12} = \mu_{13} = \mu_{14}$

H_1: There is a significant difference on solar radiation intensity for the different weeks during the dry season.i.e. At least, one mean is different from the others.

To Find the Critical Value:

d.f.N = degree of freedom number of groups = k – 1

d.f.D. = degree of freedom sample sum = N – k

Where: k is number of groups = 14

N is sum of all samples = 12 x 7 + 8 = 92

d.f.N. = k – 1 = 14 – 1 = 13

d.f.D. = N – k = 92 - 14 = 78

From the F-distribution table, the critical value obtained at $\alpha = 0.05$ is 1.848

Table 4: F- distribution of the Anova of Weekly Averages for Solar radiation intensity (W/m^2)

Groups	*Count*	*Sum*	*Average*	*Variance*		
Week 1	5	1.000	0.200	0.000		
Week 2	7	1.400	0.200	0.000		
Week 3	7	1.746	0.249	0.013		
Week 4	7	2.607	0.372	0.034		
Week 5	7	2.473	0.353	0.022		
Week 6	7	2.041	0.292	0.009		
Week 7	7	1.423	0.203	0.000		
Week 8	7	1.119	0.160	0.012		
Week 9	7	1.343	0.192	0.000		
Week 10	7	2.144	0.306	0.034		
Week 11	7	0.150	0.021	0.003		
Week 12	7	0.000	0.000	0.000		
Week 13	7	0.474	0.068	0.007		
Week 14	3	0.093	0.031	0.003		
ANOVA						
Source of Variation	***SS***	***Df***	***MS***	***F***	***P-value***	***F crit***
Between Groups	1.249	13	0.096	9.203	0.000	1.848
Within Groups	0.814	78	0.010			
Total	**2.063**	**91**				

Discussions

In this study, the results of the variations/trends observed in presented Table 1,Table 2, Table 3 and Table 4 and cross plots of weekly averages of weather variables encompassing solar radiation intensity(W/m^2) ,relative humidity(%),and rainfall(mm) are discussed for dry season(November,2016–January,2017).We use the descriptive statistics to determine the central tendencies and distributions of the collected data as computed using SPSS and presented in Table 3. Cross plots of the weekly averages of the solar radiation intensity(W/m^2) and rainfall(mm); and solar radiation intensity(W/m^2) and relative humidity(%) are displayed Figures 7 and Figure 8 respectively in order to have a qualitative analysis of the explicit relationship that exist between the integral independent weather variables(rainfall(mm) and relative humidity(%) and the dependent weather variable (Solar radiation intensity(W/m^2).

Solar Radiation Intensity

A close examination of the ninety-two (92) solar radiation intensities measurements for dry season as shown in Table 1 revealed that the solar radiation intensity is at maximum on Sunday 25 December, 2016 with a value of 155.657W/m^2 and at minimum on Monday 21 November, 2016 with a value of 40.791 W/m^2 for the dry season. On weekly averages, solar radiation intensity has its peak of about 134.724 W/m^2 recorded during week 10,and in the month of November and it decreases gradually to a minimum of 87.964W/m^2 recorded in the week 1.The mean solar radiation intensity is 106.1903 W/m^2.

Rainfall and Solar Radiation intensity

From Table 1,it can be observed that in the dry season(November,2016- January,2017), rainfall reached its maximum, 0.264mm on Thursday 17 November ,Saturday 10 December, 2016 and Monday 27 January,2017 and its minimum, that is days of no rainfall 0.000mm for fourteen(14) days. From Table 2, on weekly averages, the maximum amount of rainfall 0.087mmis recorded in week 1 and the minimum 0.021mm recorded in week 14. The mean average rainfall is 0.06513mm as shown in Table 3.That means that there is an inverse relationship between rainfall and solar radiations as weeks of low rainfall coincides with weeks of high magnitudes solar radiation intensity and verse versa. This inverse relationship was furthermore, revealed Figure 7 where points of higher solar radiation intensities intersect with points of lower amounts of rainfall. It shows that an increase in rainfall leads to decrease in solar radiation intensity and a decrease in rainfall, results in increase in solar radiation intensity.

Relative Humidity and Solar Radiation Intensity

Relative humidity is a measure of the amount of water vapour which is present in air and it is expressed as a percentage of the amount that is needed for saturation at the same temperature". It can also be seen as "the ratio of partial pressure of water vapour to the equilibrium vapour pressure of water at a given temperature". The relative humidity from measurements ranges from 32.27% to 77.06% with a mean average of 68.0466% for dry season (November, 2016- January, 2017). From Figure 8 it can be seen that a change in relative humidity gives an insignificant change in solar radiation intensity. A negative relationship was expected between relative humidity and solar radiation intensity, in other words, relative humidity should negatively influence the intensity of solar radiation. This is qualitative but a quantitative approach may give results that can correspond with this expectation. This insignificant influence might be as a result of the low magnitudes of the relative humidity during the dry season of the study period.

Interpretation of the ANOVA

In other to ascertain the insignificant influence of the relative humidity on solar radiation intensity during the dry season as observed for the qualitative analysis, we employed the ANOVA analysis. From Table 4, it was inferred that, since F (= 1.480) is less than the critical value (= 1.848), and also since the p-value (= 0.144) is greater than α (= 0.05), we therefore accept the null hypothesis; and state that there is no significant influence on solar radiation intensity by relative humidity for the different weeks during the dry season, i.e. $\mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5 = \mu_6 = \mu_7 = \mu_8 = \mu_9 = \mu_{10} = \mu_{11} = \mu_{12} = \mu_{13} = \mu_{14}$.This result confirmed that there is a negative influence on the solar radiation intensity as the computed value is close to the critical value with an accuracy of 0.368. However, the integral influence of the relative humidity on the solar radiation intensity is not significant during the period of the measurement in the dry season.

Conclusion

Based on the findings of this study, it can be concluded that:

i. The changes in amount of rainfall (mm) and relative humidity (%) negatively influence the magnitude of solar radiation intensity (W/m^2) during the dry season that is from November through January.

ii. The variations in the amount of rainfall (mm) significantly influence the solar radiation intensity (W/m^2) while that of the relative humidity is not obvious during the dry season in Port Harcourt.

iii. Solar radiation intensity ranges from $40.8W/m^2$ to $155.0W/m^2$ with a mean average of $106.2W/m^2$ for the dry season

iv. Rainfall has its minimum and maximum values at 0.00mm and 0.264mm respectively with a mean average of 0.06513mm.

v. The relative humidity from measurements ranges from 32.27% to 77.06% with a mean average of 68.0466% for dry season.

Recommendations

i. The scope of the study should be expanded to include other independent weather variables such as air pressure, wind speed; standard temperature and air temperature on solar radiation intensity.

ii. Apart from the study weather variables, other factors that influence solar radiation intensity such as cloud cover, sunshine duration, topography, angle of inclination/ location etc should be integrated in order to increase the influence resolution on the subject.

iii. The study duration should be increased to cover other months of the dry season and the rainy season months included to make a year.

iv. Similar works should also be carried out in other parts of River State and Nigeria as a whole to generate a map of influences of weather variables with other factors on solar radiation intensity in Nigeria.

v. The essential of the study should be used as a data in the data bank of the aviation industries, agricultural sector, manufacturing industries, meteorological institutions and governmental environmental ministries and agencies for effective planning and implementation of policies for sustainable developments

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