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EXPERIMENTAL ANALYSIS OF PHOTOVOLTAIC SOLAR RADIATION SYSTEMS: A CASE OF ANAMBRA STATE, NIGERIA

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ABSTRACTS

This research work focused on the variability of global solar radiation over the area of Extension site which is situatued in Federal Polytechnic Oko, Orumba North Local Government Area, Anambra State, Nigeria. (6°20'N. 7^{U}00'E) which was located in South Eastern part of Nigeria for the month of December 2016. The global solar radiation was measured every thirty minutes from 6:00am to 6:00pm for the period of five days. To measure the intensity of solar radiation in a particular geographical area is one of the necessary tools used for the investigation of the intensity of solar power radiation and necessary for the implementation of photovoltaic systems in that particular geographical area. To determine the solar radiation intensity, data were collected over a given period of days using an instrument called solarimeter. Solarimeter is an instrument used to determine the intensity or thermal radiation and photovoltaic principles of the sun in a particular geographical area. The data collected were analyzed to observe the behavior or the data and what the data portrays. The data were analyzed using radial plot, line plot, scatter plot main effect, correlations and probability plots. From the analysis, it was observed that the Sun radiation is highest from around 12 noon to 2 pm of the day time and lowest around 6AM to 7AM in the morning hours and around 6 PM in the evenings of 6th to 10th February, 2017.

The high intensity is as a result of high atmospheric temperature in the area. The correlations of the intensity and the temperature reveals that they are correlated to each other. The probability plots show that the exponential probability plots are more significance than normal probability plots. The result shows the intensity of the sun light is high in afternoon and lower in the early hours of mornings and late hours of evenings. The average solar intensity of extension site in Federal Polytechnic Oko, is 356,644w/m^2. The result will help in positioning solar panels, in order to determine the efficiency of solar panel, being critical in the selection of solar panels that will be necessary and more effective in that particular geographical area.

KEYWORDS: Sun, Solar, Radiation, Intensity, Temperature, Solarimeter, Photovoltaic.

1. INTRODUCTION

Solar radiation is the radiant energy or radiation emitted by the sun. It is also called electromagnetic energy or short-wave radiation.

Solar radiation is a general term for the electromagnetic radiation emitted by the sun. Solar radiation can be captured and turned into useful forms of energy, such as heat and electricity, using a variety of technologies. However, the technical feasibility and economical operation of these technologies at a specific location depends on the available solar resource.[24,25]

1.1 Basic Principles

Every location on Earth receives sunlight at least part of the year. The amount of solar radiation that reaches any one spot on the Earth's surface varies according to:

- Geographic location
- Time of day
- Season
- Local landscape
- Local weather.

Because the Earth is round, the sun strikes the surface at different angles, ranging from 0° (just above the horizon) to 90° (directly overhead). When the sun's rays are vertical, the Earth's surface gets all the energy possible. The more slanted the sun's rays are, the longer they travel through the atmosphere, becoming more scattered and diffuse. Because the Earth is round, the frigid polar regions never get a high sun, and because of the tilted axis of rotation, these areas receive no sun at all during part of the year.

The Earth revolves around the sun in an elliptical orbit and is closer to the sun during part of the year. When the sun is nearer the Earth, the Earth's surface receives a little more solar energy. The Earth is nearer the sun when it is summer in the southern hemisphere and winter in the northern hemisphere. However, the presence of vast oceans moderates the hotter summers and colder winters one would expect to see in the southern hemisphere as a result of this difference.

The 23.5° tilt in the Earth's axis of rotation is a more significant factor in determining the amount of sunlight striking the Earth at a particular location. Tilting results in longer days in the northern hemisphere from the spring (vernal) equinox to the fall (autumnal) equinox and longer days in the southern hemisphere during the other 6 months. Days and nights are both exactly 12 hours long on the equinoxes, which occur each year on or around March 23 and September 22.

Countries such as the United States, which lie in the middle latitudes, receive more solar energy in the summer not only because days are longer, but also because the sun is nearly overhead. The sun's rays are far more slanted during the shorter days of the winter months. Cities such as Denver, Colorado, (near 40° latitude) receive nearly three times more solar energy in June than they do in December.

The rotation of the Earth is also responsible for hourly variations in sunlight. In the early morning and late afternoon, the sun is low in the sky. Its rays travel further through the atmosphere than at noon, when the sun is at its highest point. On a clear day, the greatest amount of solar energy reaches a solar collector around solar noon.

1.2 Diffuse and Direct Solar Radiation

As sunlight passes through the atmosphere, some of it is absorbed, scattered, and reflected by:

- Air molecules
- Water vapor
- Clouds
- Dust
- Pollutants
- Forest fires
- Volcanoes.

This is called diffuse solar radiation. The solar radiation that reaches the Earth's surface without being diffused is called direct beam solar radiation. The sum of the diffuse and direct solar radiation is called global solar radiation. Atmospheric conditions can reduce direct beam radiation by 10% on clear, dry days and by 100% during thick, cloudy days.

1.3 Measurement of Sun Intensity

Scientists measure the amount of sunlight falling on specific locations at different times of the year. They then estimate the amount of sunlight falling on regions at the same latitude with similar climates. Measurements of solar energy are typically expressed as total radiation on a horizontal surface, or as total radiation on a surface tracking the sun.

Radiation data for solar electric (photovoltaic) systems are often represented as kilowatt-hours per square meter (kWh/m^2). Direct estimates of solar energy may also be expressed as watts per square meter (W/m^2).

1.4 Distribution of Sun Intensity

The solar resource across the Nigeria is ample for photovoltaic (PV) systems because they use both direct and scattered sunlight. Other technologies may be more limited. However, the amount of power generated by any solar technology at a particular site depends on how much of the sun's energy reaches it. Thus, solar technologies function most efficiently in the southwestern United States, which receives the greatest amount of solar energy.[26]

2. Photovoltaics

The term "photovoltaic" comes from the Greek meaning "light", and from "volt", the unit of electro-motive force, the volt, which in turn comes from the last name of the Italian physicist Alessandro Volta, inventor of the battery (electrochemical cell). The term "photo-voltaic" has been in use in English since 1849.[13]

Photovoltaics (PV) is a term which covers the conversion of light into electricity using semiconducting materials that exhibit the photovoltaic effect, a phenomenon studied in physics, photochemistry, and electrochemistry.

A typical photovoltaic system employs solar panels, each comprising a number of solar cells, which generate electrical power. PV installations may be ground-mounted, rooftop mounted or wall mounted. The mount may be fixed, or use a solar tracker to follow the sun across the sky.

Solar PV has specific advantages as an energy source: its operation generates no pollution.[1] and no greenhouse gas emissions once installed, it shows simple scalability in respect of power needs and silicon has large availability in the Earth's crust.[2]

PV systems have the major disadvantage that the power output is dependent on direct sunlight, so about 10-25% is lost if a tracking system is not used, since the cell will not be directly facing the sun at all times.[3] Dust, clouds, and other things in the atmosphere also diminish the power output.[4,5] Another main issue is the concentration of the production in the hours corresponding to main insolation, which don't usually match the peaks in demand in human activity cycles.[2] Unless current societal patterns of consumption and electrical networks mutually adjust to this scenario, electricity still needs to be made up by other power sources, usually hydrocarbon.

Photovoltaic systems have long been used in specialized applications, and standalone and grid-connected PV systems have been in use since the 1990s.[6] They were first mass-produced in 2000, when German environmentalists and the Eurosolar organization got government funding for a ten thousand roof program.[7]

Advances in technology and increased manufacturing scale have in any case reduced the cost, increased the reliability, and increased the efficiency of photovoltaic installations.[6,8] Net metering and financial incentives, such as preferential feed-in tariffs for solar-generated electricity, have supported solar PV installations in many countries.[9]

After hydro and wind powers, PV is the third renewable energy source in terms of globally capacity. In 2014, worldwide installed PV capacity increased to 177 gigawatts (GW), which is two percent of global electricity demand.[10] China, followed by Japan and the United States, is the fastest growing market, while Germany remains the world's largest producer, with solar PV providing seven percent of annual domestic electricity consumption.[11] With current technology (as of 2013), photovoltaics recoups the energy needed to manufacture them in 1.5 years in Southern Europe and 2.5 years in Northern Europe.[12]

2.1 Solar cells

Photovoltaics are best known as a method for generating electric power by using solar cells to convert energy from the sun into a flow of electrons by the photovoltaic effect.[14,15]

Solar cells produce direct current electricity from sunlight which can be used to power equipment or to recharge a battery. The first practical application of photovoltaics was to power orbiting satellites and other spacecraft, but today the majority of photovoltaic modules are used for grid connected power generation. In this case an inverter is required to convert the DC to AC. There is a smaller market for off-grid power for remote dwellings, boats, recreational vehicles, electric cars, roadside emergency telephones, remote sensing, and cathodic protection of pipelines.

Photovoltaic power generation employs solar panels composed of a number of solar cells containing a photovoltaic material.[16] Copper solar cables connect modules (module cable), arrays (array cable), and sub-fields. Because of the growing demand for renewable energy sources, the manufacturing of solar cells and photovoltaic arrays has advanced considerably in recent years.[17,18,19]

Solar photovoltaic power generation has long been seen as a clean energy technology which draws upon the planet's most plentiful and widely distributed renewable energy source – the sun. Cells require protection from the environment and are usually packaged tightly in solar panels.

Photovoltaic power capacity is measured as maximum power output under standardized test conditions (STC) in watts peak ("W_p").[20] The actual power output at a particular point in time may be less than or greater than this standardized, or "rated," value, depending on geographical location, time of day, weather conditions, and other factors.[21] Solar photovoltaic array capacity factors are typically under 25%, which is lower than many other industrial sources of electricity.[22]

Electrical efficiency (also called conversion efficiency) is a contributing factor in the selection of a photovoltaic system. However, the most efficient solar panels are typically the most expensive, and may not be commercially available. Therefore, selection is also driven by cost efficiency and other factors.

The electrical efficiency of a PV cell is a physical property which represents how much electrical power a cell can produce for a given insolation. The basic expression for maximum efficiency of a photovoltaic cell is given by the ratio of output power to the incident solar power (radiation flux time's area).[23]

3. RESEARCH METHOD

The research method adopted is the analysis of the sun intensity and its temperature variability in the selected case study area using statistical tools and design of expert tool to experiment the analysis of the data and the intensity of the Sun in the geographical area. The tools applied are chart analysis, correlations analysis, Probability analysis and main effect analysis. The results will portray the influence of Sun intensity and temperature variations in the case study area.

4. Analysis and Results

Table 1: The values of solar intensity for five days in February 2016.

S/N	Time	Intensity of the sun day 1 (W/M²)	Intensity of the sun day 2 (W/M²)	Intensity of the sun day 3 (W/M²)	Intensity of the sun day 4 (W/M²)	Intensity of the sun day 5 (W/M²)
1	6:00	2.1	3.1	1.9	1.2	1.7
2	6:30	6.4	4.3	9.3	7.7	4
3	7:00	25.1	37.7	21.4	26.5	27.8
4	7:30	75.6	85.4	79.6	43.2	57.8
5	8:00	142.5	106.5	147.5	88.2	207.9
6	8:30	224.3	334.6	264.2	181.6	239.4
7	9:00	438.3	380.5	371.2	3 46. 2	351.6
8	9:30	436.5	339.4	475	316.7	410.6
9	10:00	226.1	271.5	612.1	195.2	602.6
10	10:30	237.5	636.1	255.2	193.2	718.9
11	11:00	741.2	476.4	394.3	856.1	819.3
12	11:30	898.6	959.6	459.7	861.3	908
13	12:00	986	898.1	616	992	986
14	12:30	858.4	491.6	917.6	944.6	1013.3
15	1:00	856.1	318.3	960.9	843.9	998.5
16	1:30	474.2	963.5	339	717.2	934.2
17	2:00	265.4	814.3	818.2	751.9	876.8
18	2:30	264	230.7	473.1	371.8	789.6
19	3:00	374.7	554.9	572.5	374.8	686.2
20	3:30	207.4	413	215.6	318.3	547.7
21	4:00	211.8	180.4	154.1	249.7	449.3
22	4:30	153.6	111.8	134	173.1	130.2
23	5:00	86.5	127.1	104	149	160.7
24	5:30	47.1	43.9	57.7	80.1	52.2
25	6:00	13.3	8.6	18.7	30.9	21.2

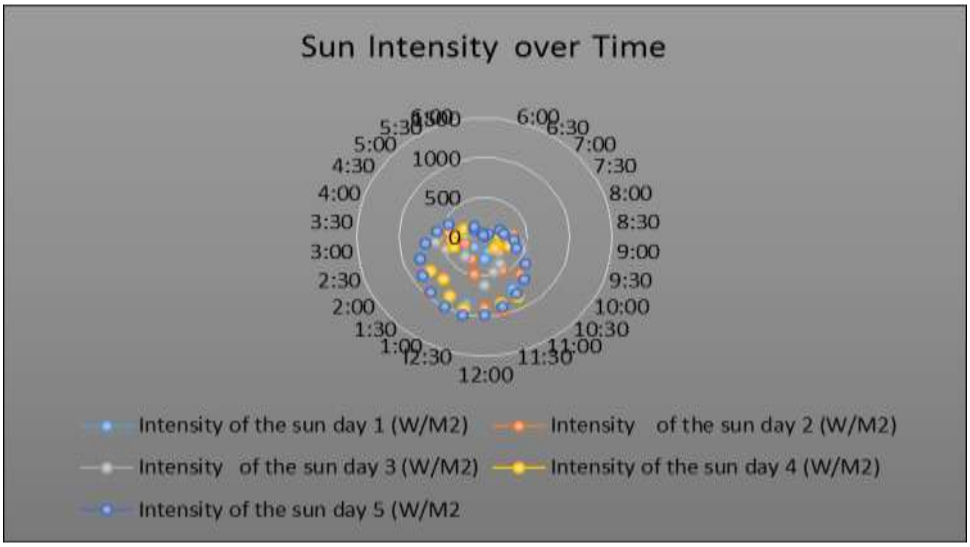

Figure 1: Radial Plot of Sun Intensity over Time.

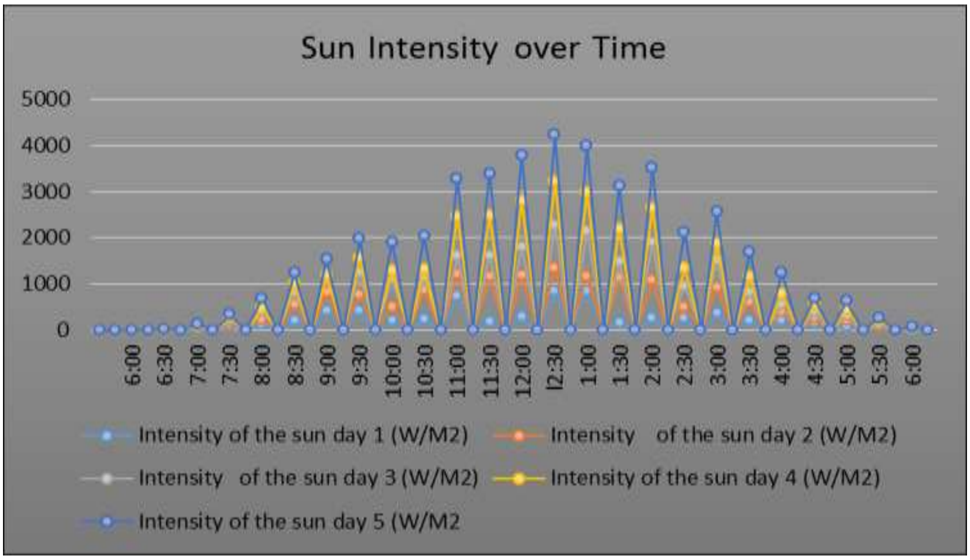

Figure 2: Line Plot of Sun Intensity over Time.

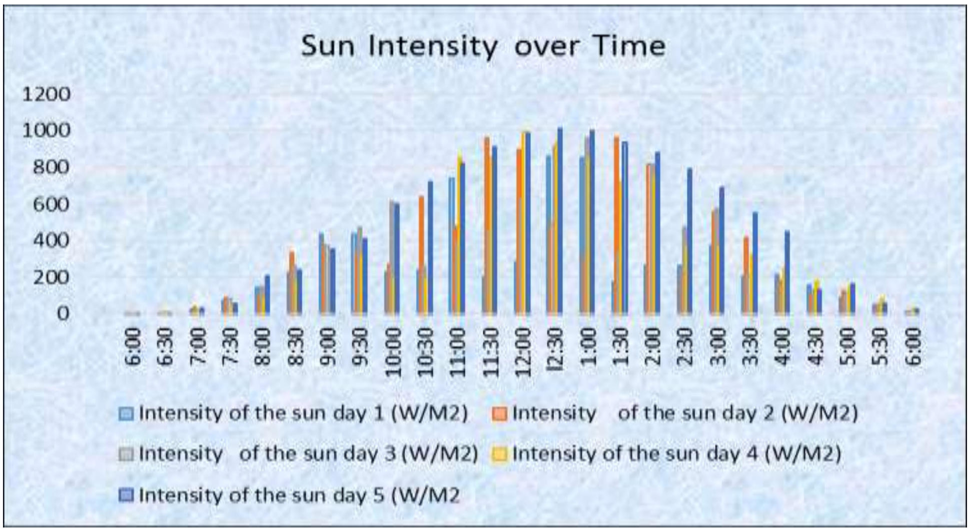

Figure 3: Column Plot for Sun Intensity over Time.

Table 2: Pearson Correlations of Sun Intensity.

		SunIntensity1	SunIntensity2	SunIntensity3	SunIntensity4	SunIntensity5	Yield
SunIntensity1	Pearson Correlation	1	.347*	.793**	.718**	.636**	.768**
	Sig. (1-tailed)		.045	.000	.000	.000	.000
	N	25	25	25	25	25	25
SunIntensity2	Pearson Correlation	.347*	1	.600**	.798**	.804**	.823**
	Sig. (1-tailed)	.045		.001	.000	.000	.000
	N	25	25	25	25	25	25
SunIntensity3	Pearson Correlation	.793**	.600**	1	.804**	.819**	.903**
	Sig. (1-tailed)	.000	.001		.000	.000	.000
	N	25	25	25	25	25	25
SunIntensity4	Pearson Correlation	.718**	.798**	.804**	1	.880**	.956**
	Sig. (1-tailed)	.000	.000	.000		.000	.000
	N	25	25	25	25	25	25
SunIntensity5	Pearson Correlation	.636**	.804**	.819**	.880**	1	.949**
	Sig. (1-tailed)	.000	.000	.000	.000		.000
	N	25	25	25	25	25	25
Yield	Pearson Correlation	.768**	.823**	.903**	.956**	.949**	1
	Sig. (1-tailed)	.000	.000	.000	.000	.000	
	N	25	25	25	25	25	25

***. Correlation is significant at the 0.05 level (1-tailed).**

****. Correlation is significant at the 0.01 level (1-tailed).**

Table 3: Nonparametric Correlations of Sun Intensity.

			SunIntensity1	SunIntensity2	SunIntensity3	SunIntensity4	SunIntensity5	Yield
Kendall's tau_b	SunIntensity1	Correlation Coefficient	1.000	.540**	.760**	.687**	.567**	.740**
		Sig. (1-tailed)	.	.000	.000	.000	.000	.000
		N	25	25	25	25	25	25
	SunIntensity2	Correlation Coefficient	.540**	1.000	.607**	.733**	.667**	.733**
		Sig. (1-tailed)	.000	.	.000	.000	.000	.000
		N	25	25	25	25	25	25
	SunIntensity3	Correlation Coefficient	.760**	.607**	1.000	.740**	.660**	.820**
		Sig. (1-tailed)	.000	.000	.	.000	.000	.000
		N	25	25	25	25	25	25
	SunIntensity4	Correlation Coefficient	.687**	.733**	.740**	1.000	.733**	.867**
		Sig. (1-tailed)	.000	.000	.000	.	.000	.000
		N	25	25	25	25	25	25
	SunIntensity5	Correlation Coefficient	.567**	.667**	.660**	.733**	1.000	.827**
		Sig. (1-tailed)	.000	.000	.000	.000	.	.000
		N	25	25	25	25	25	25
	Yield	Correlation Coefficient	.740**	.733**	.820**	.867**	.827**	1.000
		Sig. (1-tailed)	.000	.000	.000	.000	.000	.
		N	25	25	25	25	25	25
Spearman's rho	SunIntensity1	Correlation Coefficient	1.000	.696**	.902**	.835**	.680**	.852**
		Sig. (1-tailed)	.	.000	.000	.000	.000	.000
		N	25	25	25	25	25	25
	SunIntensity2	Correlation Coefficient	.696**	1.000	.762**	.875**	.795**	.873**
		Sig. (1-tailed)	.000	.	.000	.000	.000	.000
		N	25	25	25	25	25	25
	SunIntensity3	Correlation Coefficient	.902**	.762**	1.000	.889**	.812**	.934**
		Sig. (1-tailed)	.000	.000	.	.000	.000	.000
		N	25	25	25	25	25	25
	SunIntensity4	Correlation Coefficient	.835**	.875**	.889**	1.000	.875**	.967**
		Sig. (1-tailed)	.000	.000	.000	.	.000	.000
		N	25	25	25	25	25	25
	SunIntensity5	Correlation Coefficient	.680**	.795**	.812**	.875**	1.000	.925**
		Sig. (1-tailed)	.000	.000	.000	.000	.	.000
		N	25	25	25	25	25	25
	Yield	Correlation Coefficient	.852**	.873**	.934**	.967**	.925**	1.000
		Sig. (1-tailed)	.000	.000	.000	.000	.000	.
		N	25	25	25	25	25	25

****. Correlation is significant at the 0.01 level (1-tailed).**

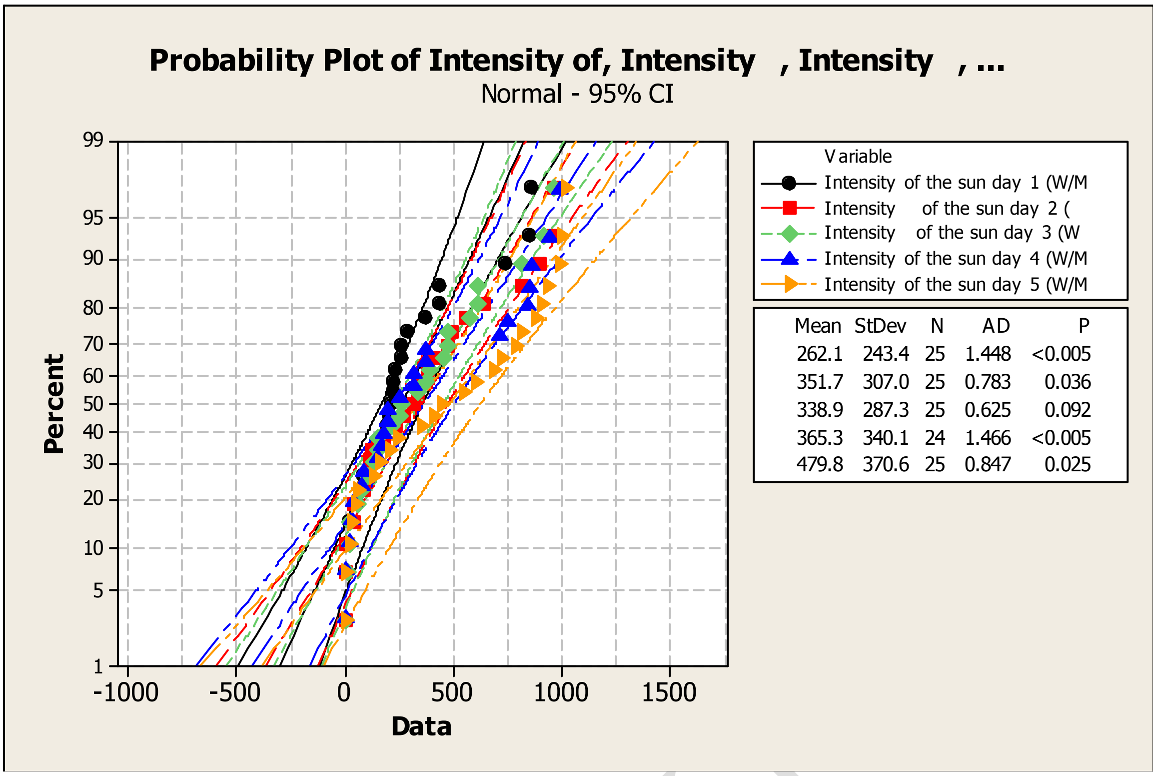

Figure 4: Normal Probability Plot of Sun Intensity over the Experimental Period.

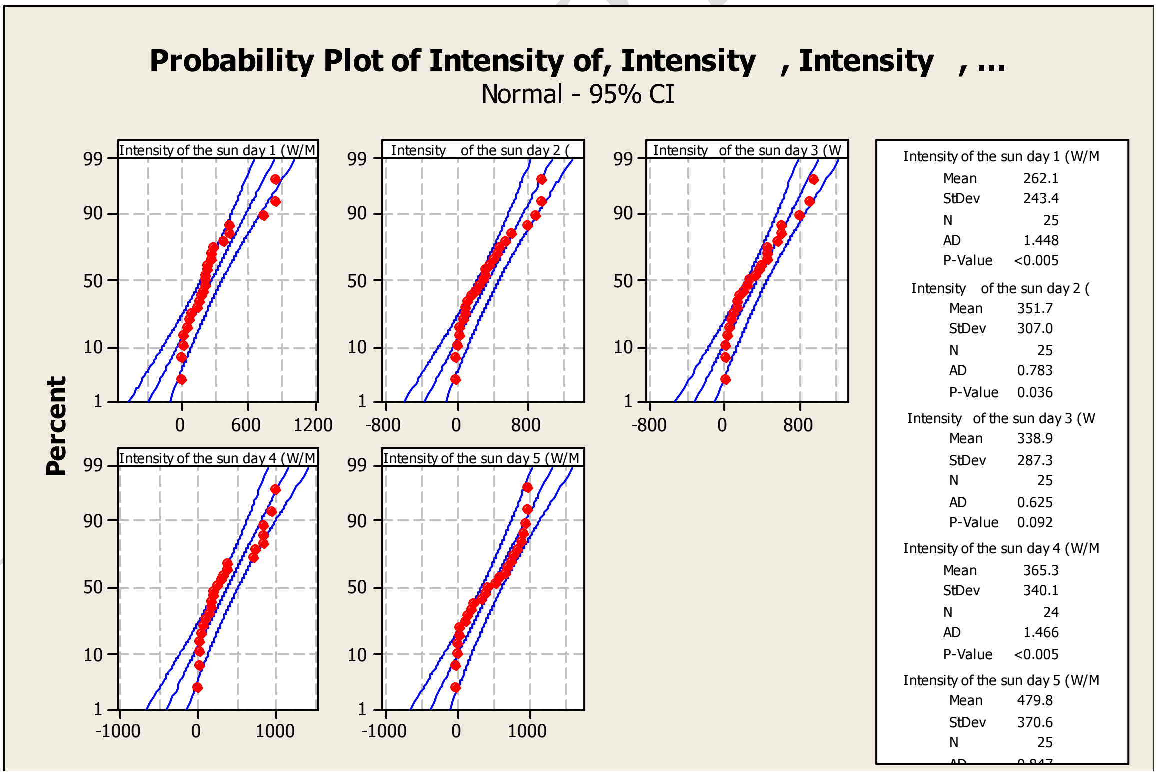

Figure 5: Individual Normal Probability Plot of Sun Intensity over the Period.

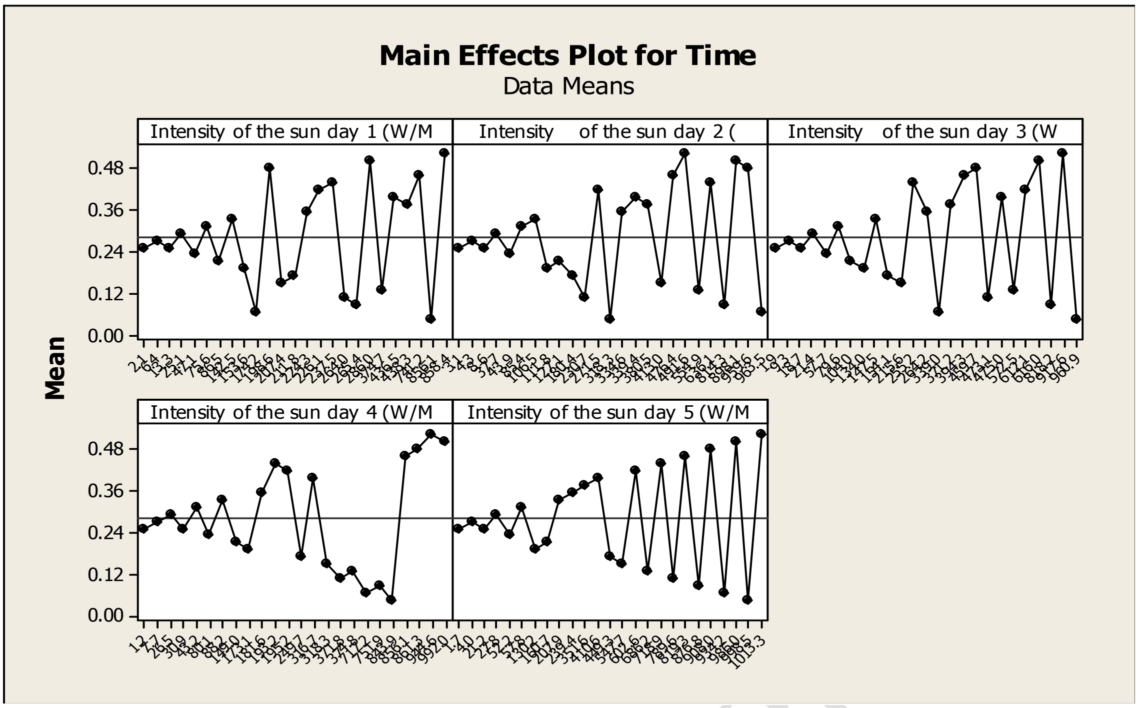

Figure 6: Main Effects Plot for Time.

Table 4: Showing the values of temperature for five days.

S/N	Time	Temperature Day 1 ("C)	Temperature Day 2 ("C)	Temperature Day 3 ("C)	Temperature Day 4 ("C)	Temperature Day 5 ("C)
1	6:00	19.4	21.1	17.9	17.5	18.1
2	6:30	20.2	21.6	19.8	18.4	19.3
3	7:00	21.5	24.3	20.2	21	20.5
4	7:30	22.3	26.8	20.7	22.3	21.4
5	8:00	22.8	23.2	23.1	23.5	23.1
6	8:30	23.2	23.8	24.3	24.6	22.6
7	9:00	23.7	25.3	24.9	25.3	24.2
8	9:30	24.6	27.3	25.1	26.3	23.9
9	10:00	26.9	28.5	27.8	26.1	27.3
10	10:30	27.4	29.1	27.1	27.5	30.4
11	11:00	27.6	31.4	30.1	31.4	32.6
12	11:30	28.2	32.1	33.1	31.2	34.6
13	12:00	29.7	34.5	34.5	34.5	37.9
14	12:30	34.2	34.7	38.7	36.7	40.1
15	1:00	38.6	39	36.9	35.2	40.6
16	1:30	40.8	37.7	37.5	37.3	38.7
17	2:00	39.5	35.2	34.2	32.2	41.2
18	2:30	37.4	37.1	36.4	28.8	37.5
19	3:00	35.2	35.3	34.3	25.6	33.7
20	3:30	33.9	34.5	32.5	24.3	26.4
21	4:00	34	31.4	30.9	23.9	22.2
22	4:30	32.7	29.6	28.1	22.6	23.9
23	5:00	31.5	29.7	25.6	22.3	20.1
24	5:30	29.6	26.8	22.2	19.6	19.7
25	6:00	23.4	23.9	20.4	20.9	18.8

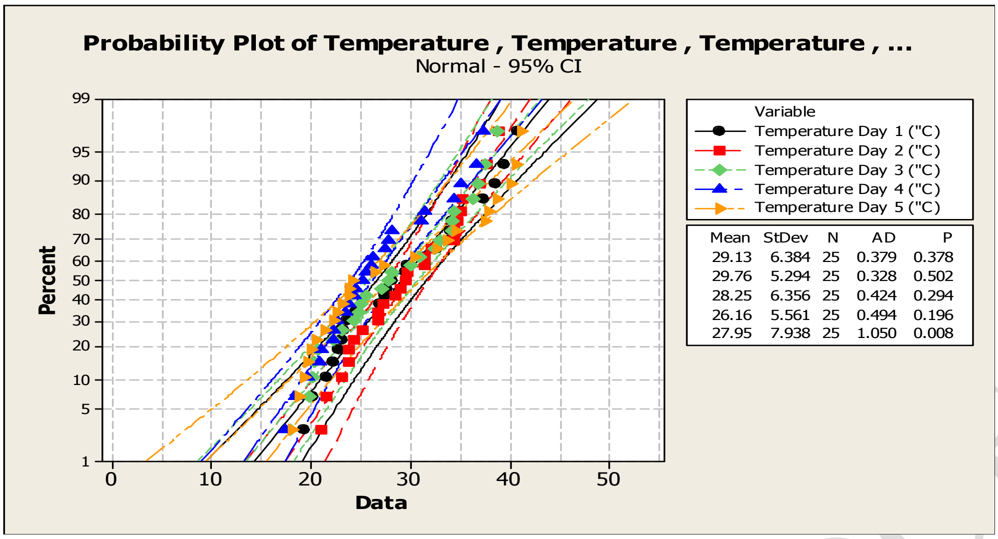

Figure 7: Normal Probability Plot of Temperature over the Experimental Period.

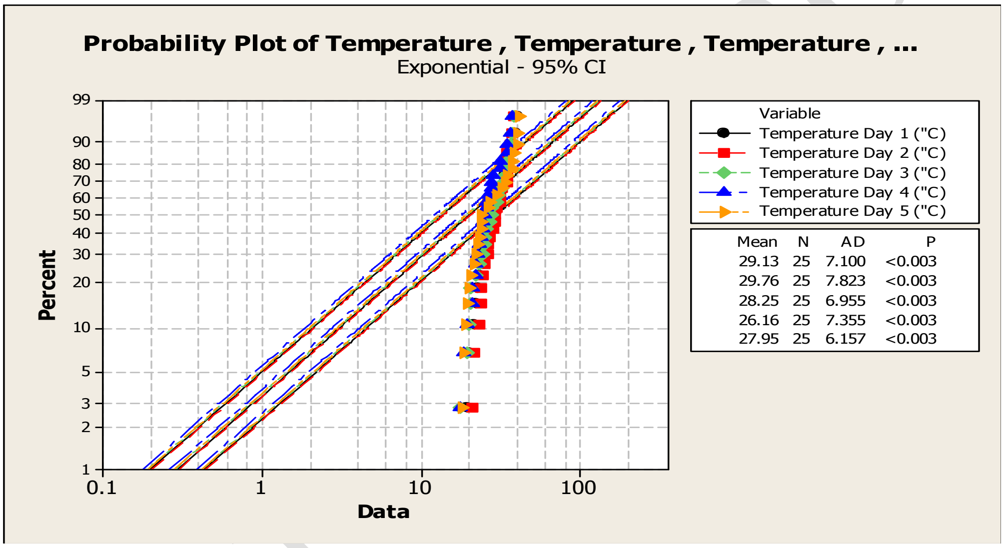

Figure 8: Exponential Probability Plot of Temperature over the Experimental Period.

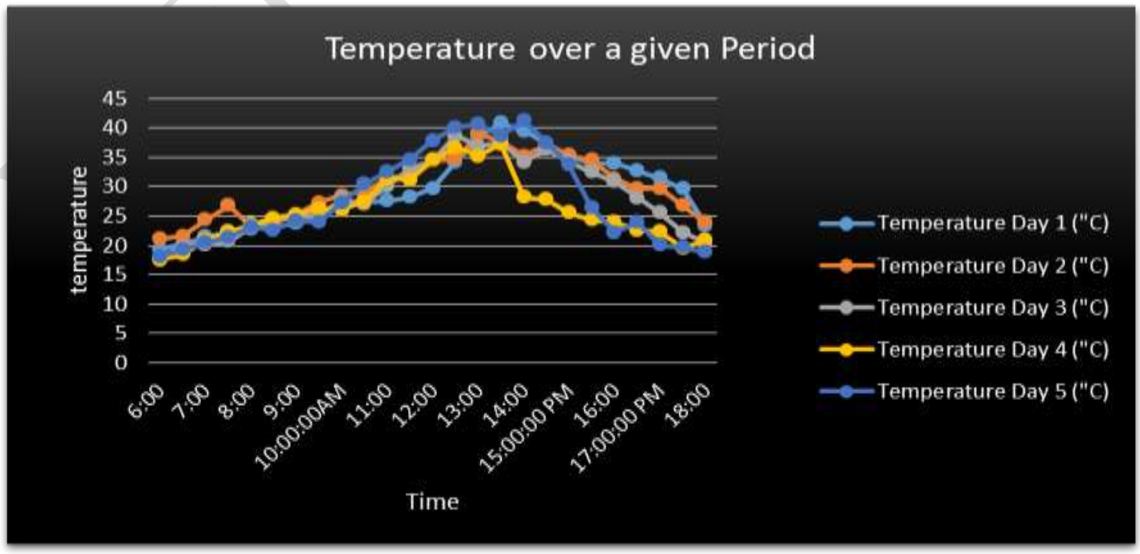

Figure 9: Line Plot of Temperature in the Given Metropolis.

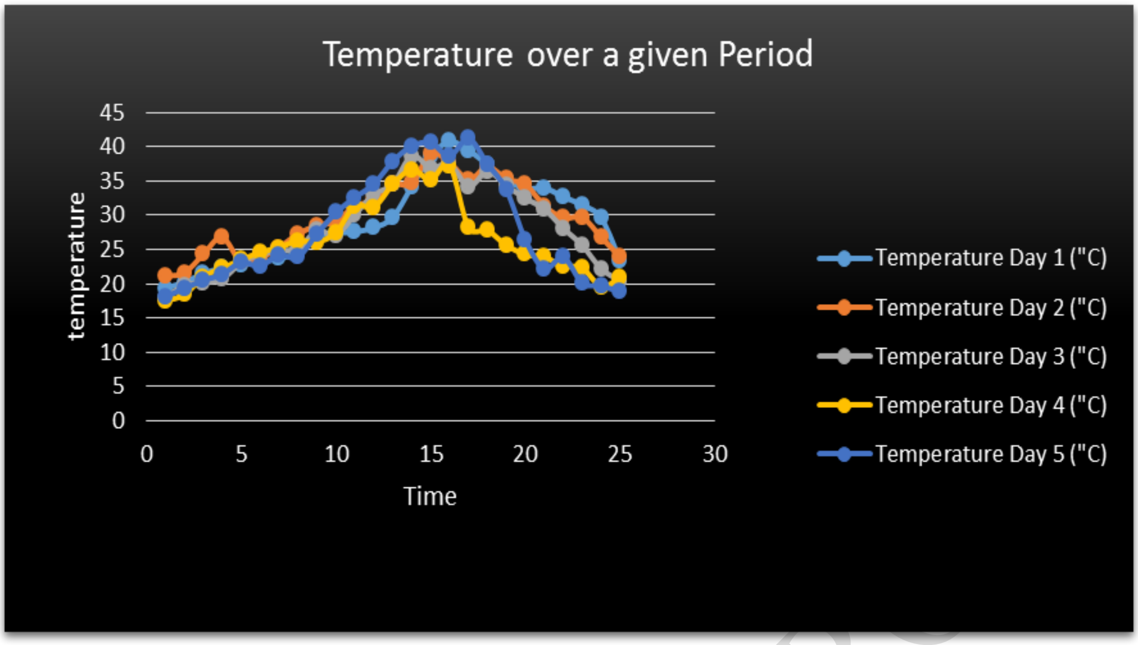

Figure 10: Scatter Plot of Temperature Variations on the Case Study.

Table 5: Pearson Correlations of Temperature.

		Temp.1	Temp.2	Temp.3	Temp.4	Temp.5	Yield
Temp.1	Pearson Correlation	1	.926**	.877**	.616**	.743**	.888**
	Sig. (1-tailed)		.000	.000	.001	.000	.000
	N	25	25	25	25	25	25
Temp.2	Pearson Correlation	.926**	1	.953**	.778**	.867**	.965**
	Sig. (1-tailed)	.000		.000	.000	.000	.000
	N	25	25	25	25	25	25
Temp.3	Pearson Correlation	.877**	.953**	1	.854**	.913**	.983**
	Sig. (1-tailed)	.000	.000		.000	.000	.000
	N	25	25	25	25	25	25
Temp.4	Pearson Correlation	.616**	.778**	.854**	1	.895**	.886**
	Sig. (1-tailed)	.001	.000	.000		.000	.000
	N	25	25	25	25	25	25
Temp.5	Pearson Correlation	.743**	.867**	.913**	.895**	1	.951**
	Sig. (1-tailed)	.000	.000	.000	.000		.000
	N	25	25	25	25	25	25
Yield	Pearson Correlation	.888**	.965**	.983**	.886**	.951**	1
	Sig. (1-tailed)	.000	.000	.000	.000	.000	
	N	25	25	25	25	25	26

****. Correlation is significant at the 0.01 level (1-tailed).**

Table 6: Nonparametric Correlations of Temperature.

			Temp.1	Temp.2	Temp.3	Temp.4	Temp.5	Yield
Kendall's tau_b	Temp.1	Correlation Coefficient	1.000	.821**	.767**	.538**	.611**	.787**
		Sig. (1-tailed)	.	.000	.000	.000	.000	.000
		N	25	25	25	25	25	25
	Temp.2	Correlation Coefficient	.821**	1.000	.834**	.604**	.678**	.848**
		Sig. (1-tailed)	.000	.	.000	.000	.000	.000
		N	25	25	25	25	25	25
	Temp.3	Correlation Coefficient	.767**	.834**	1.000	.718**	.751**	.927**
		Sig. (1-tailed)	.000	.000	.	.000	.000	.000
		N	25	25	25	25	25	25
	Temp.4	Correlation Coefficient	.538**	.604**	.718**	1.000	.803**	.751**
		Sig. (1-tailed)	.000	.000	.000	.	.000	.000
		N	25	25	25	25	25	25
	Temp.5	Correlation Coefficient	.611**	.678**	.751**	.803**	1.000	.798**
		Sig. (1-tailed)	.000	.000	.000	.000	.	.000
		N	25	25	25	25	25	25
	Yield	Correlation Coefficient	.787**	.848**	.927**	.751**	.798**	1.000
		Sig. (1-tailed)	.000	.000	.000	.000	.000	.
		N	25	25	25	25	25	26
Spearman's rho	Temp.1	Correlation Coefficient	1.000	.937**	.900**	.649**	.739**	.907**
		Sig. (1-tailed)	.	.000	.000	.000	.000	.000
		N	25	25	25	25	25	25
	Temp.2	Correlation Coefficient	.937**	1.000	.951**	.776**	.844**	.961**
		Sig. (1-tailed)	.000	.	.000	.000	.000	.000
		N	25	25	25	25	25	25
	Temp.3	Correlation Coefficient	.900**	.951**	1.000	.869**	.906**	.987**
		Sig. (1-tailed)	.000	.000	.	.000	.000	.000
		N	25	25	25	25	25	25
	Temp.4	Correlation Coefficient	.649**	.776**	.869**	1.000	.942**	.892**
		Sig. (1-tailed)	.000	.000	.000	.	.000	.000
		N	25	25	25	25	25	25
	Temp.5	Correlation Coefficient	.739**	.844**	.906**	.942**	1.000	.931**
		Sig. (1-tailed)	.000	.000	.000	.000	.	.000
		N	25	25	25	25	25	25
	Yield	Correlation Coefficient	.907**	.961**	.987**	.892**	.931**	1.000
		Sig. (1-tailed)	.000	.000	.000	.000	.000	.
		N	25	25	25	25	25	26

5. DISCUSSION

This research was carried out carefully to ensure that the solar power meter (solarimeter) was placed vertically with the sensor pointing to the direction of the sun and the temperature where noted down. The difference in the intensities noted from this research work, were as a result of changes in cloud. In this research, the peak value of solar intensity was recorded on the 10th of February, 2017 which was the 5th day of the research work having a value of **1013.3w/m^2** and the same date has the peak temperature on the experiment to the 41.2˚C. The research of this experiment shows that increase in temperature, increases the sun intensity and vice versa. From the analysis, it was observed that the Sun radiation is highest from around 12 noon to 2 pm of the day time and lowest around 6AM to 7AM in the morning hours and around 6 PM in the evenings. The high intensity is as a result of high atmospheric temperature in the area. The correlations of the intensity and the temperature reveals that they are correlated to each other. The application of Kendall's tau_b and Spearman's rho correlations is to validate pearson correlations in other to ensure the validity of their correlations. The sun intensity for the period are all significance with less than 0.05 significance level while the temperature of the experimental period are all significance with less than 0.01 significance level. The probability plots show that the exponential probability plots are more significance than normal probability plots. The result shows the intensity of the sun light is high in afternoon and lower in the early hours of mornings and late hours of evenings. The average solar intensity of extension site in Federal Polytechnic Oko, is 356,644w/m^2.

6. CONCLUSION

The study explains the importance of sun intensity of Federal Polytechnic Oko, at the extension site using the solar power meter and the temperature of the day was also recorded with mercury -in -glass thermometers. Readings were tabulated and graph where plotted to show the high level of intensity at the extension site and its environment. This research work will be of great value for the researchers, importers and dealers of solar systems, manufacturers of solar systems and federal government documentation of sun intensity and climatic issues for periodic appraisal use of sun intensity and solar systems in the geographical area.

7. RECOMMENDATION

The research is also recommended for researcher, importers of solar system, manufacturers of solar system and federal government documentation of sun intensity and climatic issues in the geographical area. The Solarimeter instrument is also advised to be used for the documentation of the climatic influence and in optimization of solar intensities of Nigerian geopolitical zone. Periodic utilization of the solarimeter instrument will help to observe the effect of climatic conditions at every interval of the year. It will also help the government and individuals both private and companies for periodic appraisal use of sun intensity and solar systems.

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