Data Article

Exploration of solar radiation data from three geo-political zones in Nigeria

Adebawale O. Adejumo a, b, Esivue A. Suleiman a, Hilary I. Okagbue a, *

a Department of Mathematics, Covenant University, Ota, Nigeria
b Department of Statistics, University of Ilorin, Ilorin, Nigeria

A R T I C L E   I N F O

Article history:
Received 19 April 2017
Accepted 9 May 2017
Available online 17 May 2017

Keywords:
ANOVA
Solar radiation
Tukey’s Post Hoc
Port Harcourt
Sokoto
Ibadan

A B S T R A C T

In this paper, readings of solar radiation received at three meteorological sites in Nigeria were analysed. Analysis of Variance (ANOVA) statistical test was carried out on the data set to observe the significant differences on radiations for each quarter of the specified years. The data were obtained in raw form from Nigerian Meteorological Agency (NIMET), Oshodi, Lagos. In order to get a clear description and visualization of the fluctuations of the radiation data, each year were considered independently, where it was discovered that for the 3rd quarter of each year, there is a great fall in the intensity of the solar radiation to as low as 73.27 (W/m²), 101.66 (W/m²), 158.51 (W/m²) for Ibadan, Port-Harcourt and Sokoto respectively. A detailed data description is available for the averages across months for each quarter. The data can provide insights on the health implications of exposure to solar radiation and the effect of solar radiation on climate change, food production, rainfall and flood patterns.

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* Corresponding author.
E-mail address: hilary.okagbue@covenantuniversity.edu.ng (H.I. Okagbue).

http://dx.doi.org/10.1016/j.dib.2017.05.017
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**Specification Table**

| Subject area | Environmental Science |
|--------------|-----------------------|
| More specific subject area | Solar Radiation |
| Type of data | Table and figure |
| How data was acquired | Unprocessed secondary data |
| Data format | Processed as Monthly Averages Across Quarters from 2011 to 2015 for Three Meteorological Sites |
| Experimental factors | Data obtained from Nigerian Meteorological Agency (NIMET) |
| Experimental features | Computational Analysis: Analysis of Variance (ANOVA) with Post Hoc Test and Correlation Analysis. |
| Data source location | Ibadan, Port-Harcourt and Sokoto Meteorological Stations. |
| Data accessibility | All the data are in this data article. |
| Software | Microsoft Excel and Minitab 17 Statistical Software |

**Value of the data**

- The energy sector of the economy can incorporate the data set and findings for the utilization of solar radiation received from the sites.
- The vitality of these data set is widely recognised in the energy research community for forecasting minutely, hourly, daily and monthly solar radiations using time series tools which could also cater for volatility that exist in the data.
- For educational purposes and environmental studies. See similar works [1–33].
- Findings from the data bring the awareness of the Nigerian government to the most suitable location for the establishment of both solar plants and research institutes to generate electricity.
- The data can provide insights on the health implications of exposure to solar radiation.

1. **Data**

The raw data for this work were obtained from Nigerian Meteorological Agency (NIMET) Oshodi Lagos, as daily averages on solar radiation for three weather stations namely; Ibadan, Sokoto and Port-Harcourt. The readings were taken using the Gunn-Bellani Radiation Integrator measuring the radiations in millilitres (ml). However, for the sake of this research, the readings were converted to Watts per Sq. meters (1 ml to 13.153 W/m²) covering from 1st of January, 2011 to 31st of December, 2015 and further transformed into monthly-quarterly averages (Table 7) for the specified years using Microsoft Excel software.

| Variable | N    | Mean  | S.E Mean | Std. Dev. | Minimum | Q1    | Median | Q3    | Maximum |
|----------|------|-------|----------|-----------|---------|-------|--------|-------|---------|
| Ibadan   | 60   | 142.24| 3.84     | 29.76     | 73.27   | 115.07| 151.91| 166.75| 186.77  |
| Sokoto   | 60   | 235.01| 4.40     | 34.08     | 158.51  | 217.05| 237.96| 258.57| 308.72  |
| Port H   | 60   | 153.29| 3.85     | 101.66    | 129.08  | 156.36| 179.17| 231.96|         |
Table 1b
Summary for the quarterly average for the sites.

| Variable | Kurtosis | Skewness |
|----------|----------|----------|
| Ibadan   | −0.77    | −0.60    |
| Sokoto   | −0.02    | −0.45    |
| Port H   | −0.57    | −0.05    |

Fig. 1. Quarterly averages of solar radiation for the three sites in the year 2011.

Fig. 2. Quarterly averages of solar radiation for the three sites in the year 2012.

Fig. 3. Quarterly averages of solar radiation for the three sites in the year 2013.

Table 1a is the statistical summary of the quarterly averages for solar radiation from the 1st of January 2011 to 31st of December 2015. Meanwhile, it was observed that on an average, Sokoto receives the highest intensity of solar radiation followed by Port Harcourt and Ibadan.
Furthermore, Table 1b shows that the data set from all sites exhibit negative kurtosis and skew, implying that the distributions are light-tailed and skewed to the left respectively.

From the graphs (Figs. 1–5), it was observed that Sokoto was top on the presented charts with an exception on December 2015. This validates that the closer the earth’s surface is to the sun, the greater the radiations it receives, which is well applicable to the case of Sokoto ranking top among the other stations with a height of 309 m above sea level. Furthermore, the solar radiation received at Sokoto increases yearly within the 1st quarter. It has to be noted that the y-axis of the figures is the solar radiation reading for the zones measured in Watt per square meter.

2. Methods and materials

The summary of the location sites of the raw data are displayed in Table 2.

Linear correlation is traditionally used to roughly determine the relationship between two variables. Table 3 shows the correlation matrix between the three meteorological stations. Though independent, the correlations among each station are positive and that of Sokoto–Ibadan and Ibadan–Port Harcourt are highly positively correlated. It is either the solar radiation levels are increasing or decreasing at the three sites simultaneously.

The ANOVA test carried out on the data set for all sites and the result was displayed in Tables 4–6. The results showed significant differences in the means for solar radiation received quarterly at the stations independently.

The significant differences in the means as revealed from the ANOVA results led to further analysis using the Tukey’s Simultaneous 95% Confidence Interval Post Hoc test. The aim is to detect the specific quarters where differences lie across the specified years.

The results revealed that for Port Harcourt, significant differences lie within all other quarters except for the 1st and 4th quarters and for the 2nd and 4th quarters yearly as seen in Fig. 6. Similarly,
Table 2
Location of the sites.

| Sites       | Latitude | Longitude | Height (m) |
|-------------|----------|-----------|------------|
| Ibadan      | 07.22°   | 03.59'    | 224.01     |
| Sokoto      | 12.55°   | 05.12'    | 309.0      |
| Port Harcourt | 05.01° | 06.57'    | 247.0      |

Table 3
3×3 Correlation matrix for the sites.

| Sites       | Ibadan  | Sokoto  | Port Harcourt |
|-------------|---------|---------|---------------|
| Ibadan      | 1       | 0.741099| 0.755118      |
| Sokoto      | 0.741099| 1       | 0.426821562   |
| Port H      | 0.755118| 0.426821562| 1            |

Table 4
Analysis of Variance (ANOVA) for Port Harcourt.

| Source of variation | D.F | S.S  | M.S   | F-value | P-value |
|---------------------|-----|------|-------|---------|---------|
| Quarters            | 3   | 31672| 10557.3| 28.29   | 0.000   |
| Error               | 56  | 20898| 373.2 |         |         |
| Total               | 59  | 52570|       |         |         |

Table 5
Analysis of Variance (ANOVA) for Sokoto.

| Source of variation | D.F | S.S  | M.S   | F-value | P-value |
|---------------------|-----|------|-------|---------|---------|
| Quarters            | 3   | 29161| 9720.4| 13.83   | 0.000   |
| Error               | 56  | 39364| 702.9 |         |         |
| Total               | 59  | 68526|       |         |         |

Table 6
Analysis of Variance (ANOVA) for Ibadan.

| Source of variation | D.F | S.S  | M.S   | F-value | P-value |
|---------------------|-----|------|-------|---------|---------|
| Quarters            | 3   | 38059| 12686.3| 50.04   | 0.000   |
| Error               | 56  | 14197| 253.5 |         |         |
| Total               | 59  | 52256|       |         |         |
Fig. 6. Tukey’s Post Hoc test for mean-quarterly differences in Port Harcourt site from 2011 to 2015.

Fig. 7. Tukey’s Post Hoc test for mean-quarterly differences in Sokoto site from 2011 to 2015.

Fig. 8. Tukey’s Post Hoc test for mean-quarterly differences in Ibadan site from 2011 to 2015.
Table 7
Monthly-quarterly solar radiation for three sites from 2011 to 2015.

| Year | Month | Quarter | Ibadan   | Sokoto   | Port Harcourt |
|------|-------|---------|----------|----------|---------------|
| 2011 | Jan   | Q1      | 152.9544 | 216.6395 | 195.3404      |
| 2011 | Feb   | Q1      | 167.1816 | 221.9066 | 173.1943      |
| 2011 | Mar   | Q1      | 179.9389 | 244.9392 | 180.448       |
| 2011 | Apr   | Q2      | 162.218  | 242.0993 | 182.9117      |
| 2011 | May   | Q2      | 154.397  | 232.1683 | 160.7612      |
| 2011 | Jun   | Q2      | 126.53   | 189.8827 | 131.3527      |
| 2011 | Jul   | Q3      | 90.88166 | 168.1862 | 121.4725      |
| 2011 | Aug   | Q3      | 91.89994 | 163.3494 | 114.3021      |
| 2011 | Sep   | Q3      | 112.588  | 218.2928 | 134.7724      |
| 2011 | Oct   | Q4      | 141.0745 | 231.2348 | 141.5836      |
| 2011 | Nov   | Q4      | 166.8653 | 259.2857 | 155.8608      |
| 2011 | Dec   | Q4      | 186.7699 | 220.9247 | 188.9337      |
| 2012 | Jan   | Q1      | 153.8454 | 233.9503 | 169.7561      |
| 2012 | Feb   | Q1      | 149.9874 | 236.8866 | 148.0371      |
| 2012 | Mar   | Q1      | 171.4956 | 255.0796 | 157.5473      |
| 2012 | Apr   | Q2      | 168.6628 | 254.1561 | 155.8032      |
| 2012 | May   | Q2      | 140.2483 | 228.6467 | 173.9798      |
| 2012 | Jun   | Q2      | 106.2308 | 198.5635 | 155.5539      |
| 2012 | Jul   | Q3      | 98.30663 | 170.3925 | 123.297       |
| 2012 | Aug   | Q3      | 84.72954 | 163.9434 | 132.4191      |
| 2012 | Sep   | Q3      | 102.2412 | 237.7151 | 139.4198      |
| 2012 | Oct   | Q4      | 148.6692 | 225.507  | 169.9258      |
| 2012 | Nov   | Q4      | 149.4159 | 235.8298 | 164.1032      |
| 2012 | Dec   | Q4      | 156.1366 | 252.3218 | 183.3756      |
| 2013 | Jan   | Q1      | 143.9172 | 241.5025 | 190.2914      |
| 2013 | Feb   | Q1      | 152.4786 | 263.7138 | 182.1664      |
| 2013 | Mar   | Q1      | 170.1379 | 274.2572 | 190.2914      |
| 2013 | Apr   | Q2      | 153.0987 | 246.2206 | 190.1896      |
| 2013 | May   | Q2      | 152.318  | 266.2807 | 155.0758      |
| 2013 | Jun   | Q2      | 122.4965 | 238.1973 | 118.5945      |
| 2013 | Jul   | Q3      | 90.37251 | 204.8868 | 104.1193      |
| 2013 | Aug   | Q3      | 91.51808 | 158.5125 | 104.4163      |
| 2013 | Sep   | Q3      | 123.5487 | 220.8356 | 103.7318      |
| 2013 | Oct   | Q4      | 147.5236 | 196.0405 | 160.1248      |
| 2013 | Nov   | Q4      | 159.2367 | 215.5635 | 140.6912      |
| 2013 | Dec   | Q4      | 161.1007 | 241.7517 | 180.2359      |
| 2014 | Jan   | Q1      | 151.5119 | 260.3407 | 187.0669      |
| 2014 | Feb   | Q1      | 165.4435 | 265.0291 | 185.4546      |
| 2014 | Mar   | Q1      | 161.6947 | 283.3369 | 149.3904      |
| 2014 | Apr   | Q2      | 177.256  | 273.8853 | 173.354       |
| 2014 | May   | Q2      | 166.4042 | 245.7454 | 155.1183      |
| 2014 | Jun   | Q2      | 135.6931 | 251.1309 | 121.3127      |
| 2014 | Jul   | Q3      | 99.66434 | 213.1179 | 105.4346      |
| 2014 | Aug   | Q3      | 73.27386 | 168.3135 | 109.7623      |
| 2014 | Sep   | Q3      | 109.8259 | 233.287  | 103.2934      |
| 2014 | Oct   | Q4      | 136.8316 | 265.9048 | 159.7854      |
| 2014 | Nov   | Q4      | 153.5371 | 289.4944 | 132.2734      |
| 2014 | Dec   | Q4      | 170.6895 | 273.8075 | 168.4408      |
| 2015 | Jan   | Q1      | 179.5146 | 253.1279 | 188.5943      |
| 2015 | Feb   | Q1      | 179.7237 | 308.7152 | 166.6179      |
| 2015 | Mar   | Q1      | 175.399  | 268.7174 | 169.0348      |
| 2015 | Apr   | Q2      | 177.212  | 293.1761 | 157.4829      |
| 2015 | May   | Q2      | 178.2418 | 274.8512 | 145.487       |
| 2015 | Jun   | Q2      | 131.3527 | 256.4359 | 124.2063      |
| 2015 | Jul   | Q3      | 106.962  | 227.5436 | 101.6585      |
| 2015 | Aug   | Q3      | 105.1376 | 201.4077 | 112.5626      |
| 2015 | Sep   | Q3      | 110.3959 | 218.6873 | 128.3276      |
| 2015 | Oct   | Q4      | 132.8434 | 244.4301 | 156.8578      |
| 2015 | Nov   | Q4      | 152.7041 | 250.2541 | 187.9975      |
| 2015 | Dec   | Q4      | 172.3018 | 209.2145 | 231.9561      |
Fig. 7 shows that for Sokoto, the 1st and 3rd quarters, 3rd and 4th quarters and the 2nd and 3rd quarters as having significant differences. Lastly, Fig. 8 shows that for Ibadan, significance differences exists between the 1st and 3rd Quarters, 2nd and 3rd Quarters and the 3rd and 4th Quarters for these years. Minitab17 software was implemented for analysis on the solar radiation data, which produced the ANOVA results and the Post Hoc test for the stations (Table 7).

Acknowledgement

This work is sponsored by Centre for Research, Innovation and Discovery, Covenant University, Ota, Nigeria.

Transparency document. Supplementary material

Transparency data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.dib.2017.05.017.

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