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Comparison of the variation of solar radiation and atmospheric parameters in Kano before, during and after covid-19 lockdown

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Abstract

This study compared the variation of solar radiation and atmospheric parameters in Kano, Nigeria before, during, and after the COVID-19 (2019, 2020, and 2021) lockdown. Data was obtained from the Nigeria Meteorological Center (NIMET) in Abuja and MINITAB's time series method and procedures were used to analyze the data. Results showed that Kano witnessed an increased amount of solar radiation during COVID-19 (2020) when compared with the values of solar radiation distribution observed before and after COVID-19 (2019 and 2021). Atmospheric ozone increased slightly in Kano during the period of COVID-19 when compared with the periods before and after COVID-19 in the same area. Relative humidity variations were observed to be lower before and during COVID-19 when compared with the values after COVID-19, whereas temperature and pressure variation distributions were maintained approximately within the same range in the years of study (2019, 2020, and 2021). These findings provide an insight into the effects of the COVID-19 lockdown on solar radiation and atmospheric parameters in Kano.

Keywords: Solar radiation; Atmospheric parameters; COVID –19; Lockdown

1. Introduction

On the Earth's environment, atmospheric interactions play a vital role in sustaining life and property. This vital role may include the complex interactions between atmospheric parameters and other parameters such as solar radiation that are essential for the continuity of life. Solar radiation, also known as insolation, is the electromagnetic radiation emitted by the sun and is composed of radiation that comes directly from the sun's disc. Solar radiation is of economic importance as a renewable energy alternative, and its amount reaching the Earth's surface depends significantly on the concentration of airborne particulate matter, gaseous pollutants, and water in the sky. Globally, solar radiation is divided into two categories: direct and diffuse solar radiation. Diffuse solar radiation is the type that results from scattering caused by gases in the Earth's atmosphere. The amount of solar radiation reaching the surface of the Earth depends significantly on the concentration of airborne particulate matter, gaseous pollutants, and water in the sky, which can further attenuate the solar energy and change the diffuse and direct radiation ratio [1]

Solar radiation is essential for life, transferring energy to plants and forming the basis of food webs. Organisms have evolved thermoregulatory behaviors and responses to concentrated periods of solar radiation as well as to changes in ambient temperature, which is also affected by solar intensity. Behavioral responses to solar radiation and other environmental variables can be paired with changes in skin surface blood circulation [2]. Atmospheric parameters play

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an important role in the radiative balance of the atmosphere. Atmospheric aerosols, for instance, serve a prime role in the Earth's radiative budget [3].

Generally, aerosols can be defined as suspended solid or liquid particles in the air, including smoke, mineral dust, sea salt, pollen, etc. Aerosols also act as condensation nuclei for cloud droplets and enhance cloud formation. Aerosol particles can modify ozone removal in the upper atmosphere. Additionally, aerosols can weaken the turbulent properties of the atmosphere, which hampers major planetary boundary layer processes and the atmospheric pollutant dispersion ability [4]. The availability of high quality in situ solar radiation data is critical for the development of solar generation in the country. As solar radiation and the presence of atmospheric aerosols have a strong relationship, this study attempts to analyze these features during the time of lockdown in Nigeria and the overall change in radiation characteristics in the vicinity of lockdown [5].

Solar radiation emitted from the sun reaches every corner of space in the form of electromagnetic waves that carry energy at the speed of light. Depending on the geographical location of the Earth and the composition of the atmosphere, the incoming irradiation at any given point appears in different shapes in terms of solar spectra. The solar irradiation energy first interacts with the atmosphere and then reaches the Earth's surface. The atmosphere absorbs approximately two thirds of the incoming irradiation due to water vapor and a lesser degree due to CO^2 that exists in the atmospheric composition. Incoming solar irradiance is shared by cloud and surface reflections, with the rest being finally absorbed by the Earth's surface. This is the final portion of the solar spectrum that can be used as a resource by photovoltaic panels to generate electricity. COVID-19 incidence in Nigeria was first recorded on February 27th, 2020 in Lagos through an Italian man who came into the country. From there, the virus spread to different parts of the country. According to [6], Lagos State and Federal Capital Territory (FCT) respectively in the southern and northern parts of Nigeria were ranked first and second with the highest incidence of COVID-19 pandemic and were regarded as the epicenter for the disease. As of February 28th, 2022, Nigeria has reported a total of 254,525 cumulative cases and 3,142 deaths from COVID-19 [6].

COVID-19 was declared a pandemic in the year 2020 by the World Health organization (WHO). The COVID-19 pandemic spread across the world, creating havoc in countries that have fallen victim to it. To minimize the spread of the disease, most countries, including Nigeria, mandated preventive measures. Lockdown caused the shutdown of industrial activities except for essential services, different travel modes, and a decline in greenhouse gas emissions and air pollution all over the world. The lockdown had an adverse effect on humans' comfortable lives, but it also gifted a low-carbon environment for humanity. Some have shown the decline in pollution levels over Nigeria during the lockdown period [7]. Therefore, this work is aimed at exploring the interactions between atmospheric parameters and solar radiation, comparing the variation of solar radiation and atmospheric parameters in Ikeja Lagos before, during, and after the COVID-19 period (2019, 2020, and 2021).

1.1. Study area

This study was conducted in Kano State, Nigeria. Kano is also large city and the capital of the same Northern Province, which is located in the northern part of Nigeria. Kano is at Latitude of 12.0 degree North and Longitude 8.5 degree east.

1.2. Data acquisition

Data from the Nigeria Meteorological (NIMET) Center in Abuja was used for this work, covering a period of three years from 2019 to 2021.

1.3. Data Computation and Analysis

The datasets comprising atmospheric parameters and solar radiations obtained from NIMET were computed and analyzed using MINITAB and Excel packages. During the process, MINITAB's time series procedures were used to compute and analyze data collected over time, commonly referred to as a time series, by examining the linear trend of the data changes over the years of study. Trend analysis uses the linear trend model by default, which is represented as:

$$y_1 = \beta_0 + \beta_1 t + et \quad \text{..........} 1$$

Where, β_1 represents the average change from one period to the next.

2. Results

The daily variation of temperature, relative humidity, atmospheric ozone, pressure, and solar radiation before, during, and after the COVID-19 lockdown is displayed in Figures 1-15.

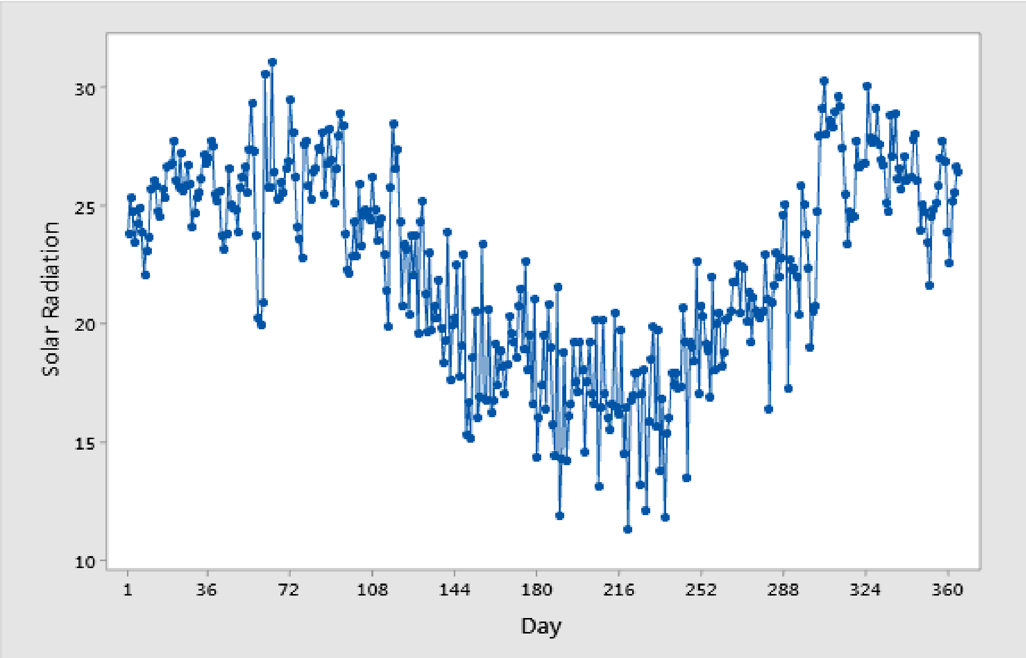

Figure 1 Variation of solar radiation before COVID-19 (2019) at Kano

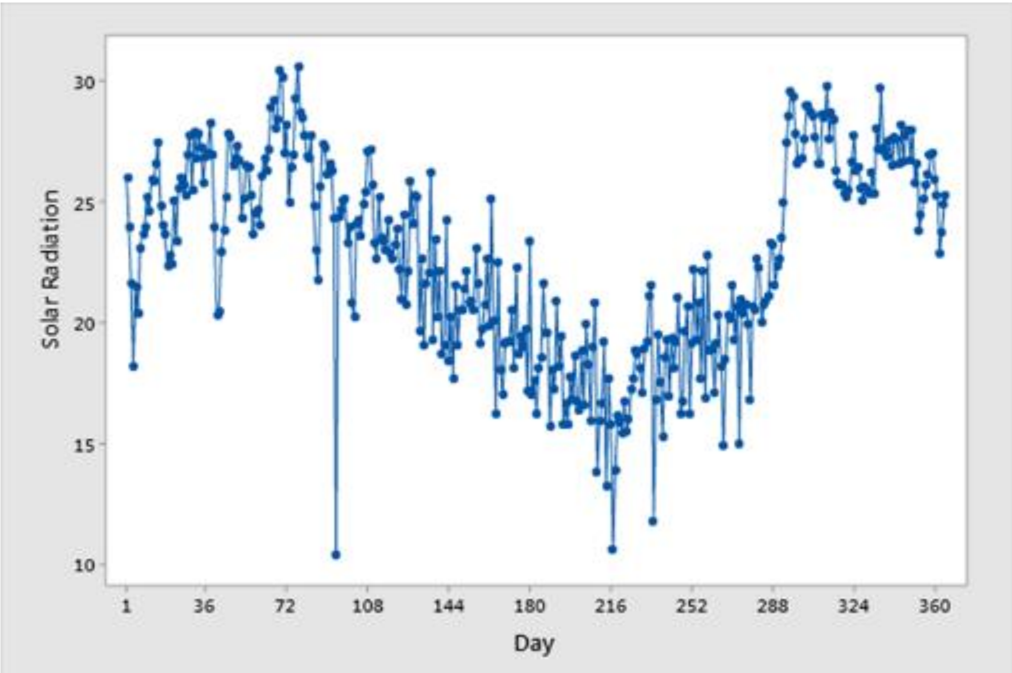

Figure 2 Variation of solar radiation during COVID-19 (2020) at Kano

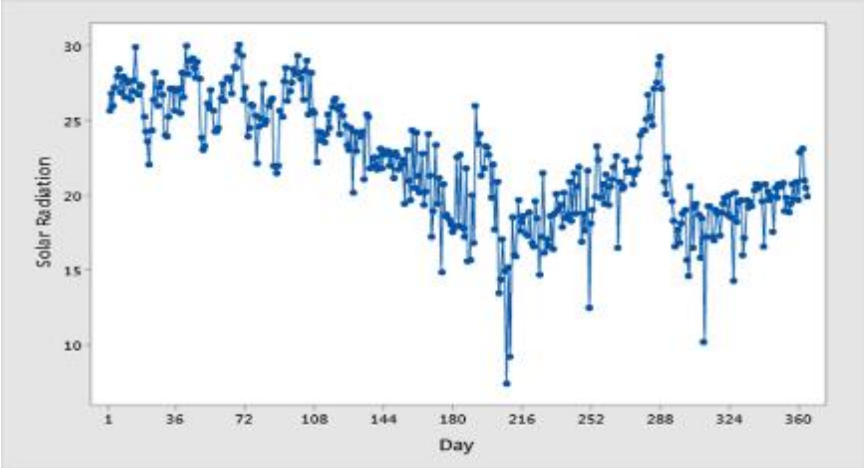

Figure 3 Variation on of solar radiation after COVID-19 (2021) at Kano

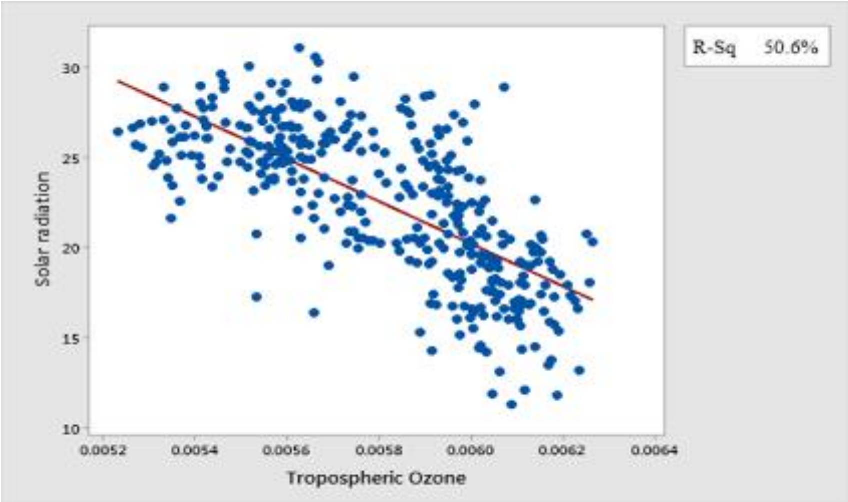

Figure 4 Solar Radiation against Tropospheric Ozone in Kano 2019

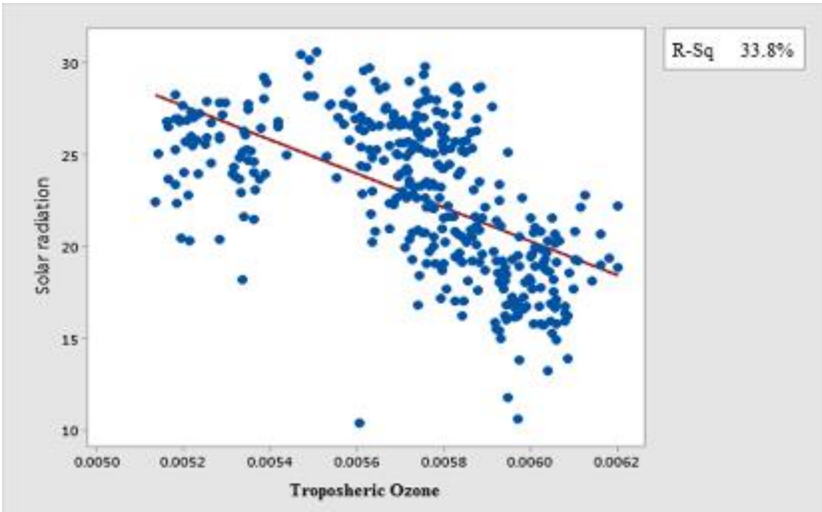

Figure 5 Solar Radiation against Tropospheric Ozone in Kano 2020

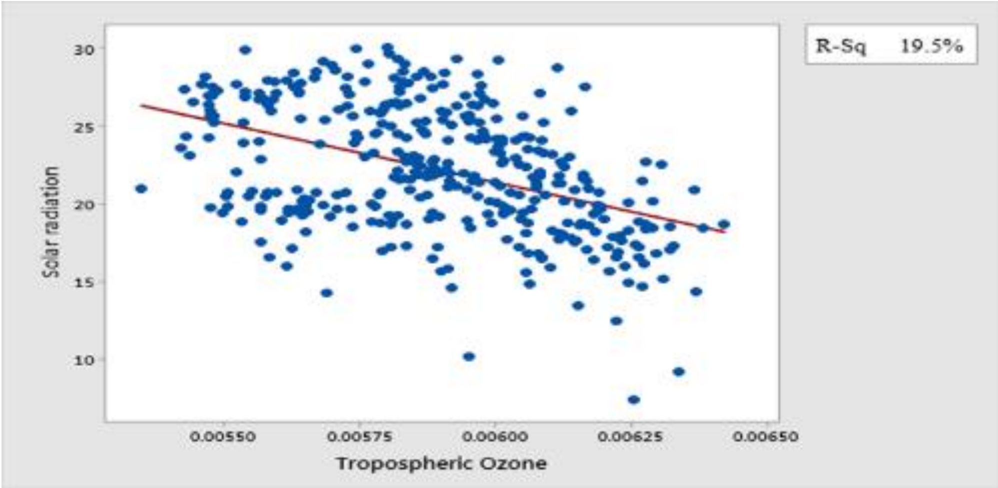

Figure 6 Solar Radiation against Troospheric Ozone in Kano 2021

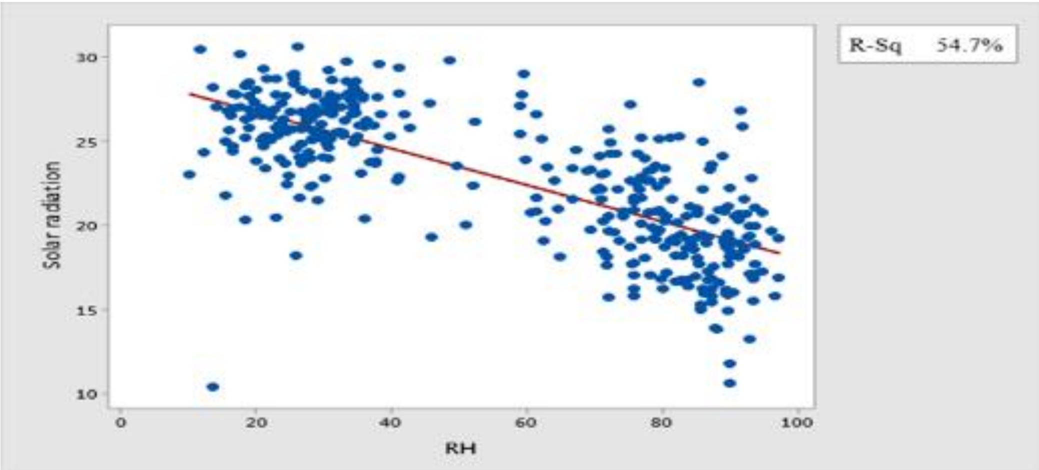

Figure 7 Solar Radiation against Relative Humidity in Kano 2019

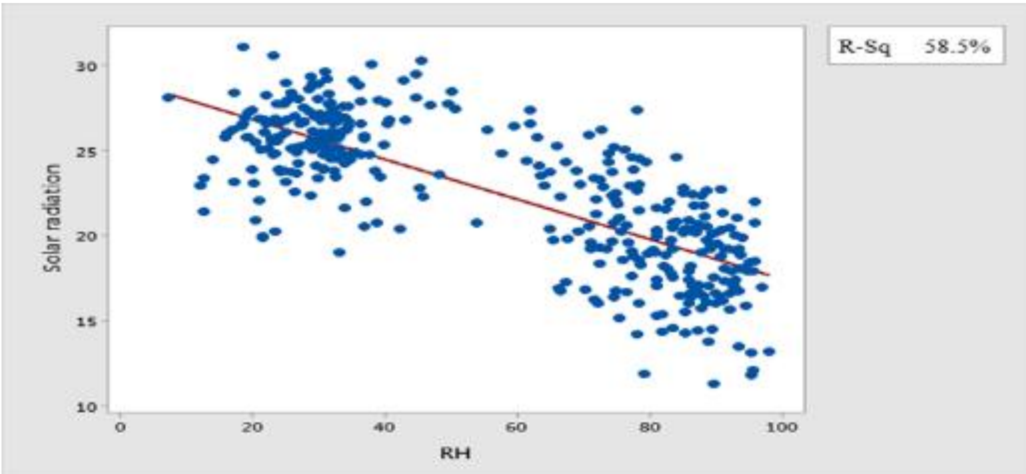

Figure 8 Solar Radiation against Relative Humidity in Kano 2020

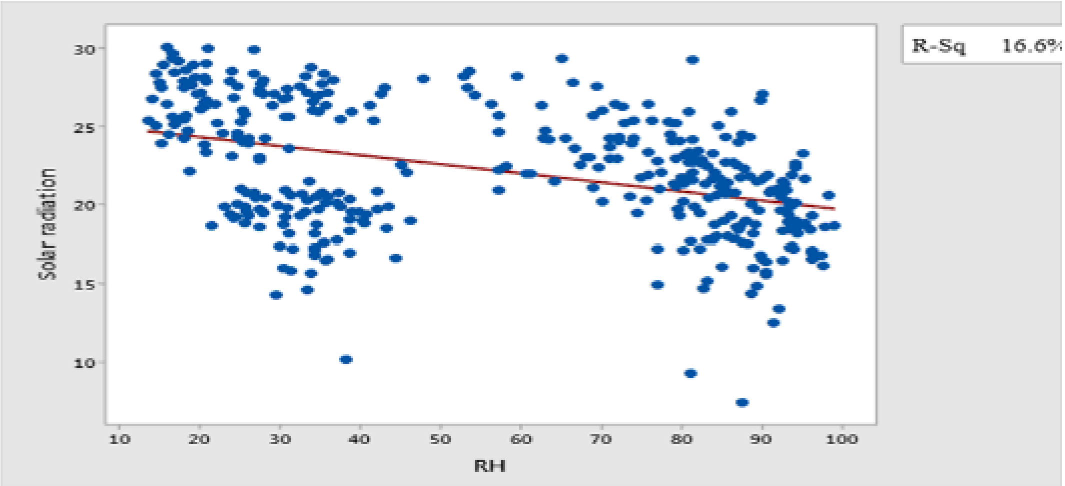

Figure 9 Solar Radiation against Relative Humidity in Kano 2021

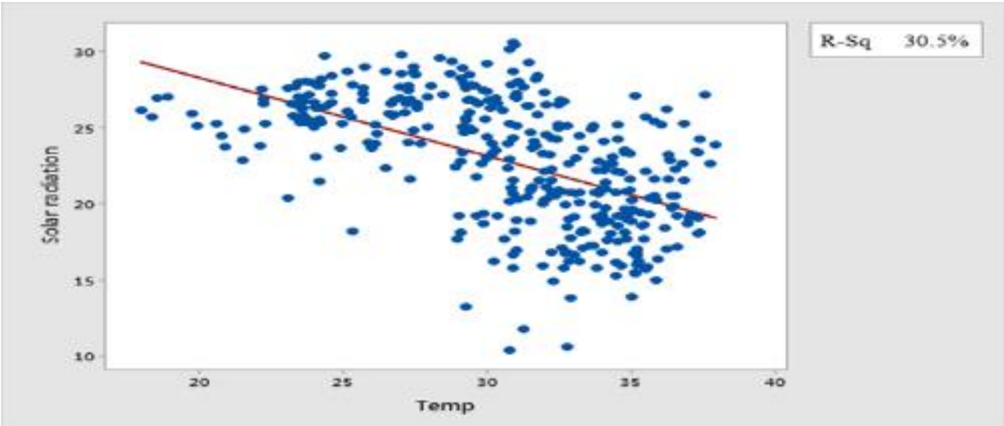

Figure 10 Solar Radiation against Temperature in Kano 2019

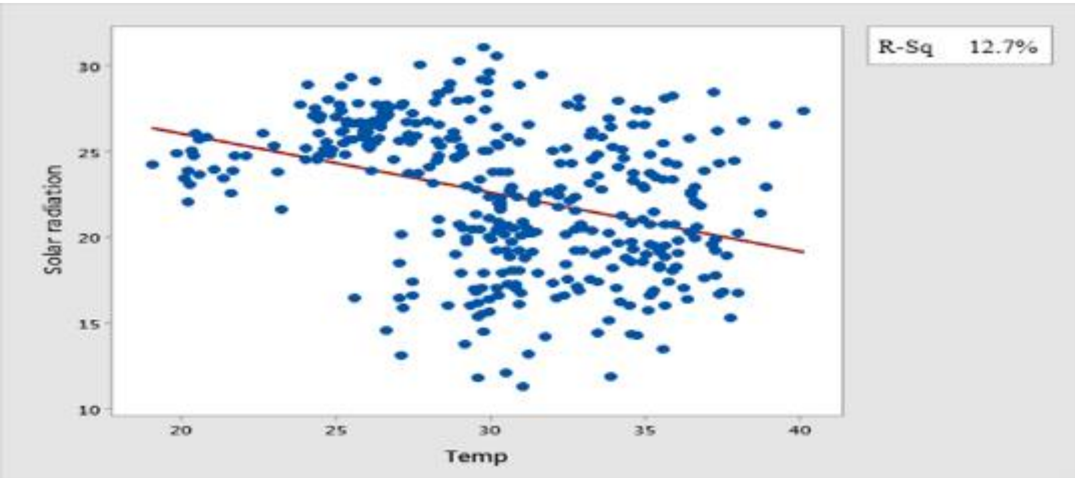

Figure 11 Solar Radiation against Temperature in Kano 2020

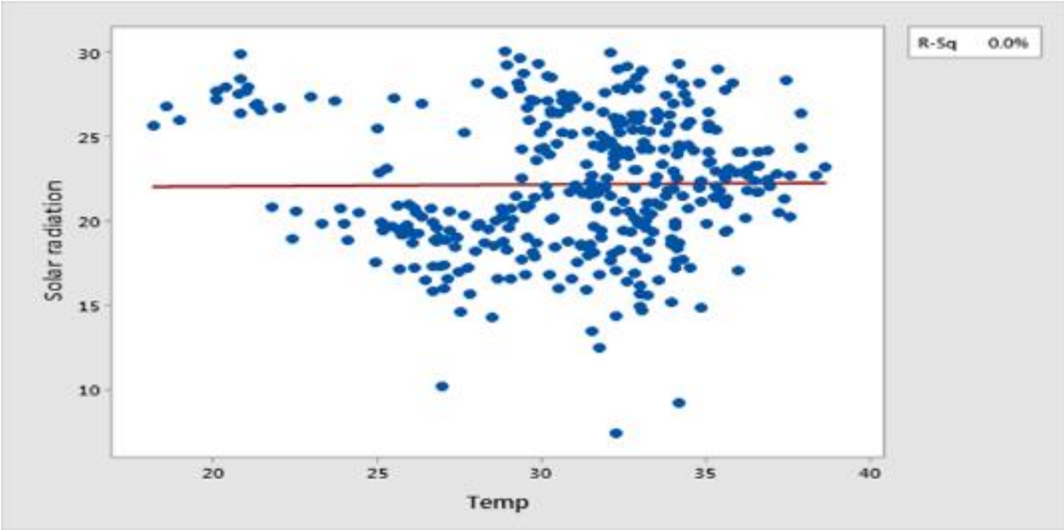

Figure 12 Solar Radiation against Temperature in Kano 2021

3. Discussion

From Figures 1, 2, and 3, which represent the variation of solar radiation before, during, and after COVID-19 in Kano, it was observed that there were concurrent fluctuations in the amount of solar radiation within the location for the period of study. A close examination of the figures showed that solar radiation amount increased rapidly during the period of COVID-19 (Figure 2). The periods before and after COVID-19 (Figures 1 and 3) showed a more gradual increase in solar radiation amount, with the peak amount of about 25.5 W/m^2 and 27 W/m^2 occurring at day 15 and 36, respectively. The figures also showed that the amount of solar radiation decreased gradually from day 1 to day 144 and from day 252 to day 300. Overall, the figures showed that the amount of solar radiation in Kano increased significantly during the period of COVID-19. This could be attributed to the reduced human activities and air pollution during the pandemic, which allowed more sunlight to reach the surface of the earth and also variations in the lenth of daylight and angle of the sun

The results suggest that there were changes in the amount of solar radiation witnessed in Kano before, during, and after the COVID-19 pandemic. During the pandemic, solar radiation fluctuations were relatively reduced, mostly within the range of 20W/m2 – 33 W/m^2, with a peak amount of 35 W/m^2 noticed at day 360 for year 2019 and 39 W/m^2 for day 360 in 2021. This may be attributed to the environmental imbalance within the location due to isolation and reduction of human activities due to the fear of the pandemic, which may have allowed solar radiation from the solar system to fall on the Earth's environment without much interference, thus reducing the amount recorded for that period.

Figures 4, 5, and 6 represent the variation of atmospheric ozone before, during, and after COVID-19 in Kano, Nigeria. Figure 5 shows that tropospheric ozone increased slightly during the pandemic. However, it increased before the pandemic for the year 2019 and after decreased in the year 2021 in the same location. This suggests that the geographical location of the region makes it more prone to higher levels of gases and solar radiation, which causes an increase in temperature. Elevated levels of troposphere ozone can lead to reduced agricultural crop and commercial forest yields, thereby reducing the growth and survivability of tree seedlings and increasing susceptibility to diseases, pests, and other stresses such as harsh weather. This analysis of Figures 4, 5, and 6 indicated that there were relatively lower values of atmospheric ozone witnessed in the early and later parts of the year (days 1-107 and 262-365) which coincided with the dry season in the area, compared to the middle of the year (days 108-261) which coincided with the rainy season in the area, before, during, and after COVID-19 in Kano for the period of study. This scenario may be due to the reaction of carbon dioxide and other gases emitted from various sources, such as vehicles, factories, and power plants, with the ozone layer in the atmosphere.

From Figures 7, 8, and 9 it was found that the distribution of relative humidity values in Kano, Nigeria, experienced less fluctuation before the COVID-19 pandemic and during the COVID-19 pandemic it was high when compared to the more vigorous and noticeable fluctuations during the period of the study after the pandemic. This may be due to the presence of water bodies surrounding the region, as well as the wet and cloudy atmosphere. Sharp decreases in relative humidity were noticed in some days at the beginning and end of the years before, during, and after the COVID-19 pandemic (i.e.

2019, 2020, and 2021). This may be attributed to the increase in relative humidity, which causes air to retain more water molecules, thus reducing the relative humidity of the region.

Figure 10, 11, and 12, representing the variation of temperature before, during, and after COVID-19 in Kano indicated that the values of temperature variation distributions were maintained within the same range in the years 2019, 2020, and 2021, which are the periods before, during, and after COVID-19, even though their distribution patterns differed. However, higher values of temperature were observed during the middle of the year than the beginning and the ending of the year in all the years studied, suggesting that the amount of moisture and solar radiation intensity in the atmosphere play a role in the temperature variation. This is because more moisture and solar radiation intensity are required to make hotter or warmer air saturated than colder air.

4. Conclusion

This research has shown that the COVID-19 pandemic had an impact on solar radiation and some atmospheric parameters in Kano. Solar radiation values changed more during the lockdown period than before and after, while ozone levels displayed a slight increase. Relative humidity was lower before and during the lockdown in the year 2020 it was high, while temperature variations were maintained within the same range in the year 2019 and 2020 but insignificant in the year 2021 of study. This indicates that the COVID-19 lockdown had an effect on the solar radiation and atmospheric parameters in Kano.

Compliance with ethical standards

Acknowledgment

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Disclosure of conflict of interest

The authors declare no conflict of interest.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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