Effect of Carbon (IV) Oxide on Solar Radiation over Umuahia

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ABSTRACT

The interplay between greenhouse gases, particularly carbon (IV) oxide (CO_2) and the Earth's climate system is a subject of growing concern and extensive scientific investigation. This study explores the intricate relationship between CO_2 concentrations and solar radiation, a fundamental driver of climate and weather patterns, by analyzing solar radiation and CO_2 data from Nigeria Meteorological Agency, and examining climate feedback mechanisms, this research sheds light on the multifaceted effects of CO_2 on solar radiation using Minitab software.

The trend for solar radiation Yt=173.85 – 0.0125 * t shows that solar radiation has been on the decrease over time. Specifically, for each unit increase in time (t), the solar radiation is expected to decrease by 0.0125 units. The initial value of solar radiation at time t=0 is estimated to be 173.85 units, and the CO_2 concentration is increasing over time Yt= 399.228 + 0.20222 * t. This means that for each unit increase in time (t), the CO_2 concentration is expected to increase by 0.20222 units. The correlation coefficient between carbon (IV) oxide (CO_2) levels and solar radiation is 0.132.This indicates a positive but weak correlation between the two variables which indicates that as CO_2 levels increase, solar radiation tends to increase slightly, but the correlation is not very strong.

(Keywords: greenhouse gases, solar radiation, carbon (IV) oxide, carbon dioxide, correlation, minitab)

INTRODUCTION

Human activities have significantly increased the concentrations of certain greenhouse gases in the atmosphere. The increased emissions of CO_2 from burning fossil fuels, for example, have led to an enhanced greenhouse effect, causing more heat to be trapped and resulting in global warming and climate change (IPCC, 2013). The impact of greenhouse gases, particularly carbon dioxide (CO_2), on Earth's climate has been a subject of extensive research. One aspect of this research involves examining how increasing levels of CO_2 affect solar radiation, which plays a crucial role in Earth's climate system.

The Earth's climate system is a complex web of interactions, driven by various natural and anthropogenic factors. In recent decades, the role of greenhouse gases, notably carbon dioxide (CO_2), in shaping the planet's climate has garnered significant attention. The steady rise in atmospheric CO_2 concentrations, primarily attributed to human activities such as the burning of fossil fuels and deforestation, has become a defining challenge of our era (Ohunakin, *et al.,* 2015). This increase in CO_2 levels contributes to the well-documented greenhouse effect, where certain gases trap heat in the Earth's atmosphere, resulting in global warming (Solomon, *et al*., 2009).

While the consequences of elevated CO_2 levels on global temperature and sea-level rise have been extensively explored, there remains a crucial dimension of this issue that demands further examination: the effects of CO_2 on solar radiation. Solar radiation, in the form of sunlight, is the primary energy source for our planet. It drives various climatic processes, such as temperature regulation, evaporation, and cloud formation, which, in turn, shape global weather patterns and long-term climate trends.

Several studies have examined temperature trends and variability in Nigeria, providing valuable insights into the broader climate patterns that impact Umuahia. Temperature data from multiple locations in Nigeria, including Umuahia, was found to be on the increasing trend in annual average temperature (Ezere, *et al.,* 2023). Adeyeri, *et al*. (2020) also reported rising temperature trends in Nigeria, noting that warming was more pronounced in the northern part of the country. The urbanization and expansion of Umuahia could contribute to the phenomenon known as the urban heat island effect, where urban areas experience higher temperatures compared to surrounding rural areas. Umuahia experience higher nighttime temperatures in urban areas compared to rural locations.

Climate modeling studies have been conducted to understand the drivers and future projections of warming in Nigeria. Umuahia is projected to experience significant warming in the coming decades, with higher temperature increases during the dry season (Ojo, *et al.,* 2019).

Several studies have investigated the potential drivers and influences of warming in Umuahia and its surrounding region. Adejuwon, *et al.* (2018) examined the role of various climate drivers, including rainfall, humidity, and solar radiation, in shaping temperature patterns in Nigeria. Their study highlighted the complex interactions between these factors and their contributions to regional warming.

Understanding the intricate relationship between CO_2 and solar radiation is fundamental to a comprehensive grasp of climate change dynamics. This relationship is not only complex but also highly dynamic, involving the absorption, scattering, and modification of solar radiation as it passes through the Earth's atmosphere. While scientific consensus affirms the overarching role of CO_2 as a greenhouse gas, its specific influence on solar radiation remains an area of ongoing research and inquiry.

The escalating levels of carbon (iv) oxide (CO_2) in the Earth's atmosphere, primarily driven by human activities, have raised significant concerns regarding their impact on the efficiency and availability of solar radiation. Solar radiation is a vital energy source for various applications, including solar power generation, agriculture, and climate regulation. This project aims to investigate the relationship between increasing CO_2 levels and alterations in the solar radiation patterns.

This work studies the effect of greenhouse gas (CO_2) on solar radiation in Umuahia, Abia State. To know how the CO_2 concentration correlates with solar radiation, also, to examine the trend of carbon (IV) oxide and solar radiation.

Area of Study

Umuahia is the specific area of study for investigating the effect of greenhouse gases (CO_2) on solar radiation. Umuahia is the capital city of Abia State, located in southeastern Nigeria. It lies within the tropical monsoon climate zone, characterized by distinct wet and dry seasons. The city experiences high temperatures throughout the year, with average monthly temperatures ranging from 25 to 30 degrees Celsius.

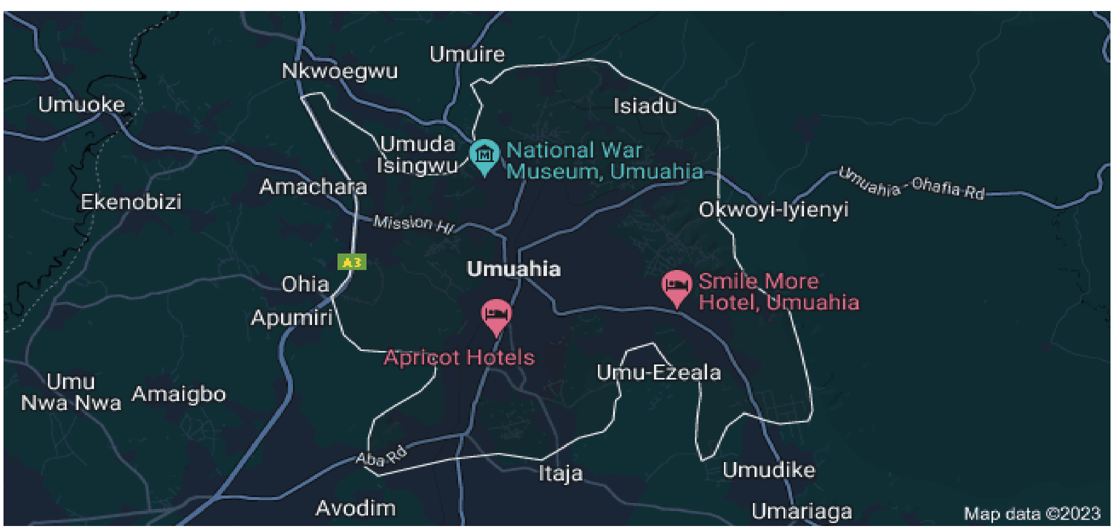

Figure 1: Map of Study Area Umuahia, Abia State.

MATERIALS AND METHOD

The greenhouse gas (CO_2) data and solar radiation data used in this work were gotten from Nigerian Meteorological Agency (NiMet) from 2015 to 2022. The data of meteorological parameter (solar radiation) and concentrations of carbon dioxide (CO_2) were organized using Microsoft Excel. Time series of monthly and seasonal variability of the concentrations of CO_2 and solar radiation were plotted using Minitab software.

Regression analyses between concentrations of CO_2 and solar radiation were also determined by using Minitab software which is a data analysis software package that is used for data analysis, Minitab provides various graphical tools to help users visualize data.

In the trend analysis, the least square method is used for the estimation of the trend equation. The least square equation is defined as follows:

$$Yt = \hat{a} + \hat{b}t \qquad \textbf{(1)}$$

Where $\hat{\ } = (n\Sigma ty - \Sigma t\Sigma y\ ) \,/\, (n\Sigma t^2 - (\Sigma t^2)$ **(2)**

and,

$$\hat{a} = \bar{y} - b\bar{t} \qquad \textbf{(3)}$$

Thus, Yt is the estimated trend value for a given time period (dependent variable),

a = the intercept that is the trend line when t=0

b = the slope of the trend line, that is, change in Yt per unit of time (coefficient of independent variable, time)

t = the time unit (independent variable)

RESULTS AND DISCUSSIONS

The results of the relationship between the greenhouse gas, carbon dioxide (CO_2) and solar radiation were determined using programming language written with MINITAB codes to determine the trend analysis, the correlation and regression.

Table 1: Trend Analysis for Carbon (iv) Oxide.

Method	
Model type	Linear Trend Model
Data	Carbon(iv)oxide
Length	86
NMissing	0

Fitted Trend Equation:

Yt = 399.228 + 0.20222×t

Fitted Trend Equation

The fitted trend equation is used to describe the trend observed in the data. In this case, it is a linear equation:

Yt = 399.228 + 0.20222×t

Yt represents the estimated CO_2 concentration at time t.

The equation suggests that the CO_2 concentration is increasing over time, with an intercept (starting value) of approximately 399.228 and a slope of 0.20222. This means that for each unit increase in time (t), the CO_2 concentration is expected to increase by 0.20222 units.

This analysis suggests that there is a linear trend in the carbon dioxide (CO_2) concentration data, with CO_2 levels increasing over time. The fitted trend equation and accuracy measures provide quantitative information about the trend and the model's performance in capturing it. The accuracy measures indicate that the model has some degree of error in predicting CO_2 concentrations, and further analysis or model refinement may be necessary to improve its accuracy if needed.

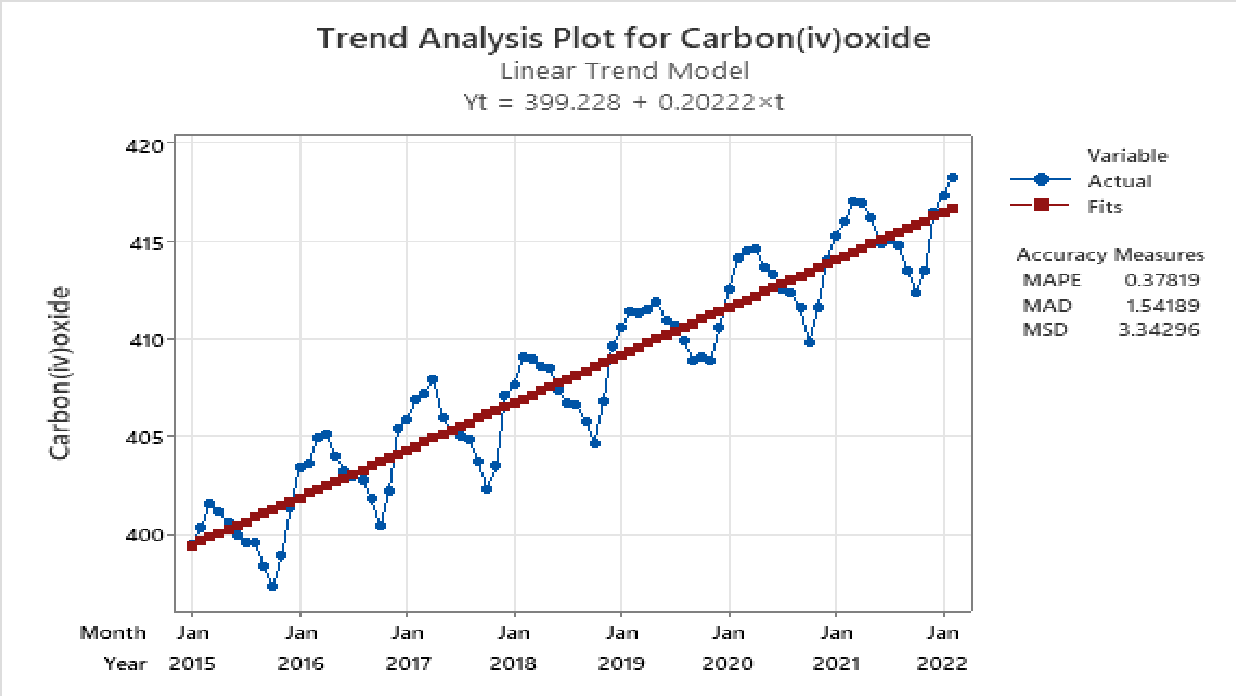

Figure 2: Trend Analysis Plot for Carbon Dioxide from 2015 to 2022.

Trend Analysis for Solar Radiation

Table 2: Trend Analysis for Solar Radiation

Method	
Model type	Linear Trend Model
Data	Solar Radiation
Length	86
NMissing	0

Fitted Trend Equation:

$$Yt = 173.85 - 0.0125 \times t$$

The fitted trend equation is used to describe the trend observed in the data. In this case, it is a linear equation:

$$Yt = 173.85 - 0.0125 \times t$$

Yt represents the estimated solar radiation at time t.

The equation suggests that the solar radiation is decreasing over time. Specifically, for each unit increase in time (t), the solar radiation is expected to decrease by 0.0125 units. The initial value of solar radiation at time t=0 is estimated to be 173.85 units.

This analysis suggests that there is a linear trend in solar radiation data, with solar radiation decreasing over time. The fitted trend equation and accuracy measures provide quantitative information about the trend and the model's performance in capturing it. The accuracy measures indicate that the model has some degree of error in predicting solar radiation values, and further analysis or model refinement may be necessary to improve its accuracy if needed.

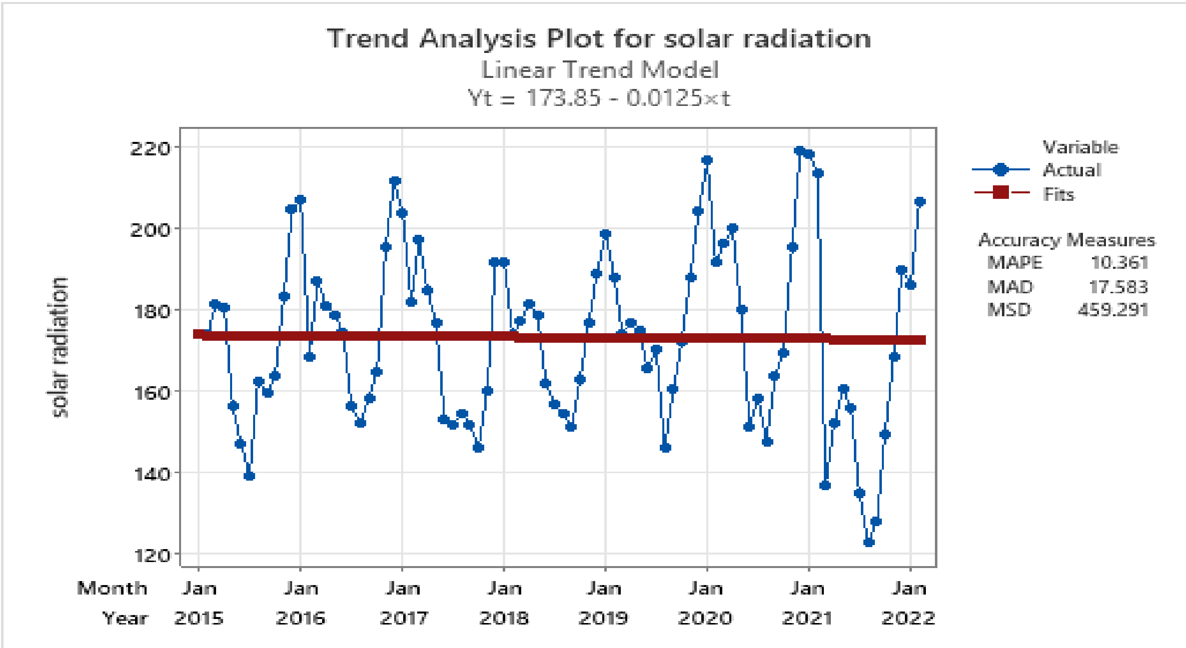

Figure 3: Trend Analysis Plot for Solar Radiation from 2015 to 2022.

Correlation

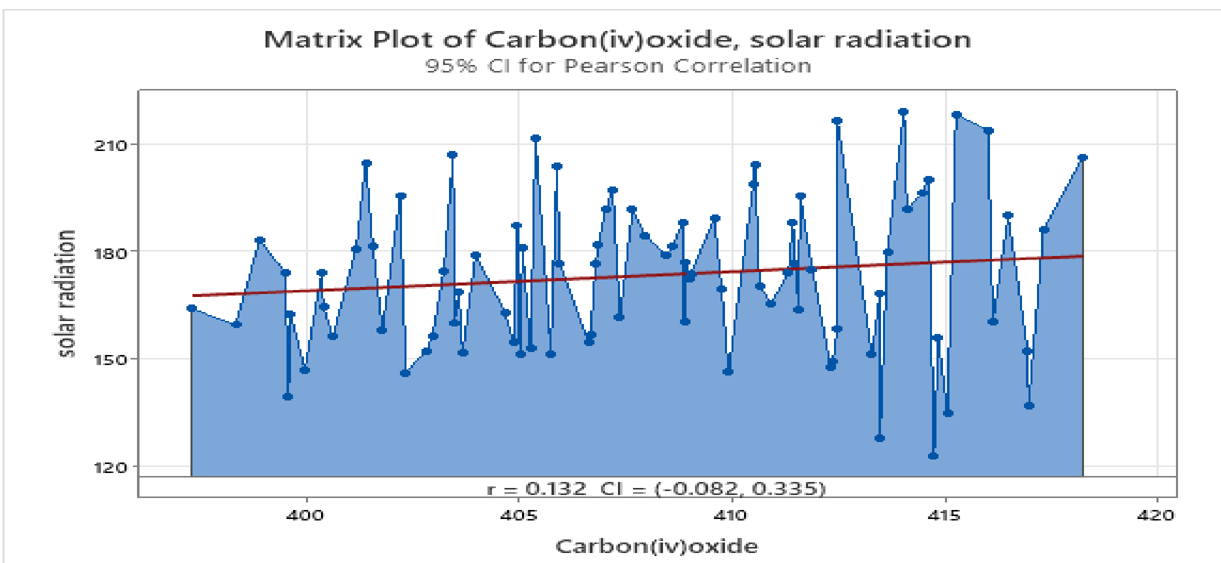

Figure 4: Correlation of Carbon Dioxide and Solar Radiation showing the Regression Fit.

Table 3: Correlation for Carbon (IV) Oxide.

Method	
Correlation Type	Pearson
Number of rows used	86
Solar Radiation	0.132

The correlation coefficient between carbon dioxide (CO_2) levels and solar radiation is 0.132.

This indicates a positive but weak correlation between the two variables. A positive correlation means that as CO_2 levels increase, solar radiation tends to increase slightly, but the correlation is not very strong.

Regression Analysis: Solar Radiation versus Carbon (iv) Oxide

Regression Equation:

solar radiation = -43 + 0.531 Carbon (iv) oxide

The regression equation that models the relationship between solar radiation and carbon dioxide (CO_2) levels is given as:

solar radiation = -43 + 0.531 * Carbon (iv) oxide

This equation suggests that solar radiation is influenced by carbon dioxide levels, with a positive coefficient of 0.531, indicating that as CO_2 levels increase, solar radiation tends to increase. However, the intercept term of -43 suggests that even when CO_2 levels are zero, there is still some level of solar radiation (negative intercept might not be practically meaningful).

Table 4: Coefficients.

Term	Coef.	SE Coef.	T-Value	P-Value	VIF
Constant	-43	177	-0.24	0.807	
Carbon (iv) oxide	0.531	0.434	1.22	0.224	1.00

Model Summary

S	R-sq	R-sq(adj)	R-sq (pred)
21.4962	1.75%	0.58%	0.00%

Table 5: Analysis of Variance.

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	1	692.0	692.0	1.50	0.224
Carbon(iv)oxide	1	692.0	692.0	1.50	0.224
Error	84	38815.3	462.1		
Total	85	39507.3			

Table 6: Fits and Diagnostics for Unusual Observations.

Obs	Solar Radiation	Fit	Resid	StdResid	
72	219.15	176.50	42.65	2.01	R
80	122.95	176.87	-53.92	-2.55	R
81	127.94	176.20	-48.25	-2.27	R

R Large residual

The coefficients section provides information about the constant (intercept) and the coefficient for carbon dioxide (CO_2).

- The constant is -43, with a standard error of 177. This value is not statistically significant based on the p-value (0.807).

- The coefficient for Carbon(iv)oxide is 0.531, with a standard error of 0.434. It also has a p-value (0.224) that is not statistically significant at conventional significance levels (typically < 0.05).

The ANOVA table summarizes the sources of variation in the model:

- The regression F-value is 1.50 with a p-value of 0.224, suggesting that the regression model, as a whole, is not statistically significant.

- The "Error" row provides information about the unexplained variation in the model.

The fits and diagnostics for unusual observations show:

- This section lists observations that have unusual residuals.
- Observations 72, 80, and 81 have relatively large residuals (difference between observed and predicted values). These are indicated as "R" for "large residual."

CONCLUSION

In summary, the analysis suggests that there is a weak positive correlation between carbon dioxide (CO_2) levels and solar radiation. However, the regression model built to predict solar radiation based on CO_2 levels does not appear to be a strong or statistically significant model, as indicated by the high p-values and low R-squared values. This suggests that other factors may have a more significant influence on solar radiation than CO_2 levels alone.

The study on the effects of greenhouse gas: carbon dioxide (CO_2) on solar radiation has provided valuable insights into the complex dynamics of our planet's climate system. The findings of this research underscore the profound implications of rising CO_2 levels for solar radiation and, by extension, global climate change. The analysis has revealed a relationship between CO_2 concentrations and solar radiation. This relationship, though often subtle, plays a pivotal role in influencing temperature patterns, weather dynamics, and climate systems. We have observed changes in solar irradiance patterns, which can impact the distribution and intensity of solar radiation reaching the Earth's surface.

Our research contributes to the foundation of knowledge that informs policy and decision-making. The evidence-based recommendations for mitigation and adaptation strategies are essential for addressing the challenges posed by CO_2-induced changes in solar radiation.

In conclusion, this study reaffirms the critical importance of understanding the effects of CO_2 on solar radiation. It emphasizes that solar radiation is not only a fundamental driver of our climate but also a key player in the broader context of climate change. As we face the pressing issues of our time, including global warming and environmental sustainability, this research underscores the need for collective action to reduce CO_2 emissions and protect the delicate balance of our planet's climate. It is our hope that this study serves as a catalyst for informed decision-making, responsible policy measures, and a commitment to a sustainable future for generations to come.

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