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Comparative Analysis of Atmospheric Carbon Dioxide Concentration and Temperature between Forest and Non-Forested Domains in Oyo State, Nigeria

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ABSTRACT: This study was carried out to assess the concentration levels of CO_2 and temperature and also to correlate their values among selected locations in Oyo State, Nigeria. CO_2 and temperature readings were taken using a portable CO_2 meter, and a GPS was use to capture co-ordinates of sample points, this was done twice a day. Data were collected from 7am to 11am for morning session while afternoon session data were collected between 1pm and 5pm making a total of 8 hours monitoring. There were negative correlation between CO_2 and temperature in all the forests while we have positive correlation between CO_2 and temperature in non-forested domains, this, by implication, means that presence of trees in the forest reserve help to reduce Carbon dioxide during the day since trees manufacture their food using CO_2 in the presence of sunlight. Also, the positive correlation between CO_2 and temperature in the towns is due to high rate of human anthropogenic activities during the day. The values of CO_2 obtained in this study were higher when compared with IPCC limit of 435 ppm (parts per million) of CO_2 emission. Routine monitoring of carbon dioxide and public education is recommended.

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A proper understanding of the relationship between the concentration of atmospheric CO_2 and global temperature is a prerequisite to evaluating anthropogenic impact on climate change (Davis, 2017). CO_2 concentration is increasing slowly but continuously with a typical seasonal fluctuation mostly due to the burning of the fossil fuels for energy needs (Tomomi, *et al.*, 2012). Carbon dioxide concentrations are rising mostly because of the fossil fuels that people are burning for energy. Fossil fuels like coal and oil contain carbon that plants pulled out of the atmosphere through photosynthesis over the span of many millions of years; we are returning that carbon to the atmosphere by felling of trees. Anthropogenic activities have been found to contribute more than 80% of the atmospheric CO_2 in non-forested domains (Koerner and Klopatek, 2002). The interaction between CO_2 and temperature will certainty exert a profound influence on the earth's environment and global agricultural production (Rosenzweig *et al*., 2014). Growing evidence suggest how global background levels of atmospheric CO_2 are increasing and his impact on environmental quality, human and ecological health (Ana *et.al*, 2015). Scientists measure the amount of greenhouse gases in the atmosphere in several ways. They use satellites and other instruments such as sensors to measure the amount of greenhouse gases in the air all around the world. Greenhouse gas such as CO_2 trap heat just like the glass roof of a greenhouse, helps warming the globe. The rise in CO_2 level has been observed to be more rapid than at any time in the past due to increase in anthropogenic activities. Carbon IV oxide (CO_2) emissions arising from human anthropogenic activities predisposes to adverse health outcomes and associated health risks, this may include headaches, dizziness, restlessness, difficulty breathing, sweating, tiredness, increased heart rate etc. We must reduce emissions of greenhouse gases to net zero to have a reasonable chance of limiting global warming to 1.5ºC to prevent global disaster. The main objective of this paper is to evaluate the atmospheric carbon dioxide concentration and temperatures between forest and non-forested domains in Oyo State, Nigeria

MATERIALS AND METHODS

Study Area: Oyo state is an inland state in the south western part of Nigeria, with its capital in Ibadan. It is bounded in the North by Kwara State, East by Osun State, South by Ogun State and in West partly by

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Ogun State and partly by the republic of Benin. Oyo state is located on the map on 7^0 22' 43" N, 7^0 37 84" N and 3^o 53' 43" E, 3^o 89' 53" E Oyo State covers an area of 28,245.3 square kilometers. It has a population of 5,580,894 (2006 census figures).The average annual temperature is 25.9^oC.

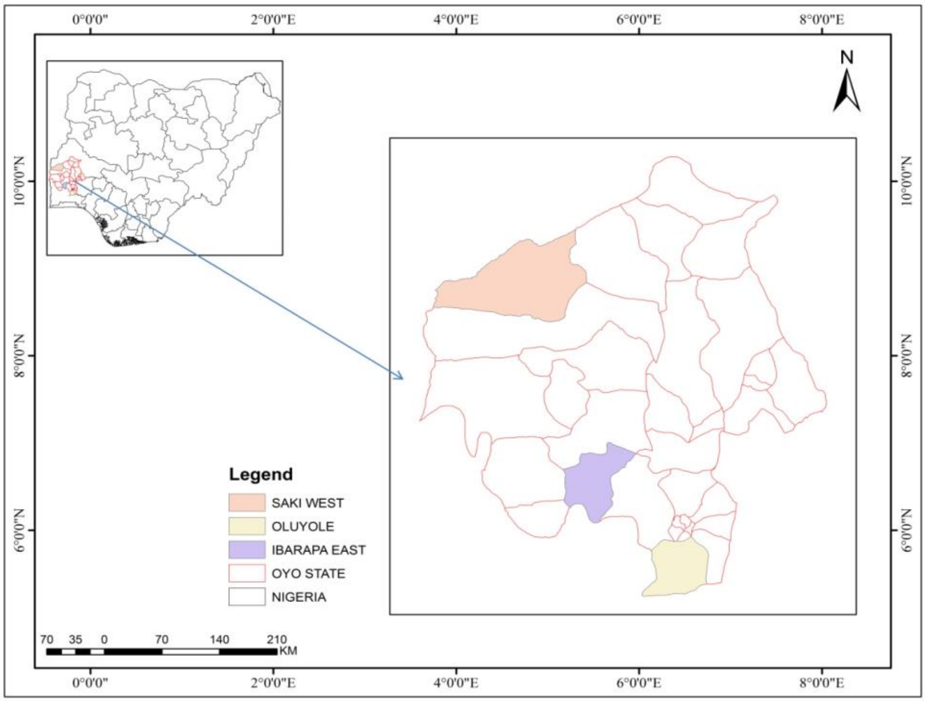

Fig 1: Map of the Study Area

Table 1: Study Locations

Number	Non-Forested Domain	Forest Domain
1	Saki Town	Wasangare Forest Reserve
2	Eruwa Town	Eruwa Forest Reserve
3	Idi Ayunre	Gambari Forest Reserve

Data Collection: Three Forests domain (Wasangare, Eruwa and Gambari) and Non-Forested domain (Saki town, Eruwa town and Idi Ayunre town) close to each Forest reserve (Table 1) were purposively selected for this study. A Garmin Geo–Positioning System device was used to navigate through the coordinates of the laid sampling points while a hand–held neutron air quality meter-AQ-9901SD was used for measuring and storing the atmospheric CO_2 and temperature of the study points, taking the emitting zones into consideration during the measurements.

Table 2: Possible emitter of carbon dioxide in the study area

S/N	Location	Observable sources
1	Idi Ayunre Town	Generators, Residential, Industries, Gas station
2	Gambari Forest Reserve	Dead wood, soil and dead leaves
3	Saki Town	Automobile, Generator, Residential, Industries, Gas station
4	Wasangare Forest Reserve	Dead wood, soil and dead leaves
5	Eruwa Town	People, Automobiles, Gas station and school environment
6	Eruwa Forest Reserve	Dead wood, soil and dead leaves, charcoal production site

Data Exploration and Analysis: Data exploration, summary and analysis was carried out using R version 4.0.3 (R Core Team, 2020) while graphics were produced using ggplot2 (Wickham, 2016)–a package in R. Tools used for data summarization are tables and bar charts.

Pearson's correlation coefficient: was used to measure the relationship between the variables considered for this study (CO_2 and temperature). It has a value between – 1 and + 1 and is of the form:

$$r = \frac{\sum_{i=1}^{n}(X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum_{i=1}^{n}(X_i - \bar{X})^2 \sum_{i=1}^{n}(Y_i - \bar{Y})^2}}$$

Where: r = correlation coefficient; X_i = values of the x–variable in a sample; $\bar{X}$ = Mean of the values of the x –variable; Y_i = values of the y–variable in a sample; $\bar{Y}$ = Mean of the values of the y–variable

Welch's t–test: was used to determine the similarity of measurements obtained on each variable in the forested area to the corresponding variable measured at the community close to the forest area. The Welch's t–test is given as:

$$t = \frac{(\bar{X}_1 - \bar{X}_2) - (\mu_1 - \mu_2)}{\sqrt{\frac{S^2{}_1}{n_1} + \frac{S^2{}_2}{n_2}}}$$

With

$$df = \frac{\frac{\sigma_1}{n_1} + \frac{\sigma_2}{n_2}}{\frac{\left(\frac{\sigma_1}{n_1}\right)^2}{n_1 - 1} + \frac{\left(\frac{\sigma_2}{n_2}\right)^2}{n_2 - 1}}$$

Where t connotes Welch's t–statistic and df represents the degree of freedom for the Welch's test.

RESULT AND DISCUSSION

Descriptive analysis: A summary of the observations on carbon (IV) oxide and temperature at the study locations are presented on Table 3.

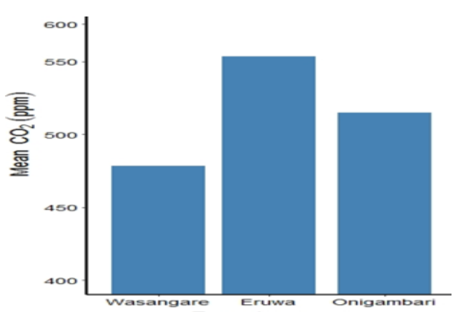

Fig 2: Mean CO_2 concentrations for the forest reserves

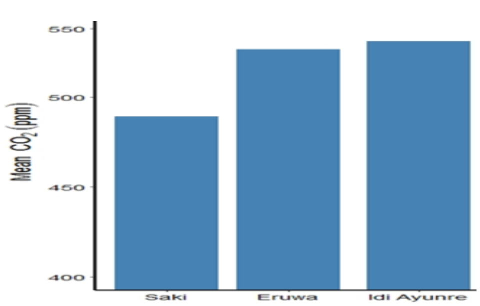

Fig 3: Mean CO_2 concentration for Non-forested domain

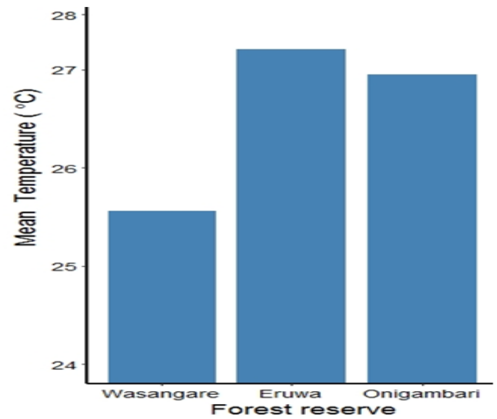

Fig 4: Mean Temperature for selected forest reserves

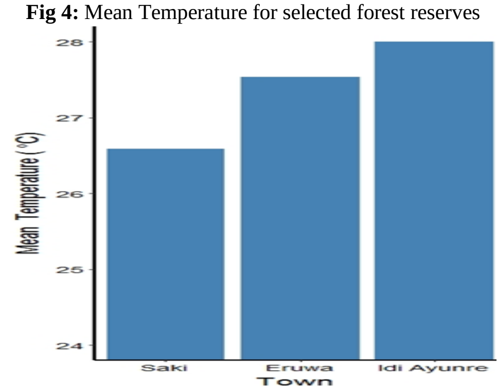

Fig 5: Mean Temperature for Non forested domain

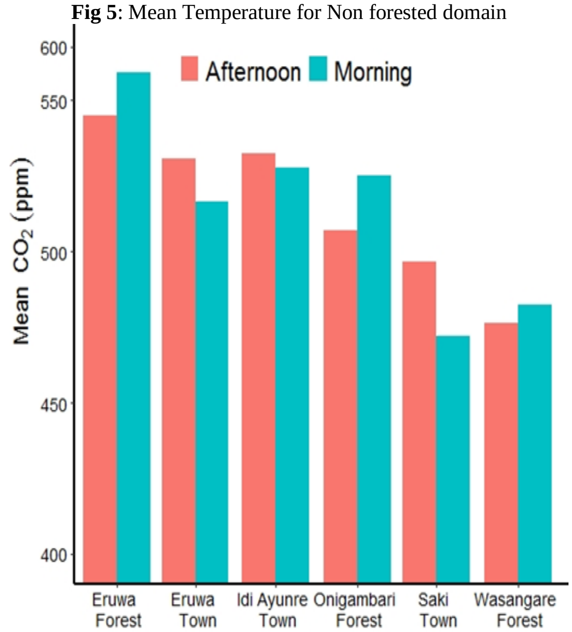

Fig 6: Mean CO_2 for Morning and Afternoon periods

The highest average CO_2 concentration was recorded at Eruwa Forest reserve while the lowest average concentration occurred at Wasangare Forest Reserve. Incidentally, the lowest mean temperature was measured at Wasangare Forest Reserve while the highest mean temperature was observed at Eruwa Forest Reserve (Table 3).

Table 3: Mean CO_2 and temperature levels of locations

Location (Forest Domain)	Mean CO_2 (ppm)	Mean Temperature (°C)	Non-Forested Domain	Mean CO_2 (ppm)	Mean Temp. (°C)
Wasangare	478.48	25.52	Saki	489.18	26.59
Eruwa Forest	553.41	27.21	Eruwa Town	526.47	27.54
Onigambari	514.95	26.95	Idi Ayunre	531.09	28.00

Table 4: Correlation between CO_2 and Temperature

Location	r	Remark
Saki Town	0.5119	Positively correlated
Wasangare Forest Reserve	-0.3849	Negatively correlated
Eruwa Town	0.5910	Positively correlated
Eruwa Forest Reserve	-0.4018	Negatively correlated
Idi Ayunre Town	0.2236	Positively correlated
Onigambari Forest Reserve	-0.5126	Negatively correlated

r*= represents Pearson's correlation coefficient*

Table 5: Welch's t–test for CO_2 comparison between the forested and non–forested domain

Non–forested area	Forested area	t–value	df	p–value	Remark
Eruwa Town	Eruwa Forest Reserve	-2.8034	23.4240	0.0042	Statistically significantly different
Saki Town	Wasangare Forest Reserve	2.5198	75.6920	0.0010	Statistically significantly different
Idi Ayunre Town	Gambari Forest Reserve	3.0327	41.4370	0.0042	Statistically significantly different

Alpha level at 0.05

In other words, Eruwa forest had the highest mean CO_2 concentration and mean temperature while Wasangare had the lowest mean concentration and mean temperature (Figure 2, Figure 4) amongst the forest reserves. On the other hand, for non-forested areas, Idi Ayunre had the highest mean CO_2 concentration and mean temperature while Saki had the lowest mean CO_2 concentration and lowest mean temperature (Figure 3, Figure 5). This study further showed a higher mean concentration of CO_2 at afternoon period than morning period for the non-forested areas selected in this study while the forest reserves showed a higher concentration of CO_2 in the morning periods than afternoon periods (Figure 6).

A Pearson's correlation test between CO_2 and temperature observations obtained from the study locations revealed a positive correlation to exist for the variables within the town locations while a negative correlation was observed to exist within each forest reserve. Consequently, the observations showed that an increase in means CO_2 characteristically related with an increase in mean temperature for the non-forested domain while an increase in mean CO_2 related with a decrease in mean temperature at the forest reserves (Table 4). The disparity in correlation coefficients between CO_2 and temperature for the forest and non-forested domain could be attributed to the fact that forests/trees sequester, or make use of carbon (IV) oxide, in the presence of sunlight (that is, increase in temperature), to produce food. Hence, the reduction of CO_2 within the forest domains compared to that observed at the non-forested areas. A Welch's t–test showed a marked statistical difference in the measurement of the CO_2 concentration for each forest reserve and non-forested domain close to them (Table 5), at 95% confidence interval (i.e. at alpha level equals 0.05).

*Conclusion***:** This result shows that the recent CO_2 increase is causing the temperature increase in non-forested domain, nonetheless, there exist weak correlations between surface temperature and atmospheric CO_2 concentration in the forest. This study reveal that values of CO_2 obtained was higher when compared with IPCC limit of CO_2 emission which is an average of 435ppm. There is the need for concerted efforts to reduce CO_2 in order to stem possible air pollution episodes in the future and this is achievable by routine monitoring of CO_2 level and increasing information programs.

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