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Urban Land uses as Catalysts to Ambient Air Quality Degradation in the Metropolitan City of Calabar, Nigeria

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ABSTRACT

This study examined urban landuses as catalysts to ambient air quality problems in Calabar metropolis, Nigeria**.** Data on emission level of CO, NO_2, SO_2, H_2S, and SPM2.5 were acquired using Gasman, while point coordinates were collected using Garmin GPSMap 60CSx device. Student's t-test statistics and Analysis of Variance (ANOVA) were employed to test the hypothesis. From findings, the null hypothesis was rejected for all the test parameters (CO, NO_2, SO_2, H_2S, and $SPM_{2.5}$) because it could not be concluded that the concentration of parameters measured were higher than the FEPA permissible limits for all the parameters. In order to help identify which ones were significantly higher or lower, the column of mean difference and t-value, where the mean difference is on the negative was consulted. This means that the concentration of the parameters in the air was within the FEPA permissible limits. Where that is the case, the calculated t-value is also negative. It should be noted that automated calculation of student's t-statistics with the SPSS does not make use of the modulus sign. The use of modulus ignores the sign in statistical analysis. For this present student, the result for CO and H_2S are within the acceptable limits while those for NO_2, SO_2 and $SPM_{2.5}$ are higher than the acceptable limits. It was therefore recommended that there should be protection of the residential land uses to avoid encroachment by incompatible uses which cause pollution. Finally, green areas should be protected due to their potentials as urban green lungs.

Key words : Air quality, blight, landuses, pollution, disaster

1. INTRODUCTION

It has been proven that as cities grow numerically, physically and functionally, an increase in energy consumption, industrial effluents, vehicular traffic and noise become unavoidable [1]-[3]. Ultimately, these would obviously impact negatively on the quality of air [4]-[9]. They also believe that weather parameters, anthropogenic and biological emissions under some growth scenarios affect air quality leading to related disaster. However, these studies did not compare air quality in the study area with safe standard in order to ascertain whether it is within the acceptable limit.

The Nigerian environment is continually, progressively and seriously susceptible to several environmental problems such as pollution of water, air, land, erosion, climate change, global warming, biodiversity loss and desert encroachment among others. Notably, air quality concern is principal focus for long term planning.

Air pollution engineered by conditions such as uncontrolled discharge of waste in residential areas, increased vehicular movement along transportation routes, amorphous development of informal enterprises and increased industrial activities, is the major characteristics of Calabar Metropolitan city. However, to manage human activities in aggregate terms, it is pertinent to know the level or concentration of pollutants being generated in Calabar metropolis. These cannot be known if pollutants level is not measured.

Finally, since economic activities constitute or result to pollution of varying degree, it is pertinent that various land uses in Calabar Metropolis which represent diverse economic activities be scrutinized for various pollutants to ensure that they conform to acceptable standards, otherwise, the people and property would be endangered.

2. STATEMENT OF THE RESEARCH PROBLEM

Studies [1]-[9] examined ambient air quality on a spatial and temporal scale globally and regionally. Unfortunately, in Calabar metropolis, air quality related studies are scanty. The metropolis is generally seen as lacking heavy industries and that no form of gas flaring or oil related upstream activities are being carried out. However, a lot of economic activities capable of impacting on air quality are constantly on the increase due to urbanization and the dynamic nature of the city. Industrial, transportation, commercial and other anthropogenic activities result to emission of effluents and degradation of air quality and human lives. Consequently, this calls for the need for a robust and constant air quality assessment in the metropolis, especially, with its nomenclature as a tourism destination inundated with several relaxation hotspots and economic activities. This research therefore aimed at monitoring air quality status in order to compare and ensure that it conforms to the acceptable threshold/standards, otherwise, the people and property would be endangered.

3. AIM AND OBJECTIVES OF THE STUDY

The aim of this research was to examine urban land uses as catalysts to ambient air quality issues in Calabar Metropolis, Nigeria. The objective was to determine the ambient air quality status in relation to existing land uses in Calabar Metropolis and compare it with safe standards.

4. RESEARCH HYPOTHESIS

H_0: Ambient air quality in Calabar Metropolis is not significantly different from the Federal Environmental Protection Agency, FEPA 1991 permissible threshold [10].

5. THE STUDY AREA

This study was carried out in the capital city of Cross River State, known as Calabar (Figure.1). Calabar is located between longitudes 8° 18' and 8^0 25" East of the Greenwich meridian and latitudes 4°55' and $5^0$10' North of the Equator. It is sandwiched between the Great Kwa River to the East and the Calabar River to the west.

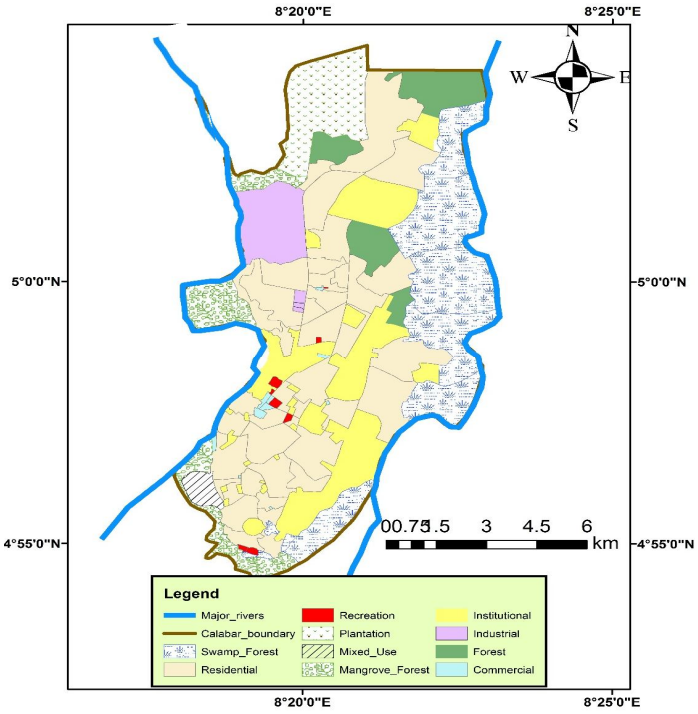

Figure.1: Land use map of Calabar Metropolis showing the study area **Source: [4]**

Calabar Metropolis, which is made up of Calabar Municipality and Calabar South Local Government Areas, covers an area of 1480sqkms. Calabar is bounded to the North by Odukpani Local Government Area and to the East by Akpabuyo Local Government Area.

6. RESEARCH METHODOLOGY

During recognizance, GPS data were acquired using a Garmin GPSmap 60CSx. Air quality data for this study were made up of continuous variables in the form of air quality readings for 5 parameters from various land uses such as industrial, transportation, commercial and residential. They were acquired using automated real-time data loggers such as Crowcon Gasman. In a more specific term, the study relied on data on ambient air quality status in Calabar Metropolis as well as air quality threshold data from FEPA, Nigeria; data on air quality status across various land uses as well as data on seasonality differential in air quality status. Data were expressed in parts per million (ppm) scale. Besides, land use maps of the study area as well as the real-time Google earth imagine data were also consulted.

7. ANALYTICAL PROCEDURE

Hypothesis one

H_0: Ambient air quality in Calabar Metropolis is not significantly different from FEPA, (1991) permissible threshold.

H_1: Ambient air quality in Calabar Metropolis is significantly different from FEPA, (1991) permissible threshold.

This hypothesis was tested using one-sample student`s t-test statistics. The t-test statistics was designed to test if the mean for a sample is significantly different from a specified value [11]. The specified value in this case is the FEPA air pollutants permissible limits for each of the measured parameters. The mathematical definition of the t-test statistics is given as:

$$t = \left| \frac{\bar{X} - \mu}{S_x} \right| \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where S_x is the standard error

$\bar{X}$ s the mean of the samples from a sample $X_1, X_2, \ldots, X_n$, of size n

μ is the specified numeric value (FEPA limit).

The reason for its use is due to its ability to determine whether or not there is a statistically significant difference between the means of two datasets. The test was conducted as a 2-tailed since it was not clear where the direction of the test would be.

8. AMBIENT AIR QUALITY STATUS IN CALABAR METROPOLIS AND FEPA SAFE STANDARDS.

Table 1 presents summary statistics for measured parameters across Calabar Metropolis. From the table, the mean and standard deviation for CO is 2.68ppm and 1.051 respectively. For NO_2, the values are 1.06ppm and 1.040. Besides, the values for SO_2 are 1.37ppm and 1.170 while for H_2S, they were 1.21ppm and 1.095. Finally, the values for SPM 2.5 were 3.22ppm and 1.072 respectively. The number of cases for the observation was 3198. The main data is presented in appendix 1a and appendix 1b.

Table 2 highlights the stipulated standard by FEPA or FMEV, Nigeria. As shown on the table, it is expected that effluents emitted in urban areas should not be beyond the figures, otherwise, the urban environment would be considered as unsafe for human habitation. For sustainability to be achieved, it is recommended that emissions level be juxtaposed to the established threshold as a measure of conformity.

Table 1: Summary statistics for measured parameters across Calabar Metropolis
Source: Author's analysis, 2020.

Parameters	Mean	S.D.	No. of cases
CO	2.6826	1.05139	3198
NO_2	1.0687	1.03977	3198
SO_2	1.3745	1.16985	3198
H_2S	1.2094	1.09490	3198
$SPM_{2.5}$	3.2234	1.07232	3198

Table 2: FEPA air pollutants permissible threshold

POLLUTANTS	SYMBOL	FEPA STANDARDS
Carbon Monoxide	CO	10-20ppm
Nitrogen Dioxide	NO_2	0.06 (113 mg/m3)
Sulphur Dioxide	SO_2	0.1ppm
Hydrogen Sulphide	H_2S	8.0
Suspended Particulate Matter	SPM2.5	0.25 (250mg/m^3)

Source: [10], [12].

9. ANALYSIS AND DISCUSSION OF FINDINGS

H_0: Ambient air quality status in Calabar Metropolis is not significantly different from FEPA, (1991) permissible threshold.

H_1: Ambient air quality status in Calabar Metropolis is significantly different from FEPA, (1991) permissible threshold.

This hypothesis was tested based on individual parameters using the student`s t-test parametric statistics. Table 3 shows the summary results from test of hypothesis one. From the result as shown, the null hypothesis was rejected for all the test parameters (CO, NO_2, SO_2, H_2S, and $SPM_{2.5}$). from the result, it could not be concluded that the concentration of parameters measured were higher than the FEPA permissible limits for all the parameters. In order to help identify which ones were significantly higher or lower, the column of mean difference and t-value, where the mean difference is on the negative is consulted. This means that the concentration of the parameters in the air was within the FEPA permissible limits. Where that is the case, the calculated t-value is also negative. It should be noted that automated calculation of student's t-statistics with the SPSS does not make use of the modulus sign. The use of modulus ignores the sign in statistical analysis. For this present student, the result for CO and H_2S are within the acceptable limits while those for NO_2, SO_2 and $SPM_{2.5}$ are higher than the acceptable limits.

10. CONCLUSION

This study examined urban landuses as catalysts to ambient air quality issues in Calabar metropolis, Nigeria. The Major objective was to determine the ambient air quality status in Calabar Metropolis and compare it with safe standards.

Table 3 : Summary of results from test of hypothesis one.

Parameter	N	Mean	Std. Dev	Mean Diff.	t-Value	df	Sig. (2 tailed)	FEPA Standard Value	Remarks
CO	3198	2.6826	1.05139	-17.31744	-935.232	3197	0.000**	20	Ho Rejected
NO_2	3198	1.0687	1.03977	1.00867	55.082	3197	0.000**	0.06	Ho Rejected
SO_2	3198	1.3745	1.16985	1.27447	61.858	3197	0.000**	0.1	Ho Rejected
H_2S	3198	1.2094	1.09490	-6.79056	-352.152	3197	0.000**	8	Ho Rejected
SPM 2.5	3198	3.2234	1.07232	2.97342	157.445	3197	0.000**	0.25	Ho Rejected

** Difference is significant at <0.001 (2-tailed)
Source: Author's analysis, 2020

The hypothesis compared ambient air quality in Calabar Metropolis vis-avis, FEPA, (1991) permissible threshold. The null hypothesis which states that ambient air quality in Calabar Metropolis is not significantly different from FEPA, (1991) permissible threshold was rejected for all the test parameters (CO, NO_2, SO_2, H_2S, and $SPM_{2.5}$), since the direction of the test was not specified in the hypothesis, it could not be concluded that the concentration of parameters measured were higher than the FEPA permissible limits for all the parameters. This means that the concentration of the parameters in the air was lower than, or rather within the FEPA permissible limits. However, the result for CO and H_2S are within the acceptable limits while those for NO_2, SO_2 and $SPM_{2.5}$ are higher than the acceptable limits.

This study has been able to establish the relationship between urban land uses and ambient air quality status in Calabar Metropolis, Nigeria.

11. RECOMMENDATION

Based on the findings of this research, certain mitigatory measures are therefore recommended for the purpose of ensuring a sustainable, clean and green Calabar Metropolis.

1. Residential zones should be exclusively maintained so as to avoid encroachment of incompatible uses which could lead to pollution and blight. Residential zones that have already been encroached, depending on the form of encroachment, should be reclaimed. For example, multiple exit routes should be closed to discourage motorists from using such as alternative routes to other destinations thereby, causing heavy traffic and congestion and pollution.
2. Open spaces and gardens should be well maintained, preserved and protected due to their potentials in sanitizing the air by acting as green lungs.
3. There is need for a periodic and real-time monitoring and envisioning of air quality status to ensure adequate and strict compliance with standards. This would help in the enforcement of related codes once violated. It would be very helpful in the continuous acquisition of more robust datasets that could be used in pre-emptive planning of the metropolis in favour of clean air act.

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Appendix

Plate 1. Generators as point sources of pollution
Source: by the author, 2021

Plate 2. Automobiles as line sources of pollution
Source: by the author, 2021