

Assessment of Ambient Air Quality for Selected Locations in Kogi State, Nigeria

Otu, J.O^{1,2*}, Onoja, P.K² Idris, M.O² Habib, L.O²
^{1,2}(NASRDA, Centre for Atmospheric Research, Anyigba, Nigeria)
²(Kogi State University, Anyigba, Nigeria)
Corresponding Author: Otu, J.O

Abstract: This study was carried out with reference to two criteria air pollutants (NO_2 and O_3) and was focused mainly on quantitative estimation of gaseous emission from automobiles and industries for selected locations in Kogi Metropolis. Air quality monitoring was conducted from 7am to 5pm twice a week for the pollutants in the chosen locations also traffic count was observed during the sampling. Theselected locations for this study were Kogi state University Anyigba, West African Ceramics Ajaokuta, Ganaja Junction Lokoja and Dangote Cement Factory Obajana. Air samples were collected at each sampling location by passing ambient air into a glass impinger of a fabricated air sampling train containing absorbents for trapping the air pollutants (NO_2 and O_3), at a flow-rate of 1 L/min for 60 min using air vacuum pump. The overall daily average NO_2 concentrations for the four sampling locations were of the range 0.062-0.209ppm, with the highest values of 0.209ppm and 0.137ppm at industrial area (Obajana) and a high traffic area (Lokoja) respectively. The overall daily average O_3 concentrations for the four sampling locations were of the range 0.052-0.111ppm, with the highest values at industrial area (Obajana) and a high traffic/commercial area (Lokoja). The NO_2 concentrations for the four locations follow the pattern; Obajana>Lokoja>Ajaokuta>Anyigba while the O_3 concentration follow the same pattern; Obajana>Lokoja>Ajaokuta>Anyigba. The ambient NO_2 concentrations for the three locations (Obajana, Lokoja and Ajaokuta) in this study exceeded the permissible limit of the United States NAAQS and the Nigerian NAAQS for 10 hour sampling which are 0.1 ppm and 0.1ppm respectively. Also the ambient O_3 concentrations for the same locations (Obajana, Ajaokuta and Lokoja) exceeded the permissible limits of the United States NAAQS and Nigerian NAAQS which are 0.07ppm and 0.07ppm respectively.

Key words: Air Pollutants, NAAQS, EPA, USEPA, Sampling train, Absorbents, Sampling Locations.

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I. Introduction

Air pollution is the introduction into the atmosphere of toxic compounds or pollutants at a concentration high enough to produce an undesirable effect on humans, animals, vegetation or materials, or significantly alter the natural balance of any ecosystem. Air quality in other hand can be defined as the degree to which the air in a particular place is pollution-free. Air pollution has become a serious problem in today's world. The impacts of air pollutants on health and the environment cannot be over emphasized. The world has recorded over seven million deaths on annual bases as a result of air pollution⁸. Evaluation of the ambient air quality in Imo State South East Nigeria for PM_{10} , NO_2 , SO_2 and CO using Gasman air monitors and a Haze dust particulate monitor ($10\mu\text{m}$) reveals that the mean concentration of the air pollutants obtained exceeded the Nigerian National Ambient Air Quality Standards (NAAQS) and the United States National Ambient Air Quality Standards (NAAQS) except for few stations². The study conducted in Ogbomoso South West Nigeria on the role of mobile source emissions on air quality through well-designed studies reveals that SO_2 , NO_x and CO pollutants concentrations were above the permissible limits set by both the Nigerian Environmental Protection Agency (EPA) and the United States Environmental Protection Agency (USEPA) for some sampling locations and within the set standards for other locations³. In most developing countries of the world vehicular growth has not been checked properly by environmental regulating authorities leading to increased levels of pollution⁷. The research work conducted in Kano North West Nigeria (A major commercial city of Nigeria) showed that traffic emissions in Kano metropolis produce air pollutants (NO_2 , SO_2 , NH_3 etc), at some sites were above the AQI stipulated by USEPA especially during the dry seasons¹. This implies that traffic emission within Kano metropolis is not within the safe limits Abam and Unachukwu reported that the AQI level of the air pollutants PM_{10} , SO_2 , NO_2 and CO studied in Calabar, Nigeria were significant having possible severe consequences⁴. A research conducted at Ilorin and Lagos Nigeria on air pollution by Abdulraheem reveals that SO_2 , O_3 and NO_x as well as VOCs contribute to tropospheric ozone formation and the three precursors vary with

locations and atmospheric conditions⁵. The aim of this research is to assess the ambient air quality with reference to two criteria pollutants (NO_2 and O_3) for four locations in Kogi State, Nigeria in order to ascertain if the pollutants levels are within the permissible limits set by the United States Environmental Protection Agency and the Nigerian Environmental Protection Agency. This research also provides daily average pollution trend in the chosen locations. This will create awareness to the public on the importance of keeping and maintaining good air quality and also to inform the policy makers about the quality of ambient air in those locations.

II. Material and Methods

This research employed the wet analysis techniques by stationing a sampling train at the sampling locations to take air samples from 7am to 5pm twice a week for each air pollutant at one hour sampling intervals. Absorbing reagents for collecting each pollutant are placed in the impinger which is connected to the manifold of the sampling train. The collected samples were stored in bottles and conveyed to the laboratory for analyses.

Instrumentation: Fabricated equipment otherwise called air sampling train was used to bubble ambient air into the absorbing solution contained in the impinger via a vacuum pump at a flow rate of 1 litre per minute.

UV/Visible Spectrophotometer: This was used to measure absorbance of analytes.

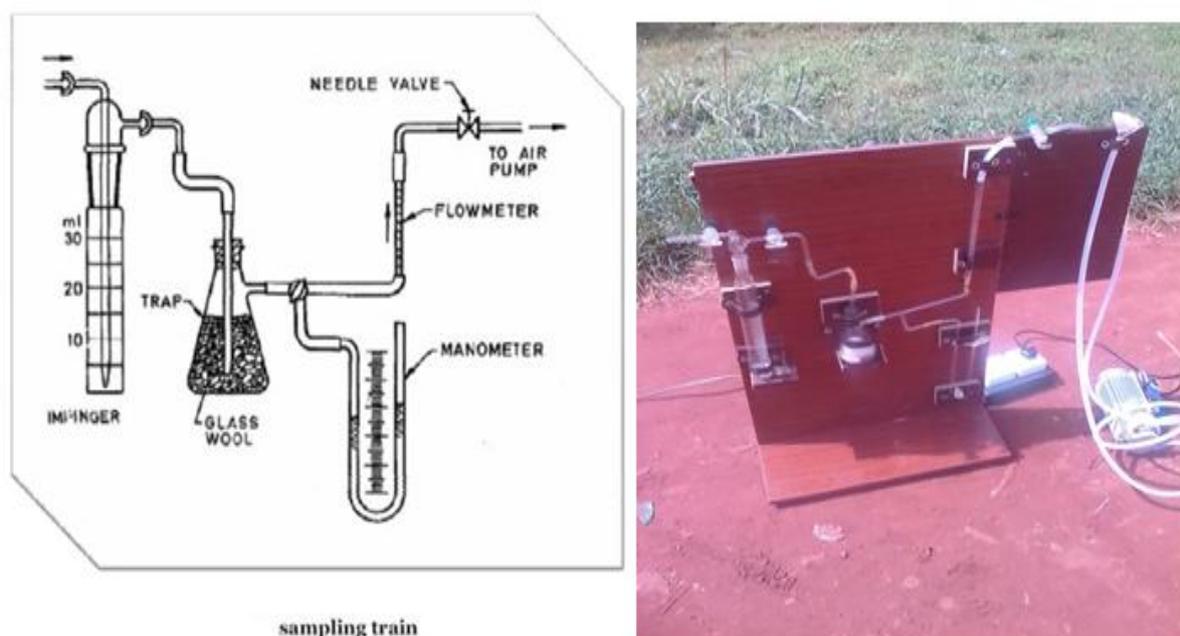


Figure no 1: Set up of the Air sampling train

Study Area: The research was conducted for four sampling locations in Kogi State North Central Nigeria. Kogi State lies on latitude 6.5° and 8.7°N , and longitude 5.4° and 7.8°E . The sampling locations were Kogi State University (KSU), Anyigba, West African Ceramics Limited (WACL) Ajaokuta, Ganaja Junction (GJ) Lokoja and Dangote Cement Plant (DCP), Obajana.

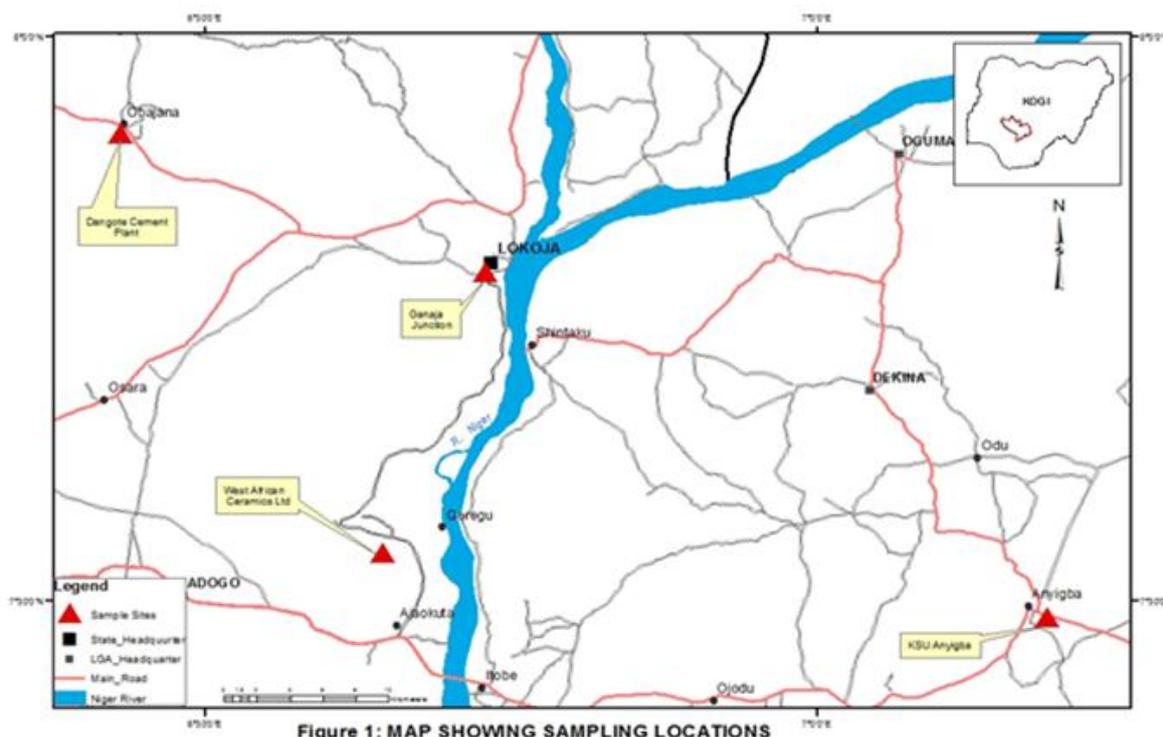


Figure no 2: Map of Kogi state showing the Sampling locations.

Study Duration: March 2016, to November, 2016.

Procedure for Sampling: A 4.00g of Sodium hydroxide was dissolved with distilled water in a 1000ml volumetric flask and 1.00g of Sodium arsenate was added and then diluted with distilled water to the mark. This reagent preparation was done in the laboratory and serves as the Absorbing solution (A) for trapping Nitrogen iv oxide(NO_2) pollutant present in ambient air into the impinger. Likewise a 13.6g of KH_2PO_4 , 14.2g of Na_2HPO_4 and 10.0 g of KI were all dissolved in sequence in 1 L volumetric flask and was diluted to the mark with distilled water, this Absorbing solution (B) was used to trap Ozone (O_3) pollutant present in ambient air.

Stoichiometry of Reactions: $2\text{NaOH} + \text{NO}_2 \rightarrow \text{NaNO}_2 + \text{NaNO}_3 + \text{H}_2\text{O}$ ----- (1)

$\text{O}_3 + 3 \text{KI} + \text{H}_2\text{O} \rightarrow \text{KI}_3 + 2 \text{KOH} + \text{O}_2$ ----- (2)

Sampling: This was carried out by positioning the sampling train at the sampling locations as shown in Figure no1, ambient air containing the pollutant was then bubbled into the impinger containing the absorbing solution at a flow rate of 1 liter per minute. Sampling was done for every one hour from 7pm to 5pm daily. A 30ml of both Absorbing solution (A) and Absorbing solution (B) were placed into the impinger to collect pollutants NO_2 and O_3 respectively. After sampling, the samples were stored in brown stoppage bottle and conveyed to the laboratory for analyses.

Reagents for Quantitative estimation of NO_2 present in the collected air samples

1. Preparation of sulphanilamide solution: A 20g of sulphanilamide was dissolved in 700ml of distilled water in a 1000ml volumetric flask, 50ml of 85% phosphoric acid was then added to it with thorough mixing and made up to the mark with distilled water.
2. Preparation of N-(1-Naphthyl)-ethylenediamine Di-hydrochloride (NEDA) solution: A 0.5g of (NEDA) solution was dissolved in 500ml of distilled water in a volumetric flask.
3. Hydrogen peroxide solution: A 0.2ml of 30% Hydrogen Peroxide (H_2O_2) was diluted with distilled water in a 250ml volumetric flask and made up to the mark.

Preparation of Standards for NO_2^- calibration curve

1. **Sodium Nitrite Stock Solution (1000 $\mu\text{g NO}_2/\text{ml}$):** A 1.5 g of a desiccated sodium nitrite was dissolved in distilled water and diluted to 1,000 ml such that a solution containing 1000 $\mu\text{gNO}_2/\text{ml}$ was obtained.
2. **Sodium Nitrite Working Standard (1.0 $\mu\text{g NO}_2/\text{ml}$):** A 5 ml of the stock solution was pipetted into a 500 ml volumetric flask and diluted with distilled water to the mark. This contains 10 $\mu\text{g NO}_2/\text{ml}$ (**solution A**). A 25ml of **solution A** above was Pipetted into a 250ml volumetric flask and diluted to the mark with absorbing solution. This contains 1.0 $\mu\text{gNO}_2/\text{ml}$.

- 3. Standards for NO₂⁻ calibration:** A working standard of 2, 4, 6, 8, 10, 12, 15 and 20 ml solution were pipetted separately into 50 ml volumetric flask in sequential order. Each was filled to 20 ml mark with absorbing solution (A). A reagent blank with 10 ml absorbing solution was also prepared. Reagents were added to each volumetric flask as in the procedure for analysis. The absorbance of each standard was recorded at 540nm. This solution was discarded after use. A plot of Absorbance (Y-axis) versus Concentration (X-axis) was plotted and the slope was determined. The reciprocal of the slope gives the calibration factor (CF).

Preparation of Standards for O₃ calibration

1. Preparation of stock Solution of 0.025 M I₂: A 16 g of potassium iodide and 3.173g of re-sublimed iodine were diluted to exactly 500 ml with distilled water. This was standardized before use, against 0.025 M Na₂S₂O₃. The sodium thiosulfate was first standardized against primary standard.

2. Preparation of 0.001M I₂ Solution: This was prepared by taking 4.00ml of the stock solution into a 100ml volumetric flask and diluted to the mark with absorbing solution B. This solution was used for the calibration curve.

Calibration of Iodine Solution: A 5.11 ml of the 0.001M I₂ solution was diluted with absorbing solution just before use to 100 ml (final volume) to make the final concentration equivalent to 1 µl of O₃/ml. The solution was discarded after use. A range of calibration points containing from 1 µl to 10 µl of ozone equivalent per 10.0 ml of solution was obtained. This is obtained by individually adding 1.0, 2.0, 4.0, 6.0, 8.0 and 10.0 mL of the calibrating iodine solution to 10.0 ml volumetric flasks. Each is brought to the calibration mark with absorbing reagent. This provides a calibrated iodine solution equivalent to 1.962µg of ozone per ml (Dara, 2004). Absorbance of each of the prepared calibration solutions at 352 nm was measured. A plot of absorbance (Y axis) versus concentration (X axis) was plotted to obtain the calibration curve. The reciprocal of the slope was also obtained which gives the calibration factor (CF).

Quantitative estimation of NO₂ in ambient Air

10ml of the collected sample was placed in a 50ml volumetric flask, 1ml of H₂O₂ solution, 10ml of sulphanilamide solution and 1.4ml of NEDA were added into the flask and mixed thoroughly after the addition and was made up to 50ml mark with distilled water. A blank solution was prepared in the same manner. After 10 min of an intense azo dye color formation, the absorbance of samples and reagent blank at 540 nm were measured and recorded using a UV/Visible Spectrophotometer.

$$C = \frac{As \times CF \times Vt}{Va \times 0.82}$$

C = concentration of NO₂ in µg/m³ CF = Calibration factor

As = Absorbance of analyte Va = Volume of air sampled, (m³)

Sampling efficiency = 0.82 Vt = volume of aliquot used for analysis (10ml)

Quantitative estimation of O₃ in Ambient Air

Within 30 to 60 minutes after sample collection, the absorbance of the sample collected was measured at 352nm using the unexposed reagent as the blank.

$$C = \frac{(As) \times CF \times 1.962}{Vs}$$

C = Concentration of O₃ in µg/m³

Va = Volume of air sampled in m³

1.962 = Conversion factor, µl to µg

CF = Calibration factor

As = Absorbance of analyte

$$\mu\text{gm}^{-3} = \frac{\text{PPM} \times \text{Molar Mass} \times 1000}{24.45}$$

(Adopted from Vowels and Connell, 1980)

Statistical Analysis

Daily hourly average were computed for the periods considered using Microsoft Excel 2010 for example values obtained from 7am to 8am were all averaged together, the same for 8am to 9am and so on for every day measurement (tables no 3 and 4). An overall averaging was done as shown in table no5 (Abdulraheemet *al*, 2009). Some plots were obtained as well. Comparison of the results with the permissible limits of the National Ambient Quality Standards of the United State Environmental Protection Agency and the Nigerian Protection Agency as well as the Ozone monitor measurement at the Center for Atmospheric Research for validity.

III. Result

Table no 1 shows the table of standards for the calibration curve of nitrite ion (NO_2^-) and the reciprocal of the plot below gives the calibration factor (CF). As the concentration of serial dilution of NO_2^- increases, the absorbance also increases in accordance with Beer Lambert's Law. The CF from the plot was used in the calculation of Concentration of NO_2 in microgram per cubic meter ($\mu\text{g}/\text{m}^3$).

Table no 1: Table of standards for the calibration curve of NO_2^-

Concentrations ($\mu\text{g}/\text{m}^3$)	0.02	0.04	0.06	0.08	0.10	0.12	0.14	0.16	0.18	0.20
Absorbance	0.043	0.045	0.047	0.05	0.052	0.054	0.055	0.058	0.06	0.062

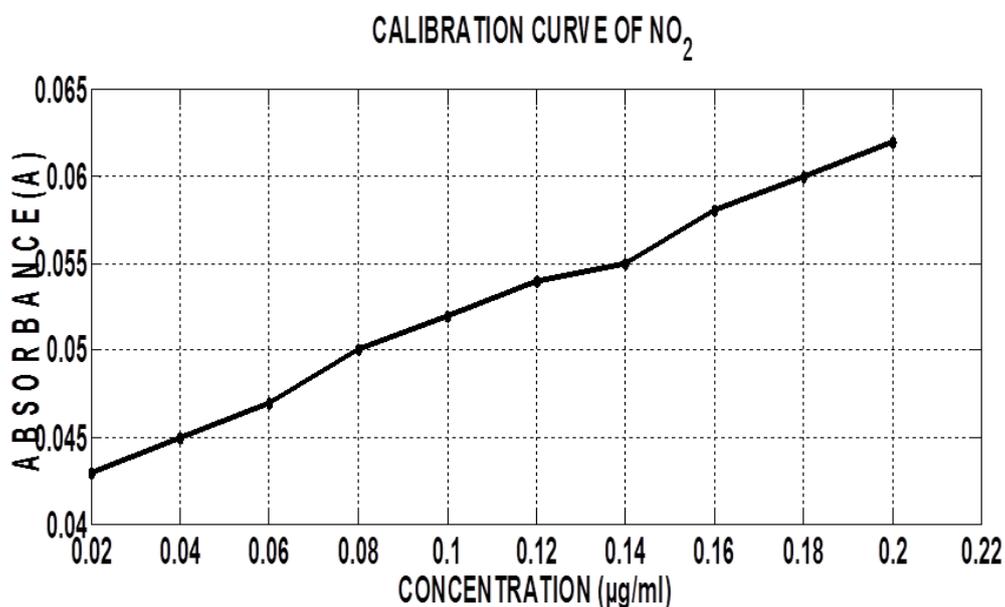


Table no 2 Shows the table of standards for the calibration curve of Ozone (O_3), the reciprocal of the plot below gives the calibration factor (CF). The CF was used in the calculation of Concentration of O_3 in microgram per cubic meter ($\mu\text{g}/\text{m}^3$).

Table no 2: Table of standards for the calibration curve of O_3

Concentrations ($\mu\text{g}/10\text{m}^3$)	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
Absorbance	0.08	0.10	0.17	0.19	0.21	0.23	0.27	0.31	0.33

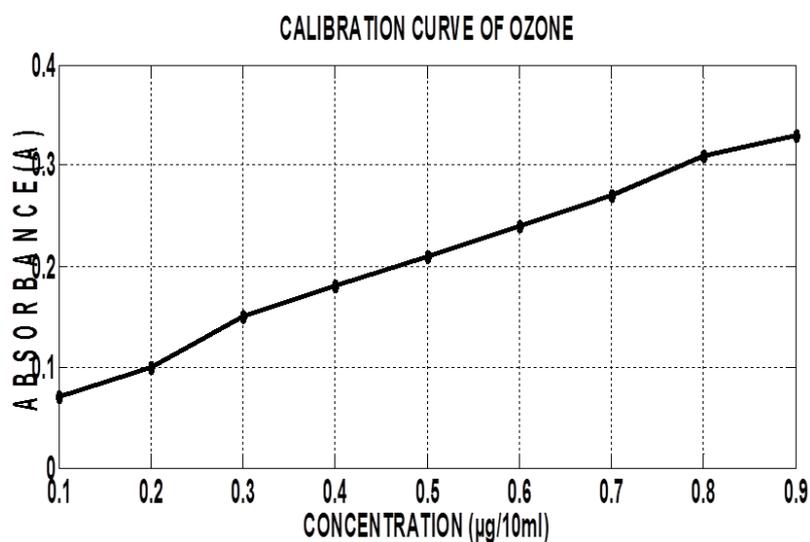


Table no 3: Shows daily hourly average concentrations of NO₂

Sampling time	KSU Main gate(ppm)	WACL Ajaokuta (ppm)	Ganaja Junction Lokoja (ppm)	Dangote Cement Plant, Obajana (ppm)
7am – 8am	0.027	0.062	0.051	0.092
8am – 9am	0.036	0.075	0.063	0.143
9am – 10am	0.046	0.081	0.066	0.157
10am – 11am	0.053	0.088	0.071	0.207
11am –12pm	0.058	0.114	0.082	0.263
12pm – 1pm	0.089	0.223	0.240	0.323
1pm – 2pm	0.111	0.251	0.261	0.351
2pm – 3pm	0.079	0.271	0.292	0.201
3pm – 4pm	0.066	0.080	0.151	0.180
4pm – 5pm	0.053	0.078	0.098	0.178

Plot of table no 3 is shown below which gives the trend of NO₂ for the locations. The values are increasing gradually until the peak hours which have the highest values for all the locations then decreases again. The ranges of NO₂ concentrations for KSU, WACL, GJ and DCP were 0.027-0.111ppm, 0.062-0.271ppm, 0.051-0.292ppm, and 0.092-0.351ppm respectively. Three out of the four locations namely WACL, GJ and DCL were hot spot because of the high level of commercial/industrial activities in those areas.

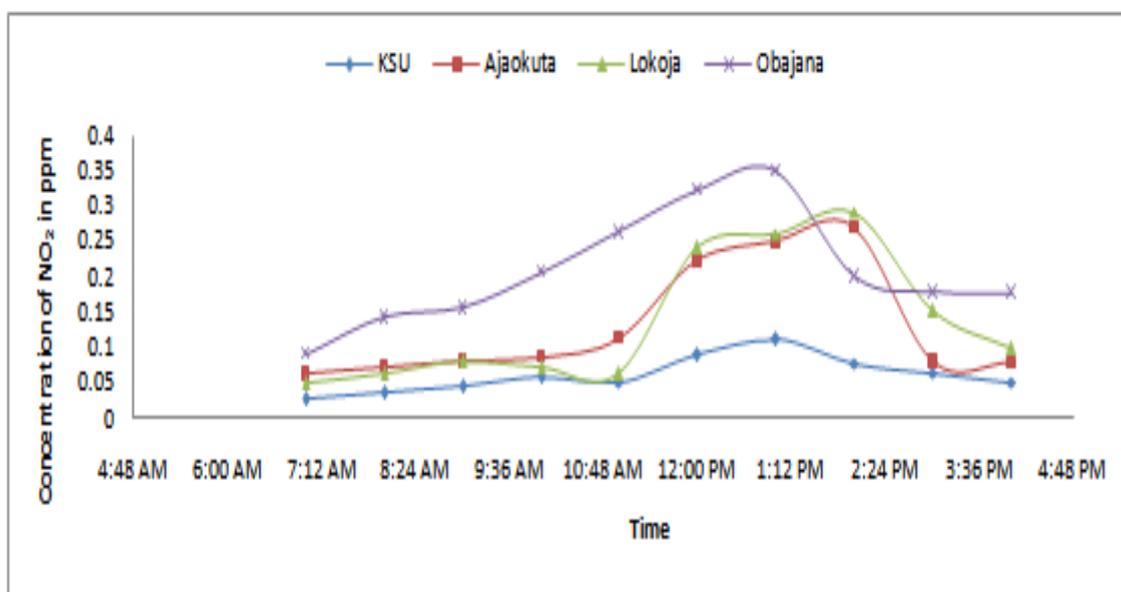


Table no 4: Shows daily hourly average concentrations of O₃

Sampling time	Opposite KSU Main gate(ppm)	Opposite WACL Ajaokuta (ppm)	Ganaja Junction Lokoja (ppm)	Dangote Cement Plant, Obajana (ppm)
7am – 8am	0.034	0.059	0.051	0.061
8am – 9am	0.045	0.063	0.062	0.066
9am – 10am	0.048	0.065	0.067	0.071
10am – 11am	0.055	0.078	0.075	0.082
11am –12pm	0.059	0.089	0.083	0.086
12pm – 1pm	0.063	0.091	0.089	0.210
1pm – 2pm	0.069	0.095	0.097	0.292
2pm – 3pm	0.072	0.078	0.080	0.109
3pm – 4pm	0.042	0.073	0.071	0.069
4pm – 5pm	0.035	0.055	0.060	0.063

Plot of table no 4 is shown below which gives the trend of O₃ for the locations. The values are increasing gradually until the peak hours which have the highest values for all the locations then decreases again. The ranges of O₃ concentrations for KSU, WACL, GJ and DCP were 0.034-0.072ppm, 0.059-0.095ppm, 0.051-0.097ppm, and 0.061-0.292ppm respectively. Three out of the four locations namely WACL, GJ and DCL have values higher than the permissible limits set by the USEPA and the Nigerian EPA.

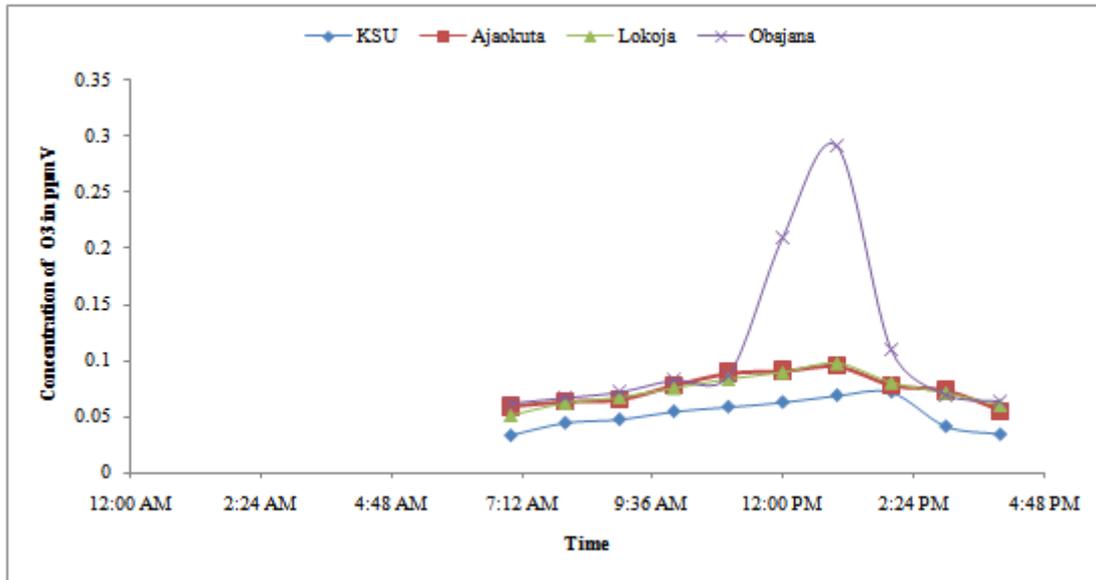


Table no 5: Show the traffic count during sampling across the locations

Location	7:12 AM	9:36 AM	12:00 PM	2:24 PM	4:48 PM
KSU	7520	7520	7520	7520	7520
Ajaokuta	7520	7520	7520	7520	7520
Lokoja	7520	7520	7520	7520	7520
Obajana	7520	7520	7520	7520	7520

Table no 6: Comparison of this study with the NAAQS of the USEPA

	KSU	WACL	Ganaja Junction lokojaDCP	Obajana
NO ₂ (ppm)	0.062(0.1*)	0.132(0.1*)	0.137(0.1*)	0.209(0.1*)
O ₃ (ppm)	0.052(0.07*)	0.075(0.07*)	0.079(0.07*)	0.111(0.07*)

The values outside the brackets are the overall average obtained from tables no3 and tables no 4 which corresponds to the daily hourly averages for NO₂ and O₃ respectively. The values in asterisks are the permissible limits set by the National Ambient Air Quality Standards (NAAQS) of the United State Environmental protection Agency (USEPA).

IV. Discussion

Table no 3 shows the dailyhourly average NO₂ concentrations for the four sampling locations in Parts per Million (ppm) for the period of study. The NO₂ concentration range of KSU Main gate was between 0.027-0.111ppm as shown in the table. The estimated traffic count at KSU Main gate was 7,520 during the sampling periods. Figure no3 shows the pattern of NO₂ variation across the sampling locations. that there was a steady

rise in NO₂ concentration from 7 am until it gets to the peak at 2pm and drops again until 5pm. The reason for the rise and fall in NO₂ concentrations at KSU Main gate was due to low number of vehicles flying the road in the early hours of the day which brings about the steady rise in NO₂ concentration in the morning hours of the day until the peak hour were vehicular movement and other sources of emissions is highest then drops towards the evening time when vehicular movement decreases.

The overall average NO₂ concentration for KSU Main gate in table no 6 is 0.062ppm which is within the permissible limits recommended by both Nigerian NAAQS and US NAAQS which is 0.1ppm. Likewise that of WACL Ajaokuta was between 0.062-0.271ppm as shown in same table. The estimated traffic count at WACL Ajaokuta was 3,310 within the sampling period (table 4.6) while the overall average NO₂ concentration for WACL Ajaokuta in is 0.132ppm which is above the permissible limits recommended by Nigerian NAAQS and US NAAQS. The NO₂ concentration at WACL Ajaokuta follow similar trend as KSU main gate explained earlier except that the highest value is at 2pm – 3pm (0.271) ppm which is the peak hour.

This location is an industrial area where ceramics materials are produced and also a busy route too for many motorists. The NO₂ concentration range of Ganaja Junction Lokoja was between 0.051-0.292ppm as shown in table no 3. The estimated traffic count at Ganaja Junction Lokoja was 11,244 within the sampling period. This is the capital city of Kogi State with the highest traffic count and the concentration of NO₂ exceeded the permissible limit. The NO₂ concentration range of Dangote Cement Plant (DCP) Obajana was between 0.092-0.351ppm and the estimated traffic count at Dangote was 5,000 within the period of sampling as shown in table no 5. The cement Plant is one of the largest cement plant in West Africa and its location is found here. The results of table no 6 shows DCP Obajana is the most polluted location of all the locations chosen with an overall average NO₂ concentration of 0.209ppm.

The result in Table no 4 shows the daily hourly average O₃ concentration of the four sampling locations. The pattern of rise and fall in the values of Ozone (O₃) is similar as in the case of NO₂ this is because O₃ is a secondary pollutant which is formed by the reaction of VOCs and NO_x in the presence of UV radiation from the sun. Hence as the Ozone precursors (VOCs and NO_x) are produced, this brings about the production of Ozone. Overall average of Ozone concentration at KSU main gate (0.052ppm) is within the permissible limits set by NAAQS by both the USEPA and the Nigerian EPA which is 0.07ppm as shown in table no 6. The other three locations have value above the permissible limit set by NAAQS by both the USEPA and the Nigerian.

V. Conclusion

This research has shown that Kogi State University is the least polluted because the ambient concentrations of the pollutants investigated (NO₂ and O₃) are within the permissible limits of the NAAQS of USEPA and the Nigerian EPA. The most polluted of all the locations is Obajana because the ambient concentrations of the pollutants investigated (NO₂ and O₃) are above the permissible limits of the NAAQS of USEPA, which is attributed to the Cement Factory in that location in addition to vehicular emissions. Evaluation of ambient air quality in the selected locations depict the pattern from more polluted to less polluted Obajana > Lokoja > Ajaokuta > Anyigba. We can also infer from the research that emissions from automobiles are the major source of air pollutants.

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