# AMBIENT AIR QUALITY AND NOISE POLLUTION MONITORING IN UYO METROPOLIS, AKWA IBOM STATE, NIGERIA

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**Abstract:** This study was carried out to monitor the air quality and noise pollution in Uyo, Akwa Ibom State, Nigeria in the wet season of 2015. The WHO and FMENV Standard/Criteria were strictly followed for the choice of sampling sites selection. The air pollutants under study were sampled three times daily for each sampling point (Morning, Afternoon and Evening). The research evaluated the variations of the air pollution in relation to the sampling locations and the researchers recommended that policy should be made by government for traffic control and traffic personnel training programme. Environmental education programme should be organized for the public. Policies to ban used/old automobile engines and polluting power generating plants should be made by the relevant authority

**Key Words:** Pollution , Population, Environmental laws, Monitoring, Concentration, Particulate matter,

## INTRODUCTION:

Air pollution in our cities has tremendously increased with rapid population growth, increase in both the commercial and private vehicles on our roads, incomplete combustion of fossil fuels, poor road network systems, industrialization and poor land use practice Ahove, (2006) as well as in proactive environmental laws and enforcement (Olowoporoku, 2011). About 22 deaths from carbon monoxide poison were reported by the Nigerian newspaper in the months of May and June 2008, and suffocation by CO fumes from power generators was cause of the death (Emmanuel,*et al.,* 2009). Air pollution levels exceed World Health Organizations (WHO). The relatively high levels of air pollution in our cities is alarming with annual average levels of total suspended particulates (TSP) at least three times as high as the WHO standards. The effects of particulate matter on human health have been noted by several scholars. Gobo *et al* (2012), Okecha (2000) and Efe (2005) asserted that high rate of respiratory diseases occasioned by increased $PM_{10}$ concentrations, were experienced by residents of most urban areas in Nigeria. Specifically, Efe (2005 and 2006) noted that residents of Refinery Road, commercial areas, traffic clogged areas and high density residential areas were the most affected.

Preservation of the environment is, therefore, essential for the very existence of the human bings. Proper management of the environment is the only way to ensure sustainable development in the society. It is therefore, essential to make the masses aware of the changes in the quality of our environment and strategies to prevent the situation from worsen further (Bhatia, 2011).

This study was carried out in accordance to the Federal and State Ministry of Environment and International Best Practice in order to ascertain the degree (if any) of the alteration of fresh/ambient air at the monitoring locations which may to some extent, impact on human life and the environment.

## OBJECTIVES OF THE PRESENT STUDY:

The objectives of the study shall include, to:

i. Monitor changes in existing physical and chemical characteristics of the air resources.
ii. Monitor the level of air pollutants (if any) in the study area in order to ascertain whether they are within safe levels (regulatory acceptable limits).

Determine if there are any pollutants above regulatory limits and whether they are from point or non- point sources.

Generate data that could provide early warning on environmental damage so that control/mitigation measures can be put in place to prevent or reduce risk to human health or deterioration of the environment.

**Description of the Study Area:**

Uyo lies between latitudes $4^{0}59^{I}$ and $5^{0}04^{I}$N and longitudes $7^{0}53^{I}$ and $8^{0}00^{I}$E (Fi . Uyo is said to situated on an elevation of about 60.96 meters (2090ft) above sea. The city is located at the centre of Akwa Ibom State and lies within the Tropical Rain Forest region, and enjoys the tropical wet and dry climate with two distinctive seasons (dry and wet). The location of Akwa Ibom State just north of the Equator and within the humid tropics and its proximity to the sea makes the State generally humid. On the basis of its geographical location the climate of Uyo, can be described as a tropical rainy type which experiences abundant rainfall with very high temperatures (Mmom, *et al.,*2014). There has been a corresponding increase in industrial activities in Uyo. Major industries in the city include small agricultural processing industries, plastic manufacturing industries, confectioneries, pharmaceutical and surgical companies, etc. On the other hand, there has been an increase in the number of vehicles for personal and commercial use in the town. Thus, traffic emission is expected to be a major source of air pollution in the town (Mmom, *et al.,*2014).

**CLIMATE AND METEOROLOGY:**

**Rainfall**

More than 80% of the total annual rainfall in the area is received between the months of May and October with the mean annual total exceeding 2500mm (FORMECU, 1998). The mean annual rainfall in the Niger Delta region is between 1500mm and 3500mm. The least rainfall is in December/January averaging between 20 – 75mm and highest in June/July ranging from 300 – 700mm. A bimodal pattern of rainfall is also observed with peaks in July and September. In this area, it is notably that rainfall during the wet season is often heavy. This encourages wet deposition of atmospheric pollutants, which also results in acid rain with its attendant environmental concerns. The acid rain more particularly is heaviest around Eket, EsitEket, Ibeno, Onna moving interland to Uyo, this is as a result of oil exploration in Ibeno and Eket area and the attendant gas flaring in the area.

**Relative Humidity**

Humidity describes the water vapour content of the atmosphere. Relative humidity is popularly used to measure air humidity. The recorded relative humidity values for this area indicated high relative humidity. This could be attributed to: nearness of the area to the coast; occurrence of cloud cover; influence of the moisture laden tropical maritime air mass; and influence of the South-West Trade Winds which dominate the area (Oguntoyinbo, 1978). The mean monthly relative humidity (%) in the area is Uyo where the study area is situated and is the reference for Humidity study.

The mean relative humidity is high during the rainy season with July through to September experiencing highest level of humidity in the year. This decreases further during the dry season months (December through February).

**Air Temperature**

Temperature is a dominant factor and air temperature varies from place to place over a period of time at a given location. The spatial distribution of temperature over the earth is influenced by: amount of insulation received, nature of surface, distance from water bodies, relief, nature of the prevailing winds and ocean current (Ayoade, 1988). The temperature in the study area is also characterized by little variation in mean air temperature.

The annual mean of daily maximum air temperature in the area ranged from 28.8°C to 30.2°C during this period. The hottest months are November to April (with means of maximum daily temperature by month ranging from $30.2^{0}$C to $31.3^{0}$C) while the coolest months are July to September (with mean maximum daily temperatures by month ranging from $27.0^{0}$C to $27.5^{0}$C), which coincide with the peak of the rainy season. The seasonal

temperature decline has been ascribed to an expression of the overall cooling of the South Atlantic and the Gulf of Guinea during this period of the year (Longhurst, 1964).

**Hydrogeology**

Uyo Local Government Area is within the elongated northwest-southeast rectangular basin known as the Imo-Kwa Ibo River Basin. The basin is principally underlain by the Deltaic, Benin, Ogwashi-Asaba and Ameki formations, and then by the Imo Shales, in that order (Offodile, 1992). The major aquiferous units are the Benin and Ameki formations. The Imo-Kwa Ibo Basin is confined to the northern edge by the Imo Shales while the Benin formation and the alluvial deposits of the Niger Delta appeared to be in hydrological contact (and thus provide combined aquiferous horizons) to the south.

**Table 1 : Mean Temperatures of Uyo and Calabar for the Selected Periods**

| Month | Uyo (1983 – 1997) | Uyo (1996 – 2008) | Calabar (1996 – 2008) |
|---|---|---|---|
| | Mean Temperature ($^0$C) | Mean Temperature ($^0$C) | Mean Temperature ($^0$C) |
| January | 26.8 | 27.5 | 27.3 |
| February | 28.4 | 28.4 | 28.2 |
| March | 2.3 | 28.1 | 27.2 |
| April | 27.9 | 27.5 | 27.3 |
| May | 27.3 | 27.0 | 27.0 |
| June | 26.8 | 26.0 | 26.1 |
| July | 26.0 | 25.4 | 25.2 |
| August | 25.3 | 25.1 | 24.9 |
| September | 25.7 | 25.5 | 25.1 |
| October | 26.2 | 26.2 | 25.8 |
| November | 26.9 | 26.7 | 26.7 |
| December | 26.7 | 27.0 | 27.1 |
| Mean | 26.9 | 26.7 | 26.7 |

**Source: University of Uyo Meteorological Station and Nigerian Meteorological Agency, Lagos**

**LITERATURE REVIEW:**

**Ambient Air Quality**

The ambient air quality seems to be complex and dynamic environmental processes. Its large temporal and spatial variations via to the changes in the emission from man - made and natural sources. It is also meteorology and specifies reaction to the puff or plume from the point source to its detection time. Topographic conditions have considerably influence as well. The air motion in the atmosphere can cause dilution of the air pollutant by dispersion. The medium which the air pollutant can be transported is the atmosphere. Other chemical reactions to produce secondary pollutants occur during air pollutants transport (Narayanan, 2009).

**Air Quality Index (AQI)**

The relative change in the group of air pollutants constituents concentration in two situations can be assessed by a measure of Air Quality Index (Chelana *et al,* 2002). The stipulated regulatory limits can be compared with the relative change in concentration of the air pollutants. Different countries have their AQI. The monitoring or modeling of air pollutants concentration in a given areas aids in calculating AQI. Different Colour codes are used to describe or range the air pollutants concentration. Thus, AQI is a colour coded chart which is used to classify the air quality of the study areas with the associated health implications. Presentation of data gathering during air quality field data monitoring to the public understanding has been one of the challenges in air quality studies. AQI is an index help for reporting air quality of the studying areas on the daily basis. It gives information about the

purity/cleanliness or the degree of the air pollutants of the areas with the associated health effects that might be a concern for individual.

**Table 2 : AQI and index interpretation**

| Index Values | Levels of Health Concern | Cautionary Statements |
|---|---|---|
| 0 – 50 | Good | None |
| 51 – 100* | Moderate | Unusually sensitive people should consider reducing prolonged or heavy exertion outdoors. |
| 101 – 150 | Unhealthy for Sensitive Groups | Active children and adults, and people with lung disease, such as asthma, should reduce prolonged or heavy exertion outdoors. |
| 151 – 200 | Unhealthy | Active children and adults, and people with lung disease, such as asthma, should avoid prolonged or heavy exertion outdoors. Everyone else, especially children, should reduce prolonged or heavy exertion outdoors. |
| 201 – 300 | Very Unhealthy | Active children and adults, and people with lung disease, such as asthma, should avoid all outdoor exertion. Everyone else, especially children, should avoid prolonged or heavy exertion outdoors. |
| 301 – 500 | Hazardous | Everyone should avoid all physical activity outdoors. |

*An AQI of 100 for ozone corresponds to an ozone level of 0.08 parts per million (averaged over 8 hours)

**Source : USEPA ( Air Quality Index Guidelines for the reporting of daily air quality)**

## METHODOLOGY:

### Research Design

The research was systematically designed to monitor the ambient air quality and noise pollution in Uyo to meet the current trend of rapid population growth and vehicular in-flow in recent time, to broaden the study scope to close the gap and complement some of the previous studies. The study was also designed to generate applicable data that could provide early warning on environmental damage so that control/mitigation measures can be put in place to prevent or reduce risk to human health or deterioration of the environment.

### Population of the Study Area

Uyo is a city and local government area. The city is a capital of Akwa Ibom state in South – South (Niger Delta) of Nigeria. The town became the capital of Akwa Ibom state on September 23rd 1987 following the creation of Akwa Ibom state from erstwhile Cross River state. The population according to the 2006 Nigeria census which comprise of Uyo and Itu is 436,606 while the urban area including Uraun is 554,906. The city has witnessed some infrastructural growth in the years since it became Akwa Ibom State capital Mmom, *et al.,*2014).

### Sample and Sampling Techniques

Field data was collected in line with standard procedures for air quality monitoring with calibrated portable air quality in-situ meters. Field data collection was carried out in line with recommended procedures for Environmental Data Collection in Nigeria FMENV, (1992) and DPR, (2002) and World Health Organisation's procedures for population density, topography, industrial clusters, and heavy traffic studies.

The sampling of the air quality and noise pollution was carried out on hourly basis for three (3) hours per sampling station (morning, afternoon and evening – peak, off peak and peak period). This was done in-situ by determining the air pollutants and noise level using a series of hand held (portable) air quality and noise level

monitoring equipment of different sensor for each air pollutant. The sensors were held at a height of about two meters in the direction of the prevailing wind. Short exposure of limits of three minutes were applied per single reading/monitoring of each air pollutant for all the air pollutants that were logged in, and the reading was recorded at stability.

**Air Quality Monitoring Criteria**

The following air quality criteria were chosen:

i. Federal Ministry of Environment (FMENV) guidelines for air quality monitoring, including the National Guideline for Environmental Audit (1991)
ii. Emissions and Hazardous Waste Management in Nigeria (1991).
iii. Akwa Ibom State Ministry of Environment and Mineral Resources Guidelines (AKEPWA Law No.8 of 2000).
iv. ISO 14001: 2004 Environmental Management System Standards.
v. World Health Organisation. Population density, topography, industrial clusters, heavy traffic guidelines.

**METHODS OF DATA COLLECTION/INSTRUMENTATION:**

**Sampling Equipment**

The sampling equipments used were portable digital hand held air quality and noise meters to monitor air pollutants and noise pollution.

The Aerocet 531S is a small, handheld, battery operated, and completely portable meter with detection limit of 1.0µg/$m^3$that measures$PM_{10,}$ $PM_{7,}$ $PM_4$, $PM_{2.5,}$ $PM_1$andTSP. The portable meter provides both particle counts and mass PM measurements as stored data logged values, real-time networked data, or printed result. Here, a known volume of ambient air is drawn through a glass fibre filter (20 x 25cm) of known weight under a fixed roof by means of a heavy duty turbine blower at a constant flow rate ranging from 1.1 – 1.7$m^3$/min. Re-weighing of the filter after sampling under controlled condition gives a direct measurement of particulate mass. Particulate matter having diameters (stoke's equivalent diameter) between 0.1 and 100µm are removed from the air stream by filtration on the glass fibre filter (Stoker *et al.,*1975). The concentration of the particulate is determined by dividing the mass of the SPM by the volume of air sampled (WHO, 1976).

The Series 500 monitor Aeroqual is a portable meter with the high sensitive replaceable sensors of different gaseous air pollutants. The portable meter measured Volatile Organic Compounds (VOCs), Nitrogen dioxide ($NO_2$), Sulphur dioxide ($SO_2$), Hydrogen Sulphite ($H_2S$), Carbon Monoxide (CO), Ammonia ($NH_3$) and Methane ($CH_4$) by the principle of light absorption and emission. The infrared waves length of the parameters are not the same (different).Nitrogen dioxide ($NO_2$) has0.001ppm detection limit, Methane ($CH_4$) detection limit is 1.0ppm while other air pollutants stated above have 0.01ppm detection limit.

**RESULTS:**

**PRESENTATION OF DATA:**

The results of respirable particulate matter (RPM) $PM_{10,}$ $PM_{7,}$ $PM_{4,}$ $PM_{2.5}$and $PM_{1,}$ Total Suspended Particulate (TSP) including gaseous air pollutants and noise level that were monitored in Uyo metropolis

**Gaseous Pollutants**

Variation of the Volatile Organic Compounds (VOCs) mean data were between 308.2-514.5ppm. This was higher than the mean value of 192.37ppm recorded at the control. The individual data for VOCs ranged from 147.8ppm - 841.0ppm. The individual site data was relatively higher than the control point. However, all the readings were below the FMENV permissible limit of 6000ppm. The highest mean concentration of VOCs was recorded at the Nwaniba Roundabout by Oron Road .

There was a noticeable variation in nitrogen dioxide ($NO_2$) mean concentration across the study locations, it varied between 0.13-0.56ppm. However, the individual concentrations at the study locations varied from < 0.001 – 0.7ppm across the monitoring sites (Fig. 4.3). The highest ambient concentration of nitrogen dioxide was noticed at the Itam Market by Goodluck Jonathan Flyover.

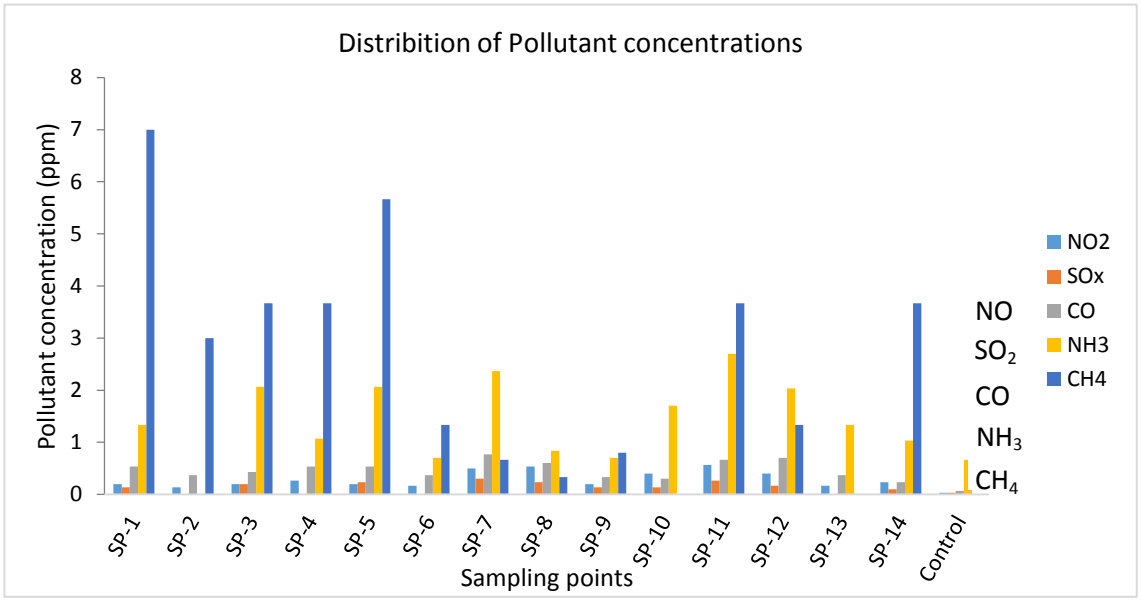


**Fig .1 : Morning, Afternoon and Evening Mean Values of $NO_2$, $SO_2$, CO, $NH_3$ and $CH_4$ of the Study Area**

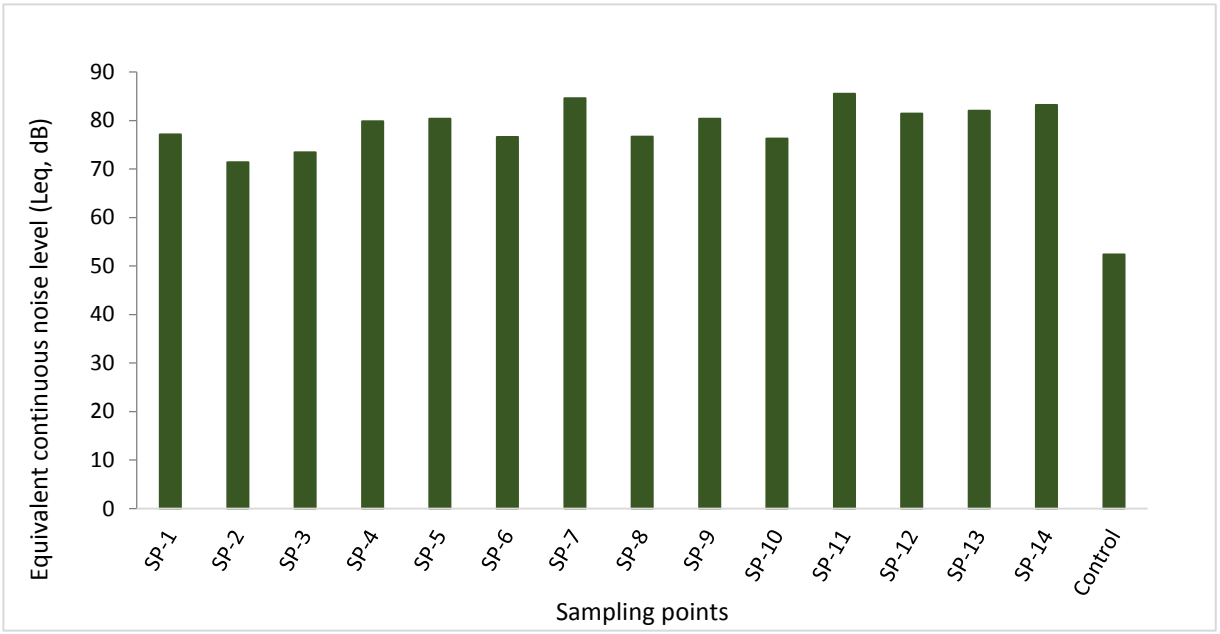


**Fig. 2: Morning, Afternoon and Evening Mean Values of Noise of the Study Area**

Mean concentration of sulphur dioxide ($SO_2$) varied between <0.01 - 0.3ppm. This was higher than the mean value of 0.03ppm recorded at the control point. The individual data for $SO_2$ ranged from <0.01ppm - 0.4ppm. The individual site data was relatively higher than the control. However, the concentrations of $SO_2$ in four (4) sampling locations were below the detectable limit of the equipment used. The highest mean concentration of $SO_2$ was recorded at the AkpanAndem Market by Udoumana.

Hydrogen sulphide ($H_2S$) was less than the detectable limit<0.01ppm of the instrument used at all the sampling sites. This is an indication of the low level of the gas in the study location.

Carbon monoxide (CO) mean concentration in the study location varied between0.3-0.76ppm. Sampling points 7 (Akpan Andem Market by Udoumana) recorded the highest mean concentrations of CO. The individual

concentration across the sampling points ranged from 0.2 - 0.9ppm. These values were more than 0.66ppm mean concentration of CO recorded within the control point(Fig. 4.3).

The mean concentration of ammonia ($NH_3$) ranged from <0.01-2.7ppm. Sampling point 11 (Itam Market by Goodluck Jonathan Flyover) recorded the highest mean value of $NH_3$. The individual concentrations of ammonia in the study location varied from <0.01 to 3.1ppm. The mean concentration of the control was 0.66ppm.

Methane ($CH_4$) concentration in the study area varied from individually from <1.0 –18.0ppm. The highest individual value was recorded within sampling point 1 (Four Lane Roundabout by Nwaniba Road). The mean concentration of methane varied from <1.0 –7.0ppm. The highest mean value was again recorded in sampling point 1 (Four Lane Roundabout by Nwaniba Road). The value recorded was higher than the control point which had <1.0ppm concentration of methane.

**Noise**

Mean variation of Noise was between 68.8- 84.9dB and was higher than the value in the control point which was 52.13dB. The highest mean value was recorded at Itam Market by Goodluck Jonathan Flyover. The individual noise levels measured at the study locations ranged from 60.2 – 88.7dB. The highest individual noise measurement was observed at the Itam Market by Goodluck Jonathan Flyover.

## DATA ANALYSIS:

### Effects of Meteorological Variables on Air Quality Parameters

The effect of the meteorological variables such as temperature **($^oC$),**wind speed **(m/s)** and humidity **(%)** on each of the air pollutants monitored at the study area during this research is calculated using regression analysis as presented below.

**i. Effects of Temperature ($^oC$), Wind speed (m/s) and Humidity (%) on $PM_1$**

$PM_1 = -29.398 + 1.890(T) – 4.573(W/S) + 0.014(H)$

$R=0.462$, $R^2 = 0.214$ (21.4%), $Adj.R^2 = 0.00$ (0%), p-value = 0.430.

Because the calculated p-value (0.430) is greater than the critical p-value (0.05), i.e. $p_{cal}$ (0.430)>$p_{crit}$ (0.05), it is concluded that the meteorological variables (temperature, wind speed and humidity) do not have significant effect on $PM_1$.

**ii. Effects of Temperature ($^oC$), Wind speed (m/s) and Humidity (%) on TSP**

$TSP= 2919.037 + 13.977(T) – 113.520(W/S) – 38.831(H)$

$R=0.709$, $R^2 = 0.503$ (50.3%), $Adj.R^2 = 0.367$ (36.7%), p-value = 0.046.

Because the calculated p-value (0.046) is less than the critical p-value (0.05), i.e. $p_{cal}$(0.046)<$p_{crit}$(0.05), it is concluded that the meteorological variables (temperature, wind speed and humidity) has significant effect on TSP.

**iii. Effects of Temperature ($^oC$), Wind speed (m/s) and Humidity (%) on VOC**

$VOC= -744.399 + 27.692(T) – 39.00(W/S) + 4.436(H)$

$R=0.437$, $R^2 = 0.191$ (19.1%), $Adj.R^2 = -0.030$ (-3.0%), p-value = 0.489.

Because the calculated p-value (0.113) is greater than the critical p-value (0.05), i.e. $p_{cal}$(0.489)>$p_{crit}$(0.05), it is concluded that the meteorological variables (temperature, wind speed and humidity) do not have significant effect on VOC.

**DISCUSSION:**

The discussion of the results of respirable particulate matter $PM_{10,}$ $PM_{7,}$ $PM_{4,}$ $PM_{2.5}$ and $PM_{1,}$ Total Suspended Particulate (TSP) including gaseous air pollutants and noise level that were monitored in Uyo metropolis are presented as follows.

**Gases**

The highest concentration of VOCs recorded at Nwaniba Roundabout by Oron Road could be attributed to the volume of diesel engines as a result of ongoing construction works at the study point(Fig. 4.2). However, the concentrations were generally lower than the FMENV permissible limit of 6000.0 ppm. Low concentrations of VOCs at a study site indicate the combustion engine is working in normal condition. VOCs are hydrocarbons used for fuelling of the generator. A smoking diesel engine indicates that more fuel is being injected into the cylinder than is being burnt and some of the fuels are only partially burnt; resulting in the emissions of unburnt carbon (Stern *et al.,*1973). The presence of VOCs in all the sampling sites was primarily due to congestion with people of different classes of business busy with their commercial activities and commercial vehicles including heavy trucks traffic at the of time monitoring could be attributed to detection of VOCs. Many studies including Ewona *et al.,* (2013) and Gobo *et al.,* (2012) also confirmed the possible presence of VOCs during heavy traffic. Hence this study is in agreement that high concentration levels VOCs are as a result of heavy traffic with high densely clustered people with commercial activities around the study location. This trend of relatively high values was observed during the peak periods (morning and evening) when many people were going and coming back from offices and other businesses.

Hence, this research is in agreement that high concentration levels of $NO_2$are as a result of heavy traffic with high densely clustered people with commercial activities around the study location. This trend of relatively high values was observed during the peak periods (morning and evening) when many people were going and coming back from offices and other businesses.

Akpan Andem Market by Udoumana recorded the highest concentration of CO due to the relatively high combustion from both diesel and PMS engines due to heavy traffic congestion and road intersection where long vehicular waiting was observed at the time of monitoring. Several researches including Ewona *et al.,* (2013), Udotong, (2015), Jimmy *et al.,* (2013), Gobo, *et al.,* (2012) and Akpan, (2014) also reported the same high values of CO at heavy traffic. The peak period was observed relative high values. Hence, the findings are in agreement that the concentration levels of CO result is due to heavy traffic with high densely clustered people with commercial activities around the study location. This was observed during the peak periods (morning and evening) when many people were going and coming back from offices and other businesses..

The highest mean concentration of methane in the study area was observed at Four Lane Roundabout by Nwaniba Road. The detection of $CH_4$ could be attributed to biogas from some Government approved dump sites. Several publications including Udotong, (2015), Ewona, *et al.,* (2013) and Hassan *et al.,* (2012) also reported the same reason for the presence of $CH_4$ in environment. Hence, this research is in agreement that the concentration levels of $CH_4$ are due to above source.

**Noise**

Noise values monitored during the study were relatively high in all the sampling locations as expected due to mechanical, vehicular movement, generator power plants, dense population and other noise associated activities. Itam Market by Goodluck Jonathan Flyover recorded the highest noise level. Heavy traffic with long waited vehicles and market activities could be the reason for the highest value of noise at this location. Various researches including Udotong, (2015) and Ewona *et al.,* (2013) also reported the same high values of noiseduring peak period. Hence, the findings are in agreement the noise levelrecordedis as a result of heavy traffic with high densely clustered people with commercial activities around the study location. This was observed during the peak periods (morning and evening) when many people were going and coming back from offices and other businesses

## CONCLUSION:

It was noted that most of the sampling points recorded air pollutants higher than both international and national acceptable standards/ limits.

Fossil fuel burning through exhausts releasing the air pollutants to the atmosphere by the means of generator power plants and transportation, such as private and commercial vehicles, heavy truck movement, high density population were identified as the primary sources of the air and noise pollution.

## REFERENCES:


1. Ahove, M.A.N. : The Nigerian Environment, National Open University of Nigeria, Lagos. Reagent Printing and Publishing Co. P 213. (2006).
2. AKEPWA. Law No.8 of : Akwa Ibom State Ministry of Environment and Mineral Resources Guidelines. (2000).
3. Akpan, P.E, Usip, E.E and Jeremiah, U.O (2014).Impacts of Traffics Volumes on Air Quality in Uyo Urban, Akwa Ibom State, Nigeria. Journal of environment and earth science vol. no. 21 P. 189 – 2000.
4. Akpofure, R. : Environmental Science – An Introduction. (2009).
5. Ayoade J.O. : Tropical Hydrology and Water Resources. (1988).
6. Bhatia, S.C. : Environmental Chemistry Published by Satish Kuma Jain and Produced by V.K Jain for New Delhi, India. (2011).
7. Canter, L. W.E. : Handbook of variables for Environmental Impact Assessment. Ann Arbour Science Publishers Inc. Ann ARBOUR. Mich. 48-106. (1977).
8. Chelana, A. B., Chalapati Rao, C. V., Phadke, K. M. and Hasan, M. Z., : Formation of an Air Quality Index for India. International Journal of Environmental Studies, 59: 331-342. (2002).
9. Community Conservation and Development Initiatives (CCDI) : Air pollution and Industrialisation in Nigeria, Ecology and Development Series number 01. edited by Ako Amadi. (2001).
10. Derek, H. and Oguntoyinbo, J.S.: Environmental Study of Uyo. (1987).
11. DPR. : Environmental Guidelines and Standards for the Petroleum Industry in Nigeria. Department of Petroleum Resources, Lagos, Nigeria. (2002).
12. Efe, S.I., : Urban Effects on Precipitation Amount, Distribution and Rain Water Quality in Warri Metropolis. Ph.D. Thesis, Dept of Geography and Regional Planning Delta State University Abraka, Delta State Nigeria. 2-47. (2005).
13. Efe, S.I., : Particulate Pollution and its Health Implications in Warri Metropolis. Delta State Nigeria. Env Anal. 11, 1339-1351. (2006).
14. Folorunsho, R. and Awosika, L.F. : Meteorological Induced Changes Along the Nigerian Coastal Zone and Implications for Integrated coastal Zone Management Plan. (1995).
15. FORMECU. : Assessment of Vegetation and Land Use Changes in Nigeria, Between 1976/78 and 1993/95. Unpublished Report by Germatizs International Inc, and Beak International Inc;36. (1998).
16. Gobo, A.E., Ideriah, T.J.K., Francis, T.E. and Stanley, H.O. : Assessment of Air Quality and Noise around Okrika Communities, Rivers State, Nigeria. Journal of Applied Science, Environmental Management (March 2012), 16: 75-83.
17. Hassan, S.M. and Abdullahi, M. E. : Evaluation of Pollutants in Ambient Air. A Case Study of Abuja, Nigeria. International Journal of Scientific and Research Publications. 2(12). 1-5. (2012).
18. ISO 14001. : Environmental Management System Standards. (2004).
19. Stern, A.C., Boubel, H. C., Lowry, R. W. Fundamentals of Air Pollution. Academic Press, New York. (1993).
20. Stoker, H.S. and Seager, L.S. : Environmental Chemistry, Air and Water Pollution. 2nd Edn. Scott Foresman and Co. Cleanview. (1975).
21. Udotong, J.I.R.: Air quality Assessment at Traffic Control Points in Uyo Metropolis, Nigeria – International Journal of Engineering and Technical Research (IJETR) vol. 3, p. 325-331. (2015).
22. USEPA: National Air Quality and Emissions Trends Report, 1998. Technical.