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Research Article

URBAN AIR POLLUTION EVALUATION AND MITIGATION: A CASE STUDY OF UYO CITY, NIGER DELTA, NIGERIA

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ABSTRACT

Air pollution has been identified as one of the most critical environmental problems confronting Uyo city. Traffic and industry are the major air pollution sources in the region. Impact on socioeconomic, ecosystems health, properties and climate have been linked with the pollution episodes in the area but which requires substantial scientific and empirical evidence. Multiple factors especially lack of equipment, inadequate skilled personnel and poor policy frame work have militated against effective and qualitative air quality studies in the area. To achieve long term goals for the region in this regard that would lead to the overall benefit of the people in the area, there is need therefore to employ a holistic and integrated approach to air pollution management that will involve all the stakeholders.

Keywords: Pollution, Uyo, Enviroment, Mitigation, Evaluation

INTRODUCTION

Air pollution can be defined as natural and anthropogenic substances in the atmosphere -air which exhibit negative impacts or effects on both biotic and abiotic inhabitants at the higher or unbearable concentration of the substances in the air. The atmosphere with its natural state has fixed a proportion of 0.03% of argon, 0.3% of carbon dioxide, 21% of oxygen and nitrogen with 78%. When these proportions of the natural state are altered with introduction of external substances such as gases, fume, aerosols, liquid drop or particulate matter from natural phenomenon (such as volcanic eruption) and man activities (such as burning of hydrocarbon), the atmospheric environment is polluted in direct proportion to the increase in concentration of the external substances being released into the atmosphere. These external substances which find their ways into the atmosphere to destabilize the natural ambient air level are known as air pollutants. Adverse effects of man's exploitation of natural resources to meet his needs have thus causes him and the ecosystem more harm than good. This is more expedient if not checked, monitored, controlled and evaluated on time for the policy decision making to caution man on his undue activities on the environment. Air pollution causes negative impacts which have local, regional, continental and global significance (Narayanan, 2009).

The focus of this research work is Uyo which is the capital of Akwa Ibom State. It may be pertinent to note that most residents of Uyo may not be aware of the level of air pollutants in the atmosphere in uyo, their effects on human life and the environment. Therefore, they show little or no concern about the quality of air they inhale.

Objectives of the Present Study:

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

Challenges of air quality studies in the Uyo city:

Air quality studies in the studied area are still in its infant stage and encumbered with several challenges. Other obvious and prominent drawbacks are as follows

- Lack of emissions inventory/database due to lack of consistent and systematic measurements
- Unavailability of air pollution and GHG monitoring stations in the Niger Delta. This is based on information from World Data Centre for Greenhouse Gases
- Few independent and research-based measurement data are not readily available for general public use
- Lack of collaboration between key regulatory authorities
- Laxity in the enforcement of emission regulations

- Air quality assessment and air pollution studies have focused mainly on urban centres

Significance of the Study:

Investigating air quality and noise level in the research work would entail monitoring and assessment of the presence and concentration of noxious gases in the study area. The gases include Volatile Organic Compounds (VOCs), Nitrogen Dioxide (NO_2), Sulphur Dioxide, (SO_2),Hydrogen Sulphide (H_2S), Carbon Monoxide (CO), Ammonia (NH_3) and Methane (CH_4), including Particulate Matter and Noise level at the selected sampling locations. This is necessary for this study because the noxious gases, particulate matter and noise are dangerous to human health and environment as detail below:

Carbon Monoxide (CO):

Carbon Monoxide (CO) is a colourless, odourless and tasteless gas produced by the incomplete combustion of carbonaceous materials or fossil fuels-gas, oil coal and wood. Adverse health effect has been observed with Carbon Monoxide concentrations of 12 – 17ppm for 8 hours Canter, (1977) while prolonged (45 minutes to 3 hours) exposure to concentration of CO between 200ppm and 800ppm often results in severe headache, dizziness, nausea and convulsions which might also lead to death (CCDI, 2001).

High Carbon Monoxide concentration can reduce the amount of Oxygen taken up by the brain to the point that the person becomes unconscious and can suffer brain damage from shortness of Oxygen, Carbon Monoxide may contribute to the green house effect and global warming (USEPA, 1990).

Carbon Monoxide (CO) is due to the incomplete combustion of Hydrocarbon. Reduction in the gaseous emission of generator will eventually lead to reduction in exposure level, as exposure to this toxic gas can lead to significant toxicity of the central nervous system and heart. It also has severe effect on the foetus of a pregnant woman (Wikipedia encyclopedia, 2006). It affects the transport of Oxygen by the blood; therefore care should be taken for it not to exceed the regulatory allowable limit.

Climate and Meteorology:

Visibility:

The weather in the area is cloudy on most days because of high relative humidity values recorded. Fogs are formed impairing visibility to less than 1km in June through September (the most humid months), morning mist is usually observed with visibility as low as 200m and remaining below 2km for a number of days, thus constituting a serious hazard to land and air transport. Generally, visibility, especially in the dry season is foggy in the early hours of the day (5 to 9am) and improves as the day progresses (Derek *et al.,*

1987).

Sunshine:

The mean sunshine in the area is between five (5) and six (6) hours in the dry season and three (3) to five (5) hours in the wet season (Ayoade, 1988). Uyo and neighbourhood experience a mean annual sunshine of 1406 which represents 31% of maximum possible amount of sunshine in the environment. The lowest values of sunshine are recorded between July and September with about 2 hours of sunshine per day due to greater amount of cloudiness in the sky (Ayoade, 1988).

Closely tied to the wet/dry season is the sunshine hour. The mean annual sunshine hour is over 1,500 hours. The longest monthly sunshine hours occur in December/January in the dry season while July usually expresses the lowest value. This is due to almost constant cloudiness from rain clouds in the wettest month. In general, the amount of net radiation can be a correlation of sunshine hours. The longer the number of sunshine hours, the greater the net radiation and therefore air temperature is highest during the dry season except when the relatively cold harmattan winds counteract this.

Geomorphology:

Flood plains, sandy ridge complexes separated by muddy swamp define the project area. Also, as in all Nigerian coastal states bordering the Atlantic Ocean, coastal erosion affects the vicinity of the project site because, the low-lying terrain consists of unconsolidated mud and sandy particles, which present no serious resistance to the impact of breaking waves and the flood currents associated with the shoreline. The groundwater depth ranges from about 1.5 to 6.0m while the natural near surface soil comprises very loose sand.

Month	Calabar	Uyo (The LGA were the study area is located)
	% Humidity	% Humidity
January	76	71
February	77	72
March	81	79
April	85	83
May	86	85
June	88	88
July	90	89
August	92	90
September	90	90
October	88	88
November	87	84
December	81	79
Mean	85	83

Table 1: Mean Monthly Percentage relative Humidity for Calabar and Uyo (1996 – 2008)

Source: Nigerian Meteorological Agency, Lagos

Air Polluted Areas in Nigeria:

The main sources of air pollution in Nigeria are the primary sources such as release of the air pollutants from the car exhaust, combustion of fossils fuels and construction operations as well as secondary sources of air pollution when the primary pollutants react chemically. The relatively high concentration of the air pollutants can easily be found in the major cities with high density population, commercial activities, industrial activities, construction works, agricultural activities, oil and gas exploration/ exploitation (Olowoporoku, 2011).

The high dominant commercial with dense population major cities in Nigeria is Lagos, Kano, Onitsha, Ibandan, Aba, Kaduna, Calabar and Markurdi etc. These cities are known for their commercial activities and high numbers vehicular movement, thus there is no doubt of air pollution in these cities.

The Niger Delta region of Nigeria which comprises Akwa Ibom, Delta, Rivers, Bayelsa, Edo, Imo, Abia and Ondo States are highly polluted with air pollutants from oil and gas activities and construction works.

Air Quality Index (AQI):

Air Quality Index is a measure or number use by a researcher to inform the public of the current degree of the air pollution and the health implication, or can be used to predict how the impact on

the air polluted areas will be. The high percentage of severe adverse health effects that will be experience by public is directly proportional to the increase in concentration of the air pollutants in Air Quality Index. Concentration of the air pollutants constituents in the study areas can be evaluated and used to calculate Air Quality Index. Air Quality Index is the vital tool to analyze and representing air quality status in a uniform manner. 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 classifies 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.

METHODOLOGY

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

iv. (AKEPWA Law No.8 of 2000).

v. ISO 14001: 2004 Environmental Management System Standards.

World Health Organisation. Population density, topography, industrial clusters, heavy traffic guidelines.

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.

Methods of Data Analysis:

The result of the air pollutants collected during the study was analyzed using descriptive statistics (Mean and Standard Deviation) and regression analysis.

Regression Analysis:

Let y represent the dependent variable (pollutant) and x_1, x_2 and x_3 represent the independent variables (which are the meteorological variables, in this case, temperature (^oC), wind speed (m/s), and humidity (%).

Mathematically,

$y = a_o + a_1x_1 + a_2x_2 + a_3x_3$

where, a_1,a_2, and a_3 are constants. Furthermore, a_0 represents the intercept on the vertical axis.

RESULTS AND DISCUSSION

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 are presented below.

i. **Effects of Temperature (^oC), Wind speed (m/s) and Humidity (%) on PM_4**

$PM_4 = 206.923 + 3.842(T) – 17.120(W/S) – 3.179(H)$

$R=0.638$, $R^2 = 0.406$ (40.6%), Adj. $R^2 = 0.245$ (24.5%), p-value = 0.113.

Because the calculated p-value (0.113) is greater than the critical p-value (0.05), i.e. p_{cal} (0.113)>p_{crit} (0.05), it is concluded that the meteorological variables (temperature, wind speed and humidity) do not have significant effect on PM_4.

ii. **Effects of Temperature (^oC), Wind speed (m/s) and Humidity (%) on $PM_{2.5}$**

$PM_{2.5} = 10.328 + 2.244(T) – 7.194 (W/S) – 0.437(H)$

$R=0.462$, $R^2 = 0.214$ (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 $PM_{2.5}$.Akpan Andem Market by Udoumana recorded the highest concentration of SO_2 because of the presence of relatively high volume of combustion activities 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 Various studies including Mmom *et al.,*(2014), Udontong, (2015) and Jimmy *et al.,*(2013) also reported the same high values of SO_2 during peak period. Hence, the findings are in agreement that the concentration levels of SO_2 is 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.

Sampling Points	**PM_{10}**	**$PM_{2.5}$**	**CO**	**SO_x**	**NO_2**	**Levels of Health Concern**	**Colours**	**Sensitive Groups**	**Health Effects Statements**
SP-1	57.4	85.8	6.1	0.2	2.3	Moderate		People with respiratory disease are the group most at risk.	
SP-2	85.1	118.4	4.2	0.0	1.5	Unhealthy for sensitive group			Unusually sensitive people should consider reducing prolonged or heavy exertion.
SP-3	64.7	117.9	4.9	0.3	2.3	Unhealthy for sensitive group			Unusually sensitive people should consider reducing prolonged or heavy exertion.
SP-4	85.4	100.5	6.1	0.0	3.0	Unhealthy for sensitive group			Unusually sensitive people should consider reducing prolonged or heavy exertion.

SP-5	94.2	140.5	6.1	0.3	2.3	Unhealthy for sensitive group			Unusually sensitive people should consider reducing prolonged or heavy exertion.
SP-6	81.7	106.0	4.2	0.0	1.9	Unhealthy for sensitive group			Unusually sensitive people should consider reducing prolonged or heavy exertion.
SP-7	98.4	98.5	8.7	0.4	5.7	Moderate		People with respiratory disease are the group most at risk.	
SP-8	77.6	41.6	6.8	0.3	6.1	Moderate		People with respiratory disease are the group most at risk.	

Table 2: Air Quality Index of the Study Area for Uyo Metropolis, Akwa Ibom State,

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.

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.

Itam Market by Gdluck Jonathan Fly Over recorded the highest mean value of NH_3. The presence of N_3 could be attributed to open dump for market rotten wastes, unclean gutter, septic tanks, household wastes, manures for agriculture, and agricultural and urban runoff (fertilizer) that were observed at the monitoring locations. Several works studies including Udotong, (2015), Gobo, *et al.,* (2012) and Hassan *et al.,* (2012) also reported the same rationale for the detection of NH_3 in our cities. Hence, this study is in agreement that the concentration levels of NH_3result is due to the above stated causes.ll 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.

The following values were obtained for gaseous pollutants; VOCs mean values ranged from 308.2 - 514.5ppm, NO_2 mean data recorded was between 0.13 - 0.56ppm, while SO_2 mean data was from <0.01 - 0.3ppm. H_2S mean value was <0.01ppm, the COmean values was between 0.23 - 0.76ppm. The mean data obtainedfor NH_3 was between <0.01 - 2.7ppm, while CH_4 mean values ranged from <1.0 – 7.0ppm and mean noise level ranged from 68.8-84.9dB. All these values recorded at the monitoring points for the air pollutants and noise pollution in the study area were higher than all the values recorded at the control point which are 50.73µg/m^{3}for PM_{10}, 30.4µg/m^3 for PM_7, 26.8µg/m^3 for PM_4, 18.7µg/m^{3}for $PM_{2.5}$, 9.2µg/m^3 for PM_1, 59.87µg/m^3 for TSP, 192.37ppmfor VOCs, 0.03ppm for NO_2, 0.03ppm for SO_2, <0.01ppm for H_2S, 0.66ppm for CO, 0.66ppm for NH_3, <1.0ppm for CH_4 and 52.13dB for Noise level. The highest values of $PM_{10}$was recorded at Itam Market by Goodluck Jonathan Flyover,PM_7 and PM_4 highestvalues were at Ekomiman Junction (Ikot Oku Ikono) while $PM_{2.5}$ and PM_1highest values were recoreded at Nwaniba Roundabout by Oron Road. TSP highest data was recorded at Itam Market by Goodluck Jonathan Flyover.

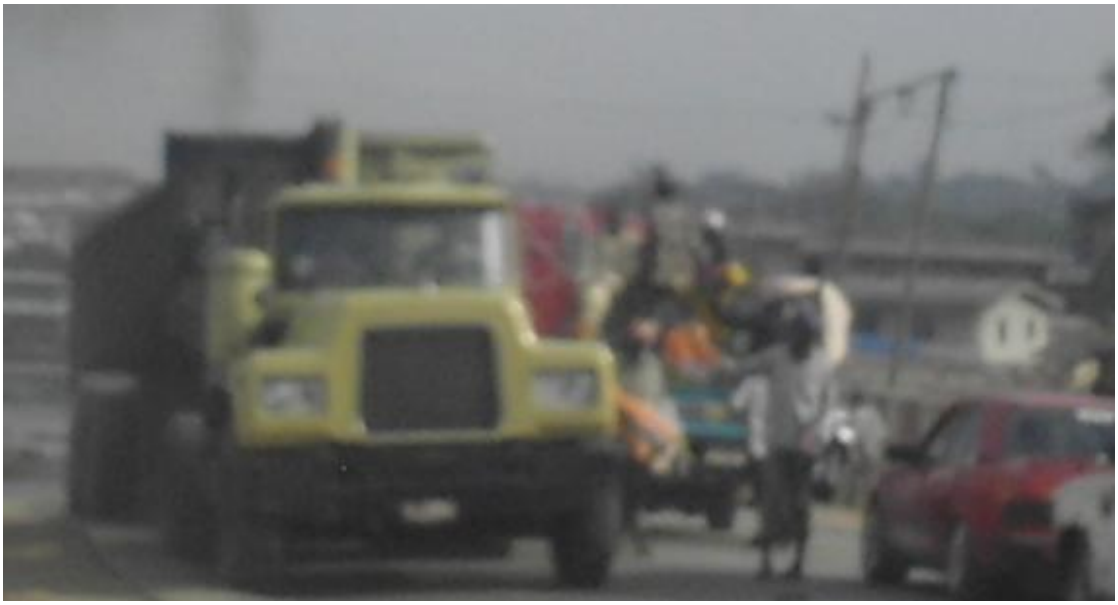
Proposed Mitigation Measures:

In order to improve on the current air quality monitoring and assessment programmes in Uyo Metropolis , there is need to embark on the following:

- Develop monitoring mechanisms, regulations and enforcement measures
- Institute planning policies to minimize pollution that may be caused by future development.
- Government agencies such as the Niger Delta Development Commission (NDDC) should collaborate with other multinationals and stakeholders in air pollution monitoring to come up with a comprehensive AQM scheme for the region.
- There should be a focus on the reduction of pollution levels from vehicles, industry, gas flaring and domestic burning of timber, to permissible levels as defined in national and international standards.

- The impact of air pollution from industrial and vehicular sources on the health of the communities in the region and its biodiversity needs to be researched in-depth.
- Existing air quality monitoring programmes should be re-examined and new ones introduced to determine the most effective means of mainstreaming national programmes with regional projects to improve air quality.
- Research on air quality should focus on source apportionment of the pollutants in the region
- In-depth epidemiological and toxicological studies using risk and exposure assessment tools need to be carried out to establish causalities between the air pollution exposure factors and the associated health problems.
- Motor vehicles annual testing and other regulations must be created or re-introduced and strictly enforced.
- Focus should be on air pollution models, real-time monitoring of pollutants and speciation of pollutants from the particulate matter.
- There is a need to engage in renewable energy, clean energy and cleaner air initiatives.
- Usage of emissions abatement control mechanisms by polluters should be enforced.

Some of the scenes of the study area:



Traffic emissions from busy urban roads

Cooking Fuel emissions from biomass combustion

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