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Air Quality Assessment at Traffic Control Points in UYO Metropolis, Nigeria

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Abstract— The contributions of toxic gases into the atmosphere from motor cycles, tricycles, motor cars and trucks were assessed at ten traffic control points in Uyo metropolis, Akwa Ibom State, Nigeria using portable digital air quality monitors (Gasman, UK). Gaseous emissions monitored in the study include CO, SO_2, NO_2, NH_3, H_2S and Cl_2 at ten sampling points (SP) and two control locations (with low traffic). Noise and other meteorological parameters were also assessed. The data generated were compared with the U. S. National Ambient Air Quality Standards (US NAAQS), Nigerian Ambient Air Quality Standards and the instruments alarm/precision levels. Highest mean concentrations of CO (35ppm), SO_2 (0.3ppm), NO_2 (0.4ppm), NH_3 (5ppm), H_2S (0.7ppm), HCN (2ppm), and Cl_2 (0.9ppm) were recorded in locations with heavy traffic as against the lowest mean values of CO (11ppm), SO_2 (<0.1ppm), NO_2 (<0.1ppm), NH_3 (2ppm), H_2S (0.4pmm), HCN (<1ppm), and Cl_2 (0.2ppm) at locations where the operation of these vehicles were minimal. Highest level of noise (66.6-110.6 dβ(A)), radiation (0.41mR/hr), and heat (542-544 Rad) were also recorded at locations with heavy traffic. Most of the gaseous pollutants measured at some of the locations were above the US NAAQS but below the instruments alarm levels. Results generated from this study, showed that operation of the various means of transports contributed significantly to high levels of gaseous pollutants at traffic control points in Uyo metropolis. The detailed gaseous emissions levels compared to statutory limits and the associated human health consequences are herein reported.

***Index Terms*— Air quality, Air pollution, Gaseous emissions, Traffic control points.**

I. INTRODUCTION

Air quality is the physical, chemical, and biological characteristics of air in the environment. It can also be related to how well the air can satisfy the three major requirements for human occupancy: thermal acceptability, maintenance of normal concentration of respiratory gases, and removal or dilution of contaminants to the level that is below health and odour discomfort threshold [1].

Air pollution occurs when air contains gases, dust, fumes or odour in harmful amounts which could be harmful to the health or comfort of humans and animals or which could cause damage to plants and materials. The degree to which a toxic air pollutant affects a person's health depends on many factors, including duration and frequency of exposures and the health susceptibility [2]. Air pollution is traced to prehistoric time when human first moved to temperate climate. They constructed shelter and use fire inside for cooking, lighting and warmth [3]. The fire led to a high level of air pollution as evidenced by the soot found in prehistoric caves [4].

The 1990 Clean Air Act (CAA) Amendment lists 188 toxic air pollutants that EPA is required to control. The list originally included 189 chemicals based on new scientific information, EPA removed caprolactam from the list in 1996, thus, the current list includes 188 pollutants. Examples of toxic air pollutants include benzene; which is found in gasoline, carbon monoxide, hydrogen cyanide, chlorine gas, ammonia, sulphur (iv) oxide, nitrogen (iv) oxide, perchloroethylene; which is emitted from dry-cleaning facilities, and methylene chloride; which is used as solvent and paint stripper by a number of industries. Examples of other listed air toxics include dioxin, asbestos, toluene, and metals such as cadmium, mercury, chromium and lead compounds [2]. The CAA, which was last amended in 1990, required EPA to set National Ambient Air Quality Standards (40 FR part 50) for pollutants considered harmful to public health and environment. It then established two types of national quality standards: the primary standards set limits to protect public health, including the health of sensitive populations such as asthmatic, children and the elderly and secondary standards which set limits to protect public welfare including protection against decreased visibility, damage to animals, crops, vegetation and buildings [2].

Primary air pollutants released gases into the atmosphere which directly pollute the air e.g. carbon monoxide from car exhausts and sulfur dioxide from combustion of fossil fuels while secondary pollutants are gases formed when primary pollutants in the atmosphere undergo chemical reactions e.g. photochemical smog.

Air is polluted from a number of sources which include area sources which consist of smaller sources, each releasing smaller amounts of toxic pollutants into the air [5]. These sources emit less than 10tons per year of a mixture of air toxics, e.g. neighborhood dry-cleaners and gas stations. Based on 1996 National Toxics Inventory data [6], major sources account for about 26% of air toxics emissions, smaller area sources and other sources (such as forest fires, etc) account for 24% and mobile sources account for 50%. Accidental release which also contribute air toxics to the atmosphere, are not included in these estimates [6].

A number of commercial and private vehicles ply the streets of Uyo metropolis. The numbers of these vehicles keep

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increasing by the day. Most of these vehicles are poorly maintained due to poor economic status and absence of emission monitoring standards. It is interesting to note that a number of petty traders stay around traffic control points to carry out their trading businesses [7]**.** They stay on this traffic control points from the wake of the day till night time (over 12 hours) when there are no more moving vehicles on the road.

Although a number of people are exposed to noxious gases at these traffic control points, little or no work has been done to see the levels of these gasses and hence estimate the effects on human health. The objective of this study was to establish the current state of Air Quality in Uyo metropolis with special reference to traffic control points. Data and information generated from this study will serve as baseline data for future air quality monitoring and planning.

II. MATERIALS AND METHOD

A. Description of Study Area

Uyo became a State capital of Akwa Ibom State on 23rd September 1987. Before now, it was a village in Cross River State, Nigeria. Since then, the population of residents in the metropolis has increased with increased traffic. Fig.1 shows the map of Uyo metropolis and the distribution of the sampling points.

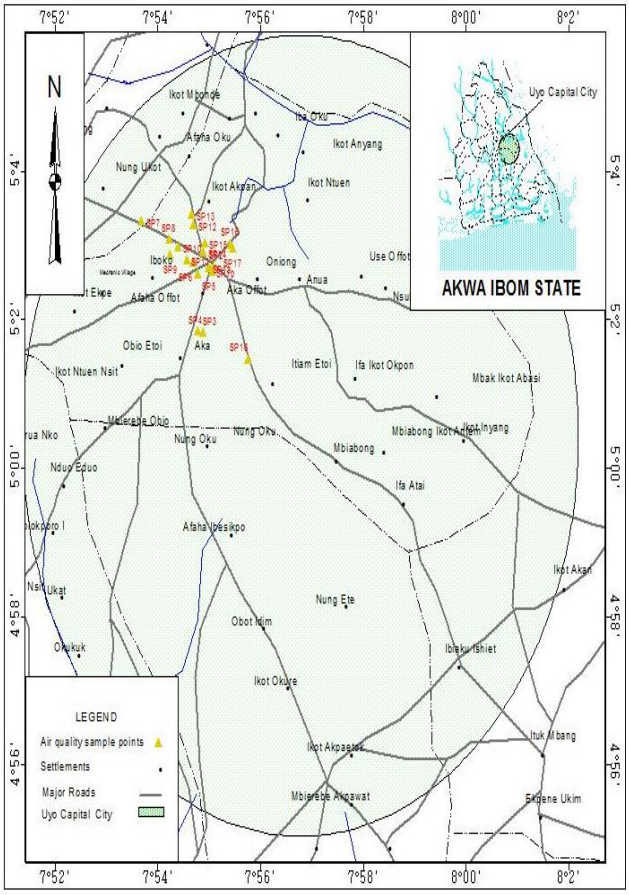

Fig. 1: Map of Uyo metropolis showing sampling points

Ten sampling and two control points were selected and geo-referenced for the monitoring study as shown in Table I.

TABLE I

GEOGRAPHICAL COORDINATES OF SAPLING STATIONS

LOCATIONS	NORTH	EAST
SP1	N 05 00’00”	E 007 05’19”
SP2	N 05 00’07”	E 007 05’16”
SP3	N 05 00’54”	E 007 05’57”
SP4	N 05 00’42”	E 007 05’09”
SP5	N 05 00’27”	E 008 00’10”
SP6	N 05 00’10”	E 007 05’27”
SP7	N 05 00’42”	E 007 05’49”
SP8	N 05 00’37”	E 007 05’36”
SP9	N 05 00’06”	E 007 05’08”
SP10	N 05 00’21”	E 007 05’18”
Sp11 (Control-1)	N 05 00’33”	E 007 05’21”
Sp12 (Control-2)	N 05 00’42”	E 007 05’37”

B. Equipment used and Parameters Measured at each Sampling point

The Growcon Gasman potable digital Air Quality monitoring equipments (Gasman, UK) were used. Their models and the respective gases they measured are as stated in Table II. At each sampling point, average of the air quality parameters listed on Table II, were obtained from three (3) measurements. Other meteorological parameters were measured by their respective instruments (Table II).

C. Quality Assurance/Quality Control (QA/QC) Measures Adopted

Appropriate quality assurance/quality control measures as directed by the equipment manufacturers were observed to ensure reproducibility of results. Also, for safety reasons, measurements were taken by the road sides using these calibrated potable gas meters. These gas meters were held above the shoulder level while taking readings. Readings in the instruments were allowed to stabilize before taking the final values.

TABLE II
EQUIPMENTS USED FOR THE AIR QUALITY STUDIES

PARAMETERS	EQUIPMENT'S MODEL	RANGE	ALARM LEVEL
Sulphur dioxide (SO_2)	SO_2 gas monitor mode 19648H	0-10ppm	2ppm
Nitrogen dioxide (NO_2)	NO_2 gas monitor model 19831H	0-10ppm	3ppm
Hydrogen sulphide (H_2S)	H_2S gas monitor model 19502H	0-50ppm	50ppm
Carbon monoxide (CO)	CO gas monitor model19252H	0-500ppm	50ppm
Hydrogen cyanide (HCN)	HCN gas monitor model19773H	0.25ppm	5ppm
Ammonia (NH_3)	NH_3 gas monitor model19730H	0-50ppm	25ppm
Chlorine gas (Cl_2)	Cl_2 gas monitor model19812H	0-5ppm	0.5ppm
Heat Radiation	Photometer (Lux meter). Model:- Lutron Lx-101 Lux meter	-	-
Noise	Noise level meter model auto-ranging Nm CO_2	-	-
Suspended particulate matter (SPM)	Haz-DustTm 10µg/m3 particulate monitor	0.1-200 µg/m3	-

III. RESULTS AND DISCUSSION

A. Field Data generated

The number of motor vehicles and tricycles at different sampling points (within 5 minutes intervals) were recorded (Table III). Figs. 2(a) and (b) show traffic build up at two of the ten sampling locations (SP3 and SP10). The busy and less busy times of the days were noted in the study. Generally, the study showed that there was no time that motor vehicles and tricycles at the less busy time outnumbered the ones during the busy times of the day.

The control locations were low traffic routes. Incidentally, no vehicle was found at the time of sampling. The results obtained from the study showed that there were more tricycles than motor vehicles in the metropolis both during the busy and the less busy times. For instance, the highest number of tricycles was 351 at SP6 (busy period). The same location also had the highest value of tricycles during the less busy time (229).

Analysis of the result also showed there was never a time that there were more vehicles or tricycles during the less busy time than the busy time. Three of the locations (SP3, SP6 and SP10) were found to have more motor vehicles and tricycles than any other locations at any time of the day. The least busy sampling location was SP8. This was however a one-way traffic route. Whereas the highest number of vehicles and tricycles were 129 (SP10) and 351 (SP6) during the busy

time, the corresponding values were 15 (SP8) and 11 (SP8) during the less busy times.

Fig. 2(a) Traffic Control point SP3

Fig. 2(b) Traffic Control point SP 10

The concentrations of the gaseous emissions and other meteorological parameters are shown in Table IV. The least level of noise was recorded at the control (SP 11) with minimum and maximum values of 36.3 and 80.6 dB(A) while the highest value was recorded at SP 3 with minimum and maximum values of 81.1 and 94.7 dB(A). Another location worth noting is SP 5 that had a noise level of 52.5 and 82.6 dB(A) for minimum and maximum values compared to the control points of 36.3 and 80.6 dB(A).

NO_2 concentration was highest at SP4 with a value of 0.40 ± 0.00ppm. The range for all the sampling locations was 0.20 ± 0.007 to 0.40 ± 0.00ppm. The two control locations however had values of <0.1 ± 0.00ppm (below detectable limits). Other values obtained were 0.37 ± 0.003ppm (SP 2) and 0.33 ± 0.030ppm (SP 9). Least values of 0.20 ± 0.007ppm and 0.23 ± 0.05ppm were obtained at SP 1 and SP 5, respectively. The fact that NO_2 was not detected at the control locations where there were no vehicles and tricycles suggests that vehicular emission sources contribute to air pollution in the metropolis.

SO_2 was detected in the ranges from 0.10 ± 0.00ppm (SP 3) to 0.33 ± 0.07ppm (SP 2). The value was equally low (0.13ppm) at SP 8. The concentrations at the two control locations were below the detectable limits. Hydrogen sulphide (H_2S) had a concentration of 0.30 ± 0.07ppm (SP1) and 0.06 ± 0.30ppm (SP 3). The two control locations however had values of 0.43 ± 0.03ppm and 0.50 ± 0.00ppm for SP 11 and SP 12, respectively. Since H_2S was recorded at all the sampling locations including the control locations, it is likely that there were contributions from some other sources other than vehicular emissions.

The concentration of CO was high at locations where traffic was much (SP3, SP4 and SP6) with values of 30.3 ± 0.05, 35.0 ± 0.00 and 35.0 ± 0.00ppm, respectively. Although traffic was also much at SP10, the level of CO was 21.0 ± 0.00ppm. The reason for the low CO is that most of the vehicles found at this sampling location were newer vehicles. SP10 controls vehicles in and out of the city (Ewet) housing estate. The distribution of NH_3 with values above 5.00ppm at SP1, SP2 and SP3 suggests an area effect. These 3 locations are within the same axis. There were also background concentrations of 2.0 ± 0.00ppm and 3.0 ± 0.00ppm at the control locations (SP11 and SP12). The value was also low at SP8 (2.0 ± 0.00ppm). This location is on the outskirt of the metropolis. Heat radiation was lowest at the control location (SP12) and highest at SP1. It was also high at SP6. On the whole, the study showed that there were emissions and other sources of air pollutants within Uyo metropolis, Nigeria.

TABLE III
NO OF VEHICLES AT TRAFFIC CONTROL POINT WITHIN 5 MINUTES INTERVAL

SAMPLING POINT	BUSY TIME (7-11AM)		LESS BUSY TIME (1-3PM)	
	VEHICLES	TRICYCLES	VEHICLES	TRICYCLES
SP1	48	163	19	60
SP2	27	77	16	34
SP3	66	275	37	148
SP4	33	126	24	66
SP5	20	40	14	35
SP6	115	351	54	229
SP7	34	94	29	57
SP8	15	20	11	18
SP9	47	86	38	75
SP10	129	235	106	220
SP11 (Control)	-	-	-	-
SP12 (Control)	-	-	-	-

TABLE IV
CONCENTRATIONS OF GASEOUS EMISSIONS AT TRAFFIC CONTROL POINTS

Sampling Points (sp)	Noise dB(A)	NO_2 (ppm)	SO_2 (ppm)	H_2S (ppm)	CO (ppm)	NH_3 (ppm)	Cl_2 (ppm)	Heat Rad	Rad mR/hr	HCN (ppm)
SP1	Min 71.5 Max 110.2	0.20±0.007	0.20± 0.00	0.30±0.07	24.0±0.00	5.3±0.30	0.5±0.00	709-712	0.33	1.0±0.00
SP2	Min 61.1 Max 110.6	0.37±0.003	0.33± 0.07	0.33±0.05	23.0±0.50	5.0±0.00	0.6±0.00	413-415	0.34	1.0±0.00
SP3	Min 81.1 Max 94.7	0.30±0.05	0.10±0.00	0.60±0.30	30.3±0.05	5.0±0.00	0.8±0.05	189-190	0.41	2.3±0.20
SP4	Min 66.6 Max 110.6	0.40±0.00	0.30±0.05	0.66±0.03	35.0±0.00	4.3±0.50	0.63±0.03	209-210	0.40	1.0±0.00
SP5	Min 52.5 Max 82.6	0.23±0.05	0.30±0.00	0.30±0.05	28.0±0.00	3.0±0.50	0.7±0.05	273-274	0.33	<1.0±0.00
SP6	Min 71.1 Max 90.9	0.30±0.05	0.23±0.05	0.57±0.00	35.0±0.00	3.0±0.20	0.9±0.00	542-544	0.34	1.0±0.00
SP7	Min 73.1 Max 89.7	0.20±0.00	0.20±0.00	0.50±0.05	20.0±0.50	4.3±0.50	0.7±0.00	191-192	0.34	1.0±0.00
SP8	Min 67.5 Max 90.9	0.27±0.07	0.13±0.03	0.53±0.03	28.0±0.00	2.0±0.00	0.5±0.00	109-110	0.32	<1.0±0.00
SP9	Min 66.6 Max 86.2	0.33±0.03	0.30±0.05	0.30±0.00	25.6±0.30	3.0±0.50	0.53±0.03	068	0.33	<1.0±0.00
SP10	Min 70.6 Max 89.2	0.27±0.05	0.20±0.00	0.40±0.00	21.0±0.00	3.7±0.50	0.4±0.00	035	0.34	<1.0±0.00
SP11 (Control)	Min 36.3 Max 80.6	<0.1±0.00	<0.1±0.00	0.43±0.03	11.3±0.30	2.0±0.00	0.2±0.00	051	0.40	<1.0±0.00
SP12 (Control)	Min 53.7 Max 88.2	<0.1±0.00	<0.1±0.00	0.50±0.00	11.6±0.30	3.0±0.00	0.4±0.00	024	0.25	<1.0±0.00

B. Comparing the Field Data with National Air Quality Standards and other Air Quality Studies

A comparison was made between the results obtained from this work and other researches carried out in other parts of the world and the National Ambient Air Quality Standards. The National Air Quality Standards (Table V) sets the concentration of carbon monoxide (CO) at 9ppm exposure level for 8 hours and 35ppm for 1 hour. In this study, a value of 35ppm was obtained at SP4 and SP6. Individuals living or doing businesses around these traffic control points are exposed to these levels of carbon monoxide for more than one hour. Also, the exposure concentration for 8 hour is supposed to be 9ppm. Values well above 9ppm were recorded for all the sampling locations and individuals are certainly exposed for more than 8 hours. This could have negative effect on humans [8]. The value set for Nitrogen dioxide (NO_2) for 1 hour is 0.1ppm. The highest value of 0.4 ppm was obtained at SP4 while the least value of 0.2ppm was obtained for SP1, SP4 and SP7. The values were however below 0.1ppm at the control locations. The concentrations set for sulphur dioxide (SO_2) in the national air quality standards is 0.03ppm. Values

obtained from this study were all above this set standard with the highest value being 0.33ppm and the least value of 0.10ppm.

A comparative assessment of ambient air quality in two urban areas (Fahaheel and Al-Riqa) adjacent to petroleum upstream / downstream facilities in Kuwait was undertaken (Table VI). The parameters considered were O_3, NO, CO, SO_2 and the results obtained showed that emissions from downstream facilities and vehicular traffic on Fahaheel highway were the main contributors of air pollutants [9].

C. Health Effects of Air Quality due to vehicular traffic

People who are exposed to toxic air pollutants at sufficient concentrations and long durations may increase their chances of getting cancer as have been reported in China [10], India [11] and in Mexico [12]. Other health effects are also experienced, depending on which air toxics an individual is exposed to [8] [13]. These health effects can include damage to immune system as well as neurological and reproductive damages such as infant mortality and low birth weight which have been reported in rural Guatemala [14] and effect on infant mortality [15], Mexico [16] and United State [17]. Other health effects include developmental and respiratory disorder such as acute lower respiratory infections [18], upper respiratory infections and otitis media [19], Chronic pulmonary disease [20], and cataract [21]. A growing body of evidence indicates that some air toxics (e.g. dioxins, and mercury) may disturb hormonal (or endocrine) systems. In some cases this happens by pollutants either mimicking or blocking the action of natural hormones. Health effects associated with endocrine disruption include reduced male fertility, birth defects and breast cancer [2].

D. Environmental Effects of Air Quality

Toxic pollutants in the air deposited on soils and surface waters can have a number of environmental impacts. Like humans, animals can experience health problems if they are exposed to sufficient concentrations of air toxics, overtime. Numerous studies conclude that deposited air toxics contribute to birth defects, reproductive failures and diseases in animals. Persistent toxic pollutants are of particular concern in aquatic ecosystems because the pollutants accumulate in sediments and may be biomagnified in tissues of animals at the top of the food chain to concentrations, many times higher than in the water or air [2].

TABLE V
NATIONAL AIR QUALITY STANDARDS

	Primary Standard		Secondary Standard
Pollutants	Level	Averaging Time	Level / Averaging Time
Carbon Monoxide	9ppm(10mg/m3)	8-hour	None
	35ppm(40mg/m3)	1-hour	
Lead	0.15µg/m3	Rolling 3-Month Average	Same as Primary
	1.5µg/m3	Quarterly average	Same as primary
Nitrogen dioxide	53ppb	Annual (Arith Av)	Same as primary
	100ppb	1-hour	None
Particulate matter (Pm10)	15oµg/m3	24-hour	Same as primary
	15oµg/m3	Annual (Arith Ave)	Same as primary
Particulate matter (Pm2.5)	35 µg/m3	24-hours	Same as primary
Ozone	0.075ppm(2008std)	8-hour	Same as primary
	0.08ppm(1997std)	8-hour	Same as primary
	0.17ppm	1-hour	Same as primary
Sulfur Dioxide	0.03ppm	Annual (Arith Ave)	0.5ppm/3-hour

TABLE VI
KUWAIT AIR QUALITY STANDARDS / STUDIES AT FAHAHEEL AND AL-RIQA

Pollutant	KUEPA hourly limit (ppb)	Number of exceedances (year, area)	Reference
SO_2	170 (0.17ppm) 0.33 ppm 0.10 ppm	4(2004, Fahaheel) 2(2004, Al-Riqa) 18(2005, Fahaheel) 12(2005, Al-Riqa)	KUEPA, law 210/2001

H_2S	140 (0.14ppm) 0.66 ppm 0.30 ppm	6(2004, Fahaheel) 2(2004, Al-Riqa) 25(2005, Fahaheel) 9(2005, Al-Riqa)	KUEPA, law 210/2001
O_3	80 (0.08ppm)	416(2004, Fahaheel) 122(2004, Al-Riqa) 154(2005, Fahaheel) 55(2005, Al-Riqa)	KUEPA, law 210/2001
NH_3	800 (0.8ppm) 5.3 ppm 2.0 ppm	None(2004, Fahaheel) None (2004,Al-Riqa) 1(2005, Fahaheel) None (2005, Al-Riqa)	KUEPA, law 210/2001

Source: Salem and Al-Khan, 2008

IV. Conclusion

Results obtained from this study showed that the air quality of Uyo metropolis is, in the most part, outside the NAAQS as at the time of the study. However, it would be necessary to monitor air quality on an hourly, daily, weekly and monthly basis to determine the air quality trend in the metropolis.

There is the need for a comprehensive and regular monitoring of the air quality in Uyo metropolis. A regional air quality monitoring programme like the Niger Delta Air Quality Monitoring programme sponsored by NDDC and implementation / enforcement of National Motor vehicles Emissions Standards are recommended.

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