Scientia Africana, Vol. 13 (No.1), June 2014. Pp120-137
 ISSN 1118 - 1931

AIR QUALITY IN PARTS OF THE UNIVERSITY OF PORT HARCOURT, RIVERS STATE

*** A. C.Tse and A. C.Oguama**

Department of Geology, University of Port Harcourt, Nigeria
**Corresponding author. E-mail akaha.tse@uniport.edu.ng*

Received: 26-08-13
Accepted: 05-02-14

ABSTRACT

The quality of air in the University of Port Harcourt was assessed in forty-one (41) locations spread out among the three major campuses in confined (offices and laboratories) and unconfined (surroundings of offices and the main business areas) environments exposed to prolonged emissions from fossil fuel powered generating machines. The aim was to determine how clean or polluted the air is, and what associated effects might be of concern. A multi-gas monitor, IBRID MX6 model was used to measure the concentrations of Carbon monoxide (CO), Carbon dioxide (CO_2), Ammonia (NH_3), Sulphur dioxides (SO_2), Ammonia (NH_3), Nitrogen dioxides (NO_2), Hydrogen sulphide (H_2S), Methane (CH_4), Volatile Organic Carbons (VOC) while an Aerosol Mass Monitor, GT-531 model measured Total Suspended Particulates which include PM_1, $PM_{2.5}$, PM_7, PM_{10}, and suspended particulate matter, SPM. Results reveals that among the three campuses, Choba Campus business area recorded anomalously high concentrations of SO_2, NO, CO, CO_2 outdoors well above regulatory limits, with CO and CO_2 having the highest values. Choba Campus and College of Graduate Studies were poor in terms of high indoor VOC concentration. The Air Quality Index which tells how clean or polluted air is, rated the air quality in the university as very poor in terms of NO, NO_2, and SO_2. There is correlation between the pollution patterns and levels and the type and levels of human activity. CO_2 and SO_2 and NO_2 have higher concentrations in areas with high emissions from generators where business centres continuously operate generators for their electricity supply. It is proposed that to reverse the trend of air quality impairment and the global warming contributions of the gases identified in this study, the shift to cleaner energy sources is imperative.

INTRODUCTION

Air pollution has been identified as one of the most critical environmental problems confronting the Niger Delta area especially from industrial and vehicular emissions and gas flaring (Tawari and Abowei, 2012). Due to the increase in commercial activities in the University of Port Harcourt, and the dependence on generators as sources of power supply for the functioning of machinery in the business units, a large unquantified amount of emissions from burning of fossil fuels from these generators occur.The use of fossil fuels to meet the world's energy needs is a contributor to an increase in greenhouse gases mainly carbon dioxide (CO_2) and methane in the Earth's atmosphere which is leading to climate change, with adverse effects on the environment. According to Akuro (2012), thequality of air around a location may be impacted by activities such as burning of fossil fuel by waste gas flaring from oil production facilities, burning of fuel in the operation of high capacity power generators for long periods and emissions from vehicles. In the University of Port Harcourt, the use of these generators for very periods of hours and even days is a consequence of the non availability of power supply from the national grid which causes long periods of power outages running into hours, days or weeks. Emissions from these generators include sulphur dioxide, oxides of nitrogen, and carbon monoxide in addition to unburnt fossil fuel that may be presented as suspended particulates and soot. These constitute threat to human health in the environment as a whole, and are sources of air pollutants with potential for effective contribution to climatic change. Urban air pollution has been identified as a critical public health problem by the World Health Organization (WHO) and other international agencies. The consequences of air pollution on public health and property are measured not only in terms of sickness, death and lost productivity but also hinder economic growth by imposing significant additional operating costs on business, industry, households, and public services. This has been supported by evidence from the work of Ana et al (2005) who have shown the deleterious impact of poor air quality on the health of some factory workers.Also, Ideriah and Stanley (2008) studied air quality around cement industries in Port Harcourt and identified the high health risk posed by the concentrations of NO_2 and suspended particulate matter above regulatory limits. Other than reduction in the quality of life, air pollution also accelerates the loss in quality of buildings and historic monuments and puts a strain on sustainable urban development, which includes economic growth, social inclusion, human well-being, and the environment. Urban emissions are major contributors to the problems of ozone layer depletion, global warming and climate change through CO_2 emissions.The ambient air quality of industrial areas of Nigeria for criteria pollutants CO, NO_2, SO_2, O_3, Particulate Matter, and Pb were monitored by Osuji and Avwiri (2005) whofound all of them to be very high as compared to World Health Organization Air Quality Guideline. Tawari and Abowei (2012) also produced data to show that the major air pollutants in Niger Delta area are CO_2, CH_4, SO_2, N_2O, NO_2, NH_3, VOCs) and Particles (PM10, PM2.5), Primary Aromatic Hydrocarbons, (PAHs) and Heavy metals. For these foregoing reasons, indoor and outdoor air quality measurements were carried out to assess the concentration of gases in the environment of the University of Port Harcourt in order to generate data on representative concentrations of air pollution in the locations and the impact of specific businesses, in this case, emissions from generators used in business centres. This was achieved by measuring the air quality indicators, including these gases (NH_3, H_2S, VOC, CH_4, SO_2, NO, CO, CO_2) and particulates (PM_1, $PM_{2.5}$, PM_7, PM_{10}, SPM) in strategic parts of the university environment including offices and business areas. Temperature and humidity and the prevailing wind speed and directions were also determined. The measured concentrations of the various parameters were compared with WHO (2000) and FEPA, now Federal Ministry of Environment, FMENV (1991) air quality guidelines which are designed to offer guidance in reducing the health impacts of air pollution.The results of the study are intended to inform the University policy-makers and to provide appropriate targets for policy options on air quality management in different parts of the university.

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MATERIALS AND METHODS

Description of the Study Area

The University of Port Harcourt lies between latitudes $4^{0}45'$ and $4^{0}45'$N and $6^{0}53'$ and $6^{0}58$E. And is organised into three satellite campuses: University Park (known locally as Abuja), Delta Park and Choba Park (Fig1). These campuses house hundreds of generators which often operated in the immediate vicinity of offices, laboratories and business centres for power supply whenever there is failure or non availability of public power.

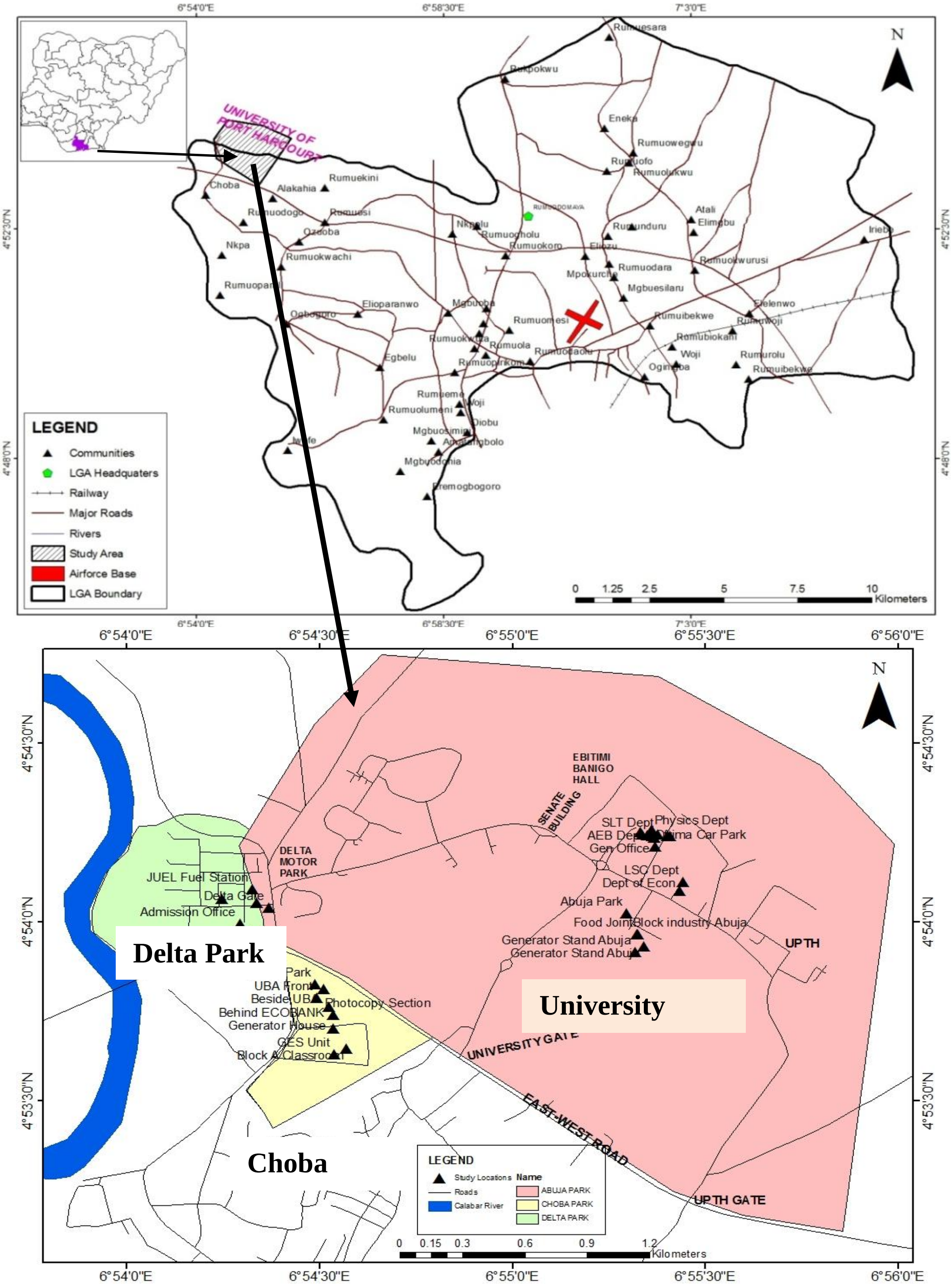

Fig 1: Map of University of Port Harcourt showing the sampling locations.

Two motor parks serving vehicles for commercial purposes are located in Choba and Abuja Parks. Open air incineration of office generated wastes, mainly paper, is also routinely carried out in the three campuses. The intersection of the East-West and the NTA-Choba roads located between Choba and Delta parks often experiences traffic gridlocks with attendant effects of increased vehicular emissions. The university is surrounded by the industrially quiet villages of Aluu to the North, Choba to the South, Rumuekini/Rumuosi and Alakahia to the East and the new Calabar River separating Emohua village to the West. The Niger Delta region within which the university is located has a tropical climate characteristic of the type found Southern Nigeria which is essentially warm and humid throughout the year.The year is characterised by rainy and dry seasons. Although rainfall occurs mainly during the rainy season from April to October, other months are not free from occasional precipitation. During the period of field observations and measurements, the temperature for the twenty four hour period varied from 28.4 to 34.7°C with an of average 28°C. Generally, average annual rainfall in Port Harcourt area is about 2500mm and the prevailing wind is south westerly (Ogba and Utang, 2009). Thus the wind blows from the south, which is the direction of the Atlantic ocean. The pattern is such that daytimes are relatively windy compared to generally calm nights. Wind speeds in Port Harcourt are lowest between October and January (1.6-1.8m/s) and highest between February and September (2.1-2.3m/s) with a mean of 2.0m/s. The wind speeds give rise to pressure variation between 1005 and 1009 millibars which occur at a minima at dawn and maxima in late afternoon. During high pressure systems, the air is usually still which allows pollution levels to build up but during low pressure systems the weather is often wet and windy, causing pollutants to be dispersed or washed out of the atmosphere by rain.

During this study, relative humidity of 72-82% and 67-78% were recorded indoors and outdoors respectively. The maximum value of 83.5% occured in the morning while the minimum (60.9%) occured in the afternoon. Relative humidity exerts tremendous influence on the emission of gaseous substances into the atmosphere and also plays a key role in the determination of sizes of suspended particulate matter (SPM).

Method of Study

Field measurements were carried out between 9am and 6pm, from 9thto 13th of July 2012 at different locations in the three main campuses of the university: University Park (known locally as Abuja), Delta Park and Choba Park. A multi-gas monitor, IBRID MX6 model was used to measure the concentrations of Carbon monoxide (CO), Carbon dioxide (CO_2), Ammonia (NH_3), Sulphur dioxides (SO_2), Ammonia (NH_3), Nitrogen dioxides (NO_2), Hydrogen sulphide (H_2S), Methane (CH_4), Volatile Organic Carbons (VOC) while an Aerosol Mass Monitor, GT-531 model measured Total Suspended Particulates, which include PM_1, $PM_{2.5}$, PM_7, PM_{10}, and suspended particulate matter, SPM. These air quality indicators were measured and monitored in confined (indoor) and unconfined (outdoor) environments which experience use of premium motor spirit powered generating machines for long periods of time due to power outages from the national grid. Confined environments were mainly staff offices and laboratories while outdoor sites were surroundings of these offices and the business areas where commercial activities are carried out, especially in Choba park. The measurements were taken at the prevailing relative humidity and ambient temperature which were measured using a pocket weather tracker (Kestrel 4500NV Model). Also Garmin Map76 model hand

Scientia Africana, Vol. 13 (No.1), June 2014. Pp120-137
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held Global Positioning System equipment was used to record the coordinates of the study locations. Measurements were done by holding the sensor to a height of about two meters in the direction of the prevailing wind for 1 – 2 minutes at the centre of each of the mapped out sections and recording the values as soon as instrument readings were steady. Results obtained were used to calculate the Air Quality Index, AQI as defined by USEPA (USEPA 1993, 2000, 2007) where

$$AQI_{pollutants} = \frac{\text{pollutant data reacting}}{\text{standard}} \times 100 \quad ...(1)$$

RESULTS

The air quality data at different locations in the 3 campuses are shown in Tables 1-5 and summarised in Table 6. These were compared to FEPA (1991) guidelines and standards for environmental pollution in Nigeria and WHO (200, 2005, 2010) air quality guidelines.

Table 1. Outdoor air quality data in Choba Park

S/N	Location	Coordinates	NH_3	H_2S	VOC	CH_4	SO_2	NO_2	NO	CO	CO_2	PM_1	$PM_{2.5}$	PM_7	PM_{10}	SPM	Temp (^0C)	Humidity (%)
1.	Business area I	N04 53' 50.8" E006 54' 29.1"	1	0	3.5	0	0.2	0	4	32	500	0.001	0.007	0.04	0.085	0.163	33.9	61.2
2.	Business area II	N04 53' 49.6" E006 54' 29.4"	2	0	3.7	0	0	0	4.8	20	300	0.1	0.027	0.074	0.142	0.265	30.8	67.4
3.	Beside UBA Bank	N04 53' 48.8" E006 54' 30.7"	1	0	3.7	0	0.2	0	5.5	48	0	0.001	0.009	0.051	0.063	0.079	32.1	65.2
4.	Front of U B A	N04 53' 47.3" E006 54' 29.7"	1	0	3.8	0	0	0	5.4	0	100	0.002	0.036	0.135	0.180	0.229	31.7	65.4
5.	Behind Eco Bank	N04 53' 45.8" E006 54' 31.5"	2	0	3.9	0	0	0	5.5	0	2200	0.001	0.008	0.069	0.103	0.148	31.1	71.2
6.	Block A, last class	N04 53' 38.8" E006 54'34.8"	2	0	3.9	0	0	0	5.4	0	300	0.001	0.004	0.017	0.021	0.027	30.1	68.2
7.	Photocoping stand, Choba car park	N04 53' 42.2" E006 54'32.2"	1	0	4.1	0	0.4	0	5.2	193	200	0	0.004	0.012	0.012	0.019	34.7	60.9
8	GES Unit (control)	N04 53' 37.8" E006 54'32.4"	2	0	4.1	0	0	0	5.1	0	0	0	0.005	0.015	0.021	0.037	29.4	72
	FEPA (1991) standards				3		0.2		0.06	20	1000				15			

Unless stated, all measurements in ppm

Table 2 Indoor air quality data in University Park

S/N		**NH_3**	**H_2S**	**VOC**	**CH_4**	**SO_2**	**NO_2**	**NO**	**CO**	**CO_2**	**PM_1**	**$PM_{2.5}$**	**PM_7**	**PM_{10}**	**SPM**	**Temp (^0C)**	**Hum (%)**
1.	Geology Dept General Ofice	1	0	1.3	0	0	0	0.5	0	0	0.001	0.007	0.032	0.039	0.045	28.5	72
2.	Physics Dept. General office	1	0	1.3	0	0	0	0.6	0	0	0.001	0.007	0.038	0.048	0.062	29.7	82
3.	Faculty Finance Office	1	0	1.6	0	0	0	0.7	0	300	0.001	0.006	0.028	0.03	0.032	29	75.5
4.	Faculty General office	1	0	1.7	0	0	0	0.9	0	0	0.001	0.006	0.03	0.038	0.048	28.9	76.5
5.	Dean's Office	1	0	1.8	0	0	0	0.8	0	0	0.001	0.006	0.029	0.033	0.038	29.2	77.5
6.	Taxonomy Laboratory	1	0	1.8	0	0	0	0.8	0	0	0.002	0.01	0.028	0.38	0.053	29.1	80.6
7.	Biochemistry Gen.Lab II	1	0	1.7	0	0	0	0	0.8	0	0.001	0.006	0.041	0.053	0.073	29.4	76.6
	FEPA (1991) standards			3		0.2		0.06	20	1000				15			

Unless stated, all measurements in ppm

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Table 3. Outdoor air quality data in University Park

S/N	**Location**	**Coordinates**	**NH_3**	**H_2S**	**VOC**	**CH_4**	**SO_2**	**NO_2**	**NO**	**CO**	**CO_2**	**PM_1**	**$PM_{2.5}$**	**PM_7**	**PM_{10}**	**SPM**	**Temp (^{0}C)**	**Hum (%)**
1.	Maths/Statistics Dept.	N04054’I5.5’’ E006055’21.7’’	0	0	1.5	0	0	0	0.6	0	300	0.001	0.006	0.025	0.028	0.03	28.4	78
2.	AEB dept.	N04054’I4.6’’ E006055’21.0’’	1	0	1.8	0	0	1.0	0	0	300	0.001	0.005	0.025	0.028	0.033	29.4	72.3
3.	SLT dept.	N04054’I4.8’’ E006055’22.7’’	0	0	1.7	0	0	0	1.0	0	0	0.001	0.006	0.026	0.033	0.042	29.9	75.4
4.	Ofrima car park	N04054’I2.7.5’’ E006055’22.3’’	1	0	1.6	0	0	0	1.0	0	0	0.001	0.006	0.025	0.031	0.038	30.1	76.7
5.	Beside ofrima	N04054’I4.5’’ E006055’24.5’’	0	0	1.5	0	0	0	1.1	0	0	0.001	0.007	0.025	0.028	0.03	30.5	74.1
6.	LSC dept	N04054’06.8’’ E006055’26.6’’	1	0	2.3	0	0	0	1.3	0	300	0.001	0.006	0.02	0.025	0.032	29.6	73
7.	Dept. Of Econs	N04054’05.3’’ E006055’26.1’’	1	0	2.4	0	0	0	1.2	0	0	0.001	0.006	0.023	0.027	0.031	30.9	70.6
8	Block industry	N04053’57.9’’ E006055’19.5’’	0	0	2.2	0	0	0	1.5	1	600	0	0.004	0.055	0.076	0.092	31.9	68
9	Gen stand	N04053’55.5’’ E006055’19.9’’	1	0	2.3	0	0	0	2.5	3.2	0	0.002	0.007	0.023	0.026	0.029	32.8	75.4
10	Few cm from gen. stand	N04053’55.8’’ E006055’19.9’’	1	0	2.5	0	0	0	3.0	0	300	0.001	0.005	0.026	0.029	0.032	32	69.3
11	Roasting joint	N04053’57.9’’ E006055’19.4’’	1	0	2.8	0	0	0	3.0	30	0	0.004	0.011	0.054	0.063	0.083	32	67.9
12	Abuja motor park.	N04054’11.8’’ E006055’11.6’’	1	0	3.1	0	0	0	4.0	0	300	0.001	0.006	0.031	0.045	0.061	31.7	70.9
13	Behind library (Control)	N04054’I4.7’’ E006055’20.3’’	0	0	1.5	0	0	0	1.2	0	0	0.001	0.006	0.023	0.026	0.027	29.5	75.7
	FEPA (1991) standards				3		0.2		0.06	20	1000				15			

Unless stated, all measurements in ppm

Table 4. Out adoor air quality data in Delta Park (Unless stated, all measurements in ppm)

SN	Location	Coordinates	NH_3	H_2S	VOC	CH_4	SO_2	NO_2	NO	CO	CO_2	PM_1	$PM_{2.5}$	PM_7	PM_{10}	SPM	Temp (^0C)	Hum (%)
1.	Delta Gate park	N04 54'0.42" E006 54' 25.8"	2	0	3.2	0	0	0	4.3	0	0	0.002	0.009	0.149	0.209	0.306	30.5	69.5
2.	Works & service	N04 54' 03.3" E006 54' 20.3"	2	0	3.5	0	0	0	3.5	0	300	0.001	0.006	0.025	0.031	0.039	29.6	72.5
3.	Juhel Fuel Station	N04 54' 05.5" E006 54' 19.7"	2	0	3.6	0	0	0	3.9	0	300	0.001	0.006	0.028	0.048	0.09	30.1	70.8
4	Admission Office	N04 54' 59.1" E006 54' 18.6"	3	0	3.7	0	0	0	3.9	0	300	0.001	0.006	0.035	0.043	0.051	30.6	69.4
5	UDPS (Control)	N04 54' 00.3" E006 54' 14.7"	1	0	3.5	0	0	0	3.6	0	0	0.001	0.006	0.026	0.035	0.044	30.8	71.7
	FEPA (1991) standards				3		0.2		0.06	20	1000				15			

Unless stated, all measurements in ppm

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 ISSN 1118 - 1931

Table 5 Air quality data in Senate building and College of Graduate Studies.

S/N	Location	Coordinates	NH_3	H_2S	VOC	CH_4	SO_2	NO_2	NO	CO	CO_2	PM_1	$PM_{2.5}$	PM_7	PM_{10}	SPM	Temp (^{0}C)	Humidity (%)
1.	Front of Senate building	N04 54' 16.6" E006 55' 08.6"	1	0	4.1	0	0	0	3.9	0	300	0.001	0.004	0.023	0.028	0.034	31.5	67.2
2.	Behind Senate building	N04 54' 17.0" E006 55' 71"	1	0	4.1	0	0	0	3.5	0	0	0.001	0.006	0.03	0.036	0.045	30.5	76.5
3.	First floor	N04 54' 15.1" E006 55' 10.0"	1	0	4.1	0	0	0	2.6	0	0	0.001	0.006	0.023	0.029	0.037	28.7	77.4
4.	2nd floor (treasury rm5)		1	0	4.3	0	0	0	2.1	0	0	0	0.008	0.034	0.043	0.059	28.4	75.9
5.	Entrance to Grad. Sch.	N04 54' 11.1" E00655' 06.4’’	0	0	4.1	0	0	0	1.8	0	0	0.001	0.004	0.018	0.032	0.069	29.2	83.5
6.	Circular Space	N04 54' 10.3" E006 55' 05.7	0	0	4	0	0	0	2.3	0	0	0.001	0.005	0.017	0.019	0.022	28.6	81.9
7.	General Office	N04 54' 10.7" E006 55' 06.1’’	0	0	3.9	0	0	0	1.9	0	0	0.001	0.007	0.028	0.036	0.05	29.2	79.2
8.	Senate building Quadrangle (control)	N04 54'15.2" E006 55' 09.6"	1	0	1.1	0	0	0	3	0	300	0.001	0.005	0.02	0.025	0.03	29.2	74.6
	FEPA (1991) standards				3		0.2		0.06	20	1000				15			

Unless stated, all measurements in ppm

Table 6: Summarising air quality results (all measurements in ppm)

S/N	Parameters	Concentrations			Nigerian ambient air quality limits	Comments
1.	CO_2	0	2200	182	1000	Above permissible limits in Choba, behind Eco Bank. High in Abuja block industry and generator stand in Choba.
2.	CO	0	193	8	20	Extremely high in motor parks in Choba and Abuja parks, photocopying stand and beside the UBA bank, Choba campus.
3.	NO	0	5.5	0.6	0.06	Above limits in almost all locations.
4.	NO_2	0	1	0.02	0.06	Above limits in AEB department.
5.	SO_2	0	0.4	0.02	0.2	Above limits in business area Choba.
6.	CH_4	0	0	0	-	Not detected
7.	H_2S	0	0	0	-	Not detected
8.	VOC	1.1	4.1	2.8	-	More concentrated in Choba, parts of Senate building and College of Graduate Studies
9.	NH_3	0	3	1	-	Highest concentration at admission office, Delta park.
10.	PM	0.001	0.306	-	$600 \mu g/m^3$	High in most locations.

Scientia Africana, Vol. 13 (No.1), June 2014. Pp120-137
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DISCUSSION

Carbon Dioxide (CO_2)

The highest concentration of CO_2 (2200 ppm) was obtained outdoor in Choba campus behind Eco Bank (Table 1) where a lyster generator suppplies the electrical power needs of the bank. According to WHO (2000), CO_2 becomes a pollutant at 1000ppm. Other locations which recorded appreciable concentration of CO_2 are the block industry in Abuja Campus (600ppm) and the generator stands (Figs. 2 and 3) of the business area in Choba campus (500ppm). All these are higher than the natural level of 315mg/l. Constant inhalation of CO_2 at these concenrations may result in health hazards. Excess emissions of CO_2, has also been proven as a major cause of global warming. Carbon dioxide (CO_2) is a by product of part of fossil fuel burning and has a life span in the atmosphere of 50-200 years with a global warming (GWP) potential of 1. Global Warming Potentials are a quantified measure of the globally averaged relative radiative forcing impacts of particular greenhouse gases with relatively long atmospheric lifetimes (IPCC 201) and is is defined as the cumulative radiative forcing – both direct and indirect integrated over a period of time from the emission of a unit mass of gas relative to some reference gas.). Carbon dioxide (CO_2) was chosen by the IPCC as this reference gas and its GWP is set equal to one (1). CO_2, CH_4, N_2O are the gases with relatively long atmospheric lifetimes that tend to be evenly distributed throughout the atmosphere, and therefore have global average concentrations enough to be assigned GWP.

Carbon Monoxide (CO)

193 ppm of CO was obtained within the vicinity of the motor park and the nearby business area in Choba (Fig. 2). This is approximately ten times higher than the Nigerian ambient air quality limit of 20 ppm. It probably represents an aggregation of emissions from the two adjoining sites where motor vehicles and generators are the sources of the emissions. Other areas with concentrations above the regulatory limits are Choba campus main business area and the generator stand in Ofrima (32 ppm), and beside the generator of UBA (48 ppm). These high concentrations which are above permissible limits could affect respiratory activities in the human nervous system and death due to asphyxiation. Khalil and Ramussen 1990 have shown that human activities such as combustion and oxidation of hydrocarbons are responsible for 60% of CO in the atmosphere while emissions from natural sources account for the remaining 40%. Relatively short-lived gases such as carbon monoxide, trophospheric ozone, other ambient air pollutants (e.g. NO_x, and NMVOCs), water vapor, and trophospheric aerosols (e.g. SO_2 products and black carbon) vary spatially, do not have a global concentration because they are destroyed quickly and emitted in different amounts in different places and consequently it is difficult to quantify their global radiative forcing impacts and hence GWP (Smith and Wigley, 2000).

Nitrogen Oxides (NO)

Nitrogen oxides of environmental importance in environmental studies are nitric oxide (NO) and nitrogen dioxide (NO_2). There are very high concentration levels of NO in almost all locations ranging from 1.8 to 5.5ppm (Figs 1-5). Generally, Delta Park (Fig.4), Senate Building, College of Graduate studies and all motor parks had average NO concentrations of approximately 4 ppm. The highest concentration was 5.5ppm beside Eco bank in Choba campus. The limit for NO by the Nigerian ambient air quality is 0.06ppm. NO is a product of high temperature combustion. According to WHO (2005), combustion of fossil fuels in stationary sources such as power generation machines and motor vehicles are the main anthropogenic sources of oxides of nitrogen. NO can form photochemical smog at higher concentrations, cause leaf damage or affects the photosynthetic activities of plants and causes respiratory problems in mammals. However in Ofrima, NO_2 was detected only at one location at a concentration of 1ppm in the general laboratory of the Department of Animal and Environmental Biology (Fig. 3). This is however above the limit of 0.06ppm. NO_2 is responsible for immune system impairment, exacerbation of asthma and chronic respiratory diseases, reduced lung function and cardiovascular disease (Schwela, 2000). NO_2 has a life span in the atmosphere of 120 years and possess a global warming potential of 310.

Sulphur Dioxide, (SO_2)

SO_2 was dectected at a concentration of 0.4 ppm in the business area at the Choba Campus (Table 1) where generators are used for business activities. It was detected at all or concentrations were below permissible limit in all other locations. According to the Nigerian ambient air quality standards, the limit for SO_2 is 0.2ppm. The largest single anthropogenic source of sulpur dioxide is the combustion of sulphur-containing fossil fuel (Akuro 2012). Sulphur Dioxide is emitted directly into the atmosphere and can remain suspended for days allowing for wide distribution of the pollutant. Excess concentration of SO_2 can lead to respiratory problems, severe headache, and reduced productivity of plants. One effect of sulphur dioxide is the formation of acid rain which causes damage to limestone and marble. Excess SO_2 can also cause damage to leather, increased rate of corrosion of iron, steel, zinc and aluminium.

Volatile Organic Carbons, (VOC)

The range of concentrations of VOCs from 3.7 to 4.0 ppm were obtained in all sampled locations except Ofirima area. The highest was 4.1 ppm in the College of Graduate Studies (Fig. 4 and Table 5). They were much more concentrated indoosr than outdoors. The sources of VOC include paints, solvents, wood preservatives, aerosol sprays, cleaners and disinfectants, and air fresheners, stored fuels and automotive products among others. Excess concentrations of VOC could cause eye, nose, and throat irritation, headaches, loss of coordination, nausea, and damage to some internal organs.

Particulate Matters (PM_1, $PM_{2.5}$, PM_7, PM_{10}, SPM)

Particulate matter is a collective term used to describe very small solid and /or liquid particles. Individual particles vary considerably in size, geometry, chemical composition, and physical properties. The concentration of the particulate matter dominated by PM_7 and PM_{10} fractions ranged from 0.001 to 0.306ppm, far below FEPA's limits of 15ppm.The concentrations were relatively higher outdoors than indoors. Their presence as aerosols in atmosphere may contribute to visibility reduction, pose a threat to public health, or simply be a nuisance because of their soiling potential. In a study of suspended particulate matter (SPM) concentration in air in 17 Nigerian cities including Port Harcourt, Ana et al (2005)

Scientia Africana, Vol. 13 (No.1), June 2014. Pp120-137
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reported that the high concentrations of PM_{10} in most Nigerian urban environments have resulted in significant prevalence of cough, catarrh, eye infection, asthma, chronic bronchitis etc. Ossai *et al.*, (1999), Okecha (2000) and Efe (2006) specifically correlated high rates of respiratory diseases among urban dwellers with increased PM_{10} concentrations in air. PM_{10} may be produced by natural processes (pollen, salt spray, soil erosion) and by human activity (soot). Their presence as aerosols in atmosphere may contribute to visibility reduction, pose a threat to public health, or simply be a nuisance because of their soiling potential.

Mkoma and Mjemah (2011) reported that particles of aerodynamic diameter smaller than 10 µm (PM10) and those smaller than 2.5 µm (PM2.5), and especially the submicrometer-sized particles affect the Earth's climate by scattering and absorbing incoming ultraviolet solar radiation and outgoing terrestrial infrared radiation and by influencing the properties and formation processes of clouds. Thus they can affect the concentration and size distribution of cloud droplets. In turn, they can alterthe radiative properties of cloud, cloud lifetime, the nature and allocation of rain clouds and as a result they interfere with the hydrological cycle.

The highest concentration of ammonia (NH_3) of 3ppm was obtained in the Admission Office in Delta Park (Fig. 6). Methane (CH_4) and hydrogen sulphide (H_2S) were not detected in any of the locations sampled.

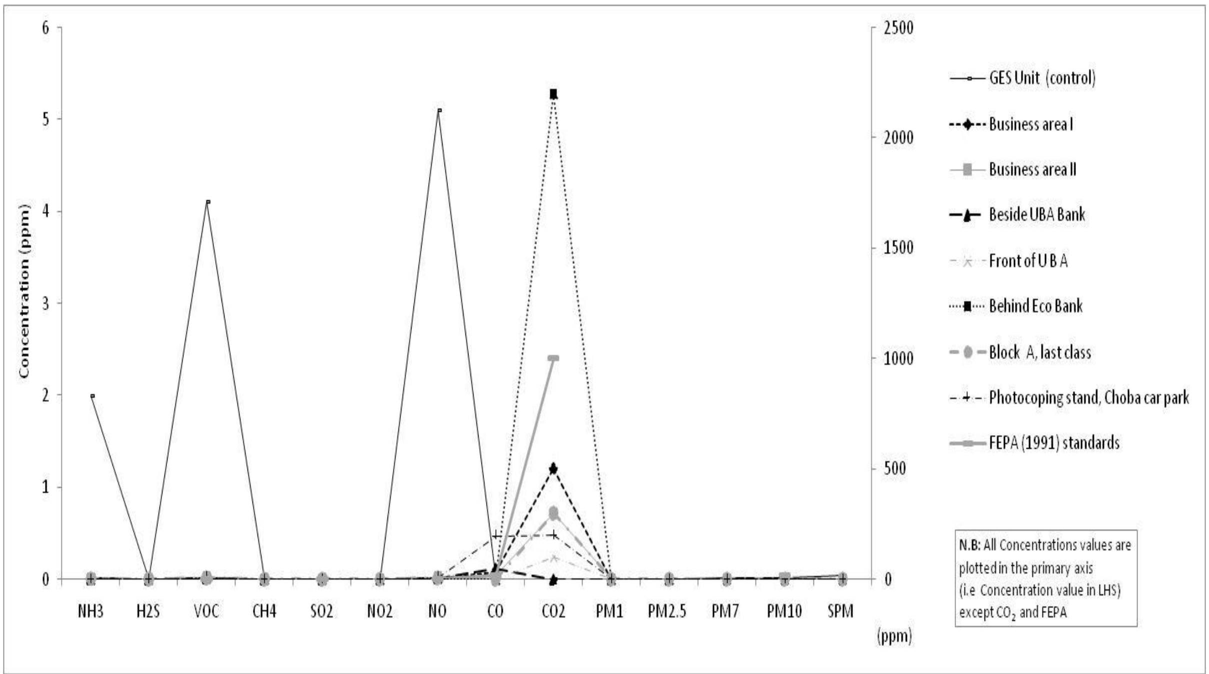

Fig. 2 Air quality indicators in Choba Park

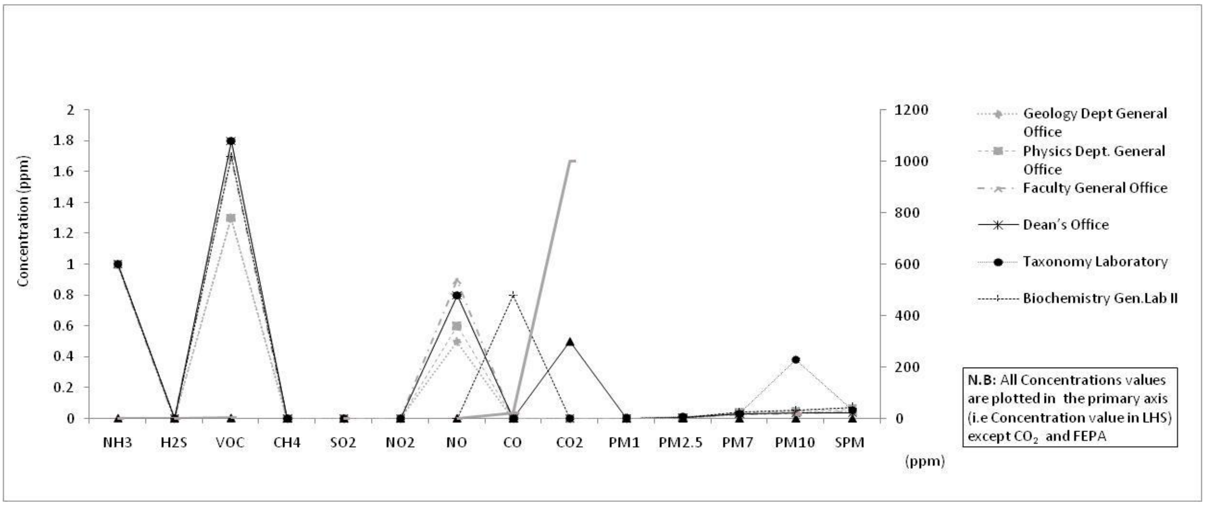

Fig.3 Air quality indicators in Ofrima building, University Park

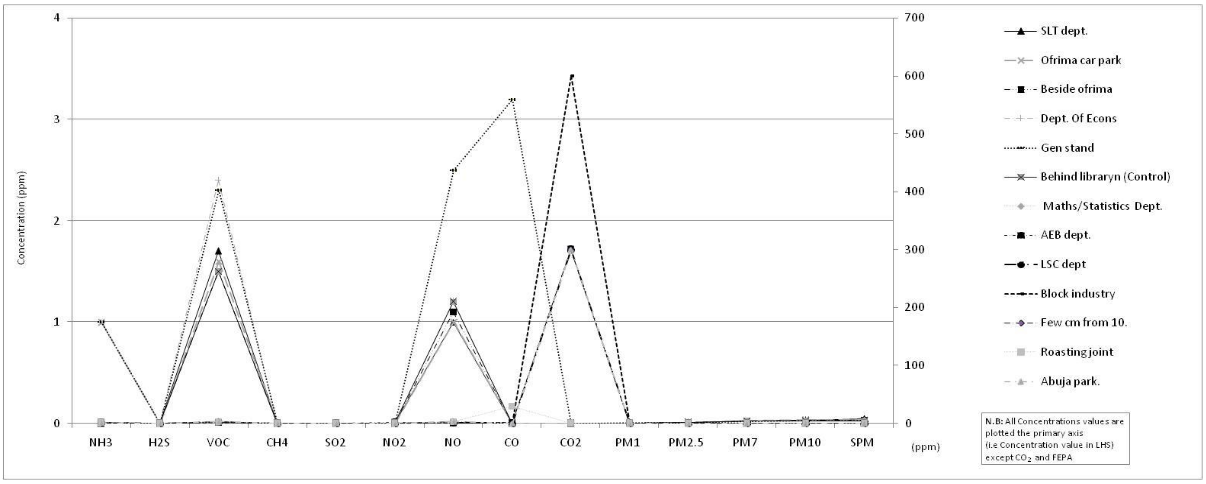

Fig.4 Air quality indicators in University Park

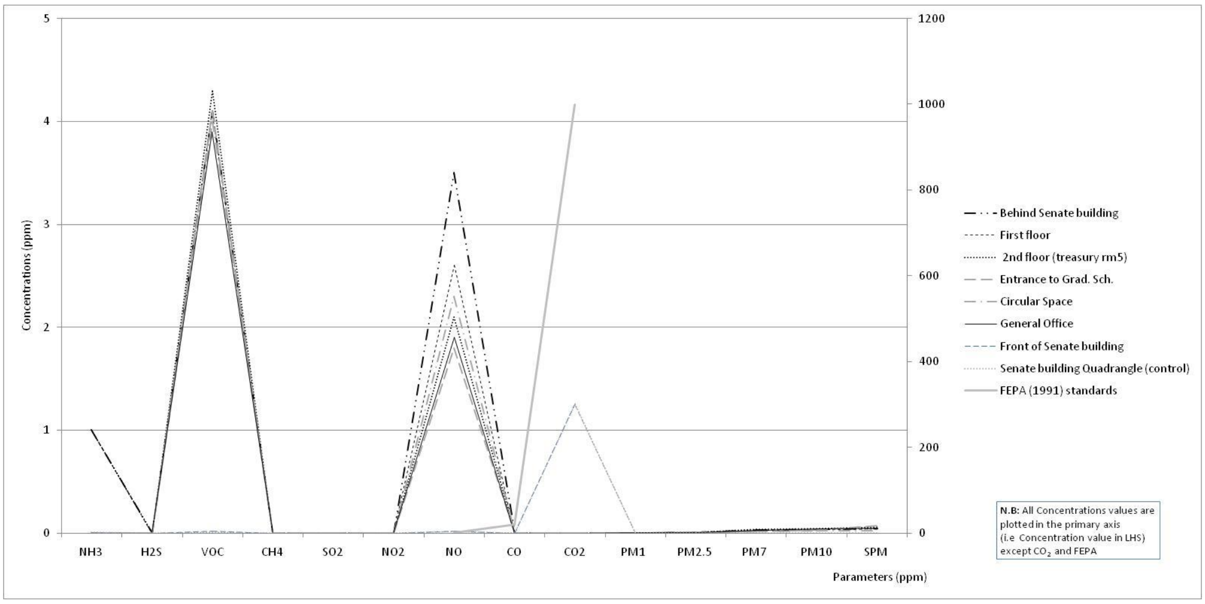

Fig. 5 Air quality indicators in College of Graduate Studies and Senate Building

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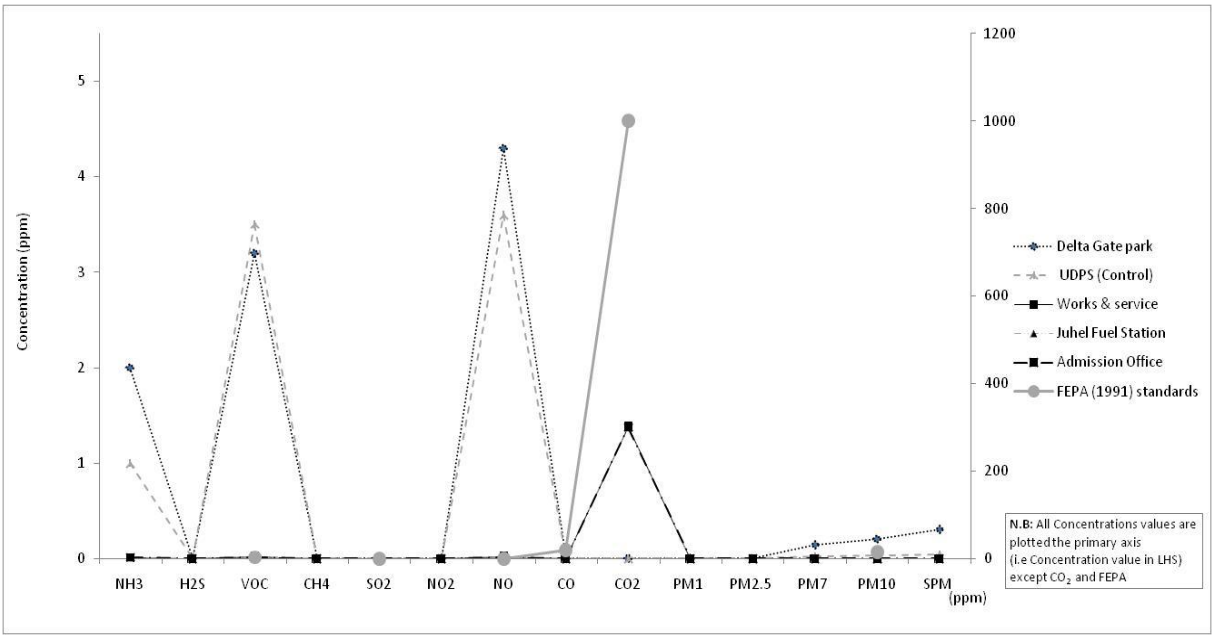

Fig. 6 Air quality indicators in Delta Park

Air Quality Index (AQI)

The AQI is an index developed by USEPA for reporting daily air quality. It tells how clean or polluted air is, and what associated health effects might be of concern. The AQI focuses on health effects that someone may experience within a few hours or days after breathing polluted air. Results of air quality index obtained in this study (Table 7), when compared with USEPA's AQI rating (Table 8) show that other than CO, the air quality in the university may be described as very poor in terms of NO, NO_2, and SO_2. Locations in Choba Park have the worst indices in terms of air quality compared to other campuses. This is due to the continuous use of generators by the several business units that burn fossil fuels, and possibly contributions from vehicular emissions from the nearby East-west and NTA-Choba road junction which are drifted by the south westerly winds into Choba park. According to Ogba and Utang (2009), the prevailing winds in the Niger Delta change with time of the year and location. In July (which coincides with the period of this study), the westerly, including south westerly and southerly winds are predominating, but the values of the westerly are comparatively low because of the influence of the southerly winds, arising from its coastal location. Thus, more pollutants would be concentrated in the direction of the prevailing winds. Generally, windy weather causes pollution to be dispersed while still weather permits pollution to build up. During this study, the wind speed ranged between 1.6-2.1m/s with an average of 1.9m/s which may be classified as calm wind. The calm wind and absence of rain during this study may have given rise to the high concentration of pollutants e.g SOx and NOx obtained (Table 7).

Table 7: Air Quality Index rating in the University of Port Harcourt

Parameters	AQI value	AQI Category	AQI Rating
CO_2	18.2ppm	Not stated	Not stated
CO	40ppm	B	Good
NO	1000ppm	E	Very poor
NO_2	33pm	E	Very poor
SO_2	20ppm	E	Very poor

Table 8: Air Quality Index for Priority Pollutants (USEPA, 2000).

AQI Category	AQI Rating	CO (ppm)	NO_x (ppm)	SO_2 (ppm)
Very Good	A	0 - 2	0 – 0.02	0 – 0.002
Good	B	21 – 40	0.02 – 0.03	0.02 – 0.03
Moderate	C	41 – 60	0.03 – 0.04	0.03 – 0.04
Poor	D	61 - 90	0.04 – 0.06	0.03 – 0.04
Very Poor	E	>90	>0.06	

Results of this work agree closely with those of the comparative study of emission levels in Lagos and two major cities of the Niger Delta area: Port-Harcourt and Warri reported by Jerome, (2000) which showed that the concentrations of TSP, NOx, SO_2, and CO in Lagos and the Niger Delta communities were above the FEPA recommended limits. Also the results of this work compare favourably with the works of Nwachuku et. al (2012) who reported that the ambient air quality observed in Rivers State was far worse than the World Health Organization Air Quality Standard indicating their unsafe levels and concomitant health risks.

This study has shown that there are sections of the university, especially Choba park, with air pollutant concentrations above limits specified by WHO and FEPA standards. Specifically the air quality is very poor in terms of CO, SO_2, and NO. There is correlation between the pollution patterns and levels and the type and levels of human activity. CO_2 and SO_2 and NO_2 have higher concentrations in areas with high emissions from generators where business centres continuously operate generators for their electricity supply. The concentrations of NO were high in almost all the locations. It is proposed that to reverse the trend of air quality impairment and the global warming contributions of the gases identified in this study, the shift to cleaner energy sources is imperative.

REFERENCES

Abam, F. I., Unachukwu, G. O. 2009. "Vehicular Emission and Air Quality Standards in Nigeria". European Journal of Scientific Research; ISSN 1450-216X, Vol. 34 No. 4, pp. 550-560

Akuro, A. 2012. Air Quality Survey of some locations in the Niger Delta Area . J. Appl. Sci. Environ. Manage. Vol. 16 (1) 125 - 134

Ana, G.R.E.E., Sridharl, M.K.C. and Olawuyi J.F. 2005. Pollution in a

Scientia Africana, Vol. 13 (No.1), June 2014. Pp120-137
© College of Natural and Applied Sciences, University of Port Harcourt, Printed in Nigeria *ISSN 1118 - 1931*

Chemical Fertilizer Complex in Nigeria: The Impact on the Health of the Workers J. Public Heal. Epidemiol.,Volume:4 Issue:2

Efe S. I. 2006. Particulate Pollution and its Health Implications in Warri Metropolis, Delta State Nigeria. Env. Anal. 11, 1339-1351.

FEPA. 1991. National Guidelines and standards for Industrial Effluents, Gaseous Emissions and Hazardous Waste Management in Nigeria pp. 59-66

Ideriah T. J.K. and H. O. Stanley. 2008. Air Quality Around Some Cement Industries In Port Harcourt, Nigeria. Scientia Africana, Vol. 7 (No.2), December 2008; pp 27-34

Intergovernmental Panel on Climate Change IPCC. 2001. Third Assessment Report - Climate Change. Chapter 6: Radiative Forcing of Change.

Jerome, A. 2000. Use of Economic instruments for Environmental Management in Nigeria. Paper presented at workshop on Environmental Management in Nigeria and Administration (NCEMA).

Mkoma S.L and Mjemah I. C. 2011. Influence of Meteorology on Ambie nt Air Quality inMorogoro, Tanzania .International Journal Of Environme ntal Sciences Volume 1, No 6.

Nwachukwu A. N. 1, Chukwuocha E. O. and Igbudu O. 2012. A survey on the effects of air pollution on diseases of the people of Rivers State, Nigeria. African Journal of Environmental Science and Technology Vol. 6(10), pp. 371-379

Ogba C.O. and Utang, B.P. 2009. Planning Air Pollution Climatology in Spatial Planning for Sustainable Development in the Niger Delta, Nigeria . FIG Working Week 2009 Surveyor's Key Role in Accelerated Development Eilat, Israel, 3-8 May, 2009 6/13

Okecha, S.A. 2000. Pollution and conservation of Nigeria's environment**.** T'Afrique International Associates, W.A.Aladinma, Owerri, Nigeria, 112pp

Ossai E.K., Iniaghe G. O, Osakwe S .A. and Agbaire P. A.1999. Pollution Problems and Environmental Effects of Chemicals, In Ekechi (ed) Reading in General Studies: History and Philosophy of Science, Abraka General Studies Dept. Pub. pp 83 – 86. Schwela, D.2000. "Air pollution and health in urban areas". Reviews on Environmental Health. 15(1-2):13-42.

Osuji L.C. and Avwiri G.O. 2005. Flared Gases and Other Pollutants Associated with Air Quality in Industrial Areas of Nigeria: An Overview. Chem. Biodivers. 2:1-8.

Smith, S.J. and Wigley, T.M.L. 2000.

Global warming potentials: 2. Accuracy. Climatic Change 44, 459-46

Tawari C.C. and J.F.N. Abowei. 2012. Air Pollution in the Niger Delta Area of Nigeria. International Journal of Fisheries and Aquatic Sciences 1(2): 94-117, 2012

U. S. Environmental Protection Agency, USEPA. 1993. Guide to Environmental Issues, Doc. No 520/B-94-01. United States Environmental Protection Agency, Washington, DC, USA

U. S. Environmental Protection Agency, USEPA. 2000. Air Quality Index for Priority Pollutants.

U.S. Environmental Protection Agency, USEPA. 2007. "Mobile Source Emissions - Pollutants". Retrieved on the 11th of November 2012 from http://www.epa.gov/otaq/invntory/overview/pollutants.

World Health Organization (WHO) 2000. Air quality guidelines for Europe". WHO Regional Office for Europe, Copenhagen

World Health Organization (WHO) 2005. Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide, Global update

World Health Organization (WHO) 2010. Air Quality Classification based on Total Suspended Particles (TSP) Values.