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Assessment of Air Quality and Noise around Okrika Communities, Rivers State, Nigeria

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ABSTRACT: The quality of air and noise levels around Okirika communities in River State were determined using portable hand held air monitors for air pollutants and anemometer for meteorological parameters. The parameters measured were suspended particulate matter, nitrogen dioxide, sulphur dioxide, hydrogen sulphide, ammonia, carbon monoxide, methane and volatile organic carbon, temperature, wind speed, wind direction and relative humidity. The results showed the highest concentrations of 0.007mg/m^3 (PM_1, dry), 0.036mg/m^3 ($PM_{2.5}$, dry), 0.286mg/m^3 (PM_7, dry), 0.378mg/m^3 (PM_{10}, dry), 0.503mg/m^3 (TSP, dry), 1.7ppm (NO_2, dry), 3.0ppm (CH_4, dry), 0.2ppm (H_2S, dry), 12.7ppm (CO, dry), 2.7ppm (NH_3, dry), and 7.0ppm (VOC, rainy). The dry season concentrations of air pollutants were higher than the rainy season concentrations. The observed differences in mean concentrations of the air pollutants between the two seasons were not significant in case of TSP ($P<0.05$) but were significant ($P<0.05$) in other pollutants. The highest mean concentrations of the gaseous pollutants exceeded permissible limits and therefore pose environmental and health concern for the inhabitants of the area. The quality of air in the area is poor and need to be regularly monitored. @JASEM

Keywords: Air quality, Okrika, Digital monitors, meteorology, Noise

Air pollution is as old as civilization itself. Air pollution comes from nature and from human activities that created pollution everyday all over the world. In nature, air pollution is created when volcanoes erupt (or volcanoes belched enormous amount of ash and sulphur dioxide into the atmosphere); forest fires burn and their smokes are blown by winds; and when winds whip up plant pollens and dust from deserts. (Aas *et al*, 1999).

There are numerous human activities, which result in the release of potential toxic substances into the atmosphere (Aas *et al*, 1999; Campbell *et al*, 1994). From human activities, the primary source of air pollutants today is the waste products released into the air from the exhaust of internal combustion engines and boilers and furnaces of industries, plants and homes. (Park, 2005).

Okrika Kingdom in Rivers State is a typical example of a place that is seriously affected as a result of air pollution from mobile, stationary and indoor sources. Both outdoor and indoor air quality data represent the true exposure for human being (Ideriah *et al*., 2001). Air pollution could be serious. This is more so around Okrika and its environs as a result of major air pollutants, particulates, dust and sooth constantly emitted from the Port Harcourt Refinery, Eleme Petrochemical Company limited and the National fertilizer Company (NAFCON). Major air pollutants include carbon monoxide usually from incomplete combustion of fossil fuel and waste incineration, sulphur oxides resulting from sulphur containing coal and oil in homes, industries, power plants etc, nitrogen oxides from high temperature fuel combustion in motor vehicles and from industries and fossil power, hydrocarbons derived from incomplete combustion of fossil fuels in automobiles and furnaces, etc, photochemical oxidants from sunlight acting on the hydrocarbons and nitrogen oxides (Ideriah *et al*., 2008). These fossils come from the fossil of ancient plants and animals that lived on earth millions of years ago.

The Niger Delta news (2004) reported that Nigeria flares more gas than any other country in the world. Approximately 75 percent of total gas production in Nigeria is flared, and about 95 percent of the associated gas, which is produced as by-product of crud oil extraction, is also flared. Gas flaring in Nigeria contributes a measurable percentage of the world's total emissions of green house gases. (Gobo, 2002).

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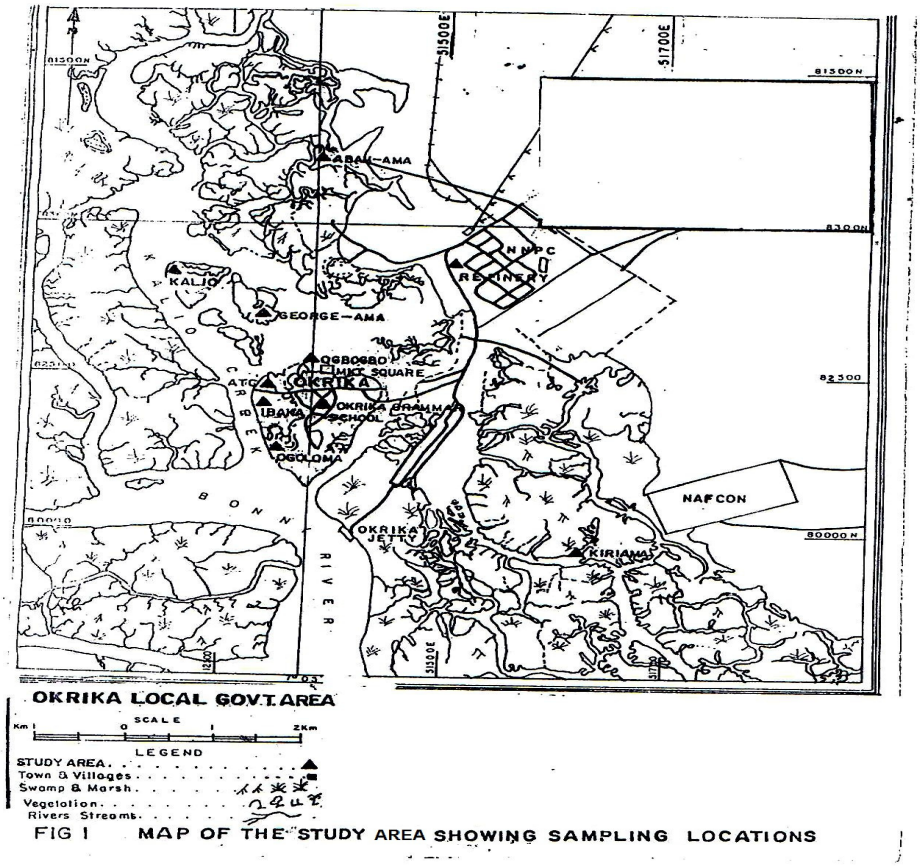

FIG 1 MAP OF THE STUDY AREA SHOWING SAMPLING LOCATIONS

The automobiles emit hydrocarbons, carbon monoxide, nitrogen oxides, lead and particulate matter, and in strong sunlight, certain of these hydrocarbons and oxides of nitrogen may be converted into 'photochemical' pollutants of oxidizing nature. No doubt, the rather improper methods of disposal of the industrial wastes not only result in loss of green belts and aquatic resources and thereby affect the fishermen's means of livelihood but also make the air odorous, unpleasant and unwholesome, thereby depriving the Okrika people of enjoying their natural endowments. No doubt too, that the heavy air pollution serves as a ready source for the spread of disease within the area. The problems continue however, because of too many vehicles and companies in too little space. Reports by various works in the past are available on the adverse effects of these pollutants on human and the environment (Corson, 2006, Park, 2005, Isirimah, 2004, Gobo, 2002, Horsfall and Spiff, 1998 and Ideriah, 2008). However, there has been no information on the assessment of air quality around Okrika in Rivers State, beyond the standard limits prescribed by the Federal Environmental Protection Agency (FMEnv, 1991) for ambient air pollutants resulting to health and environmental problems.

Scientists have predicted that Nigeria may be seriously hit by the green house effect as a result of large amount of green house gasses emitted into the atmosphere, though automobile emissions, gas flaring and bush burning (Gobo, 2002). It was also reported that in Nigeria, Automobile exhaust accounts for about 80% of the air pollution problems in the urban areas; the remaining 20% being contributed from industrial sources, the burning of refuse and forest and civil engineering activities (Osibanjo and Ajayi, 1980), also about 15-30% of the emitted lead from automobiles is airborne. It is not uncommon to find people plucking and eating raw fruits, or food hawkers displaying their stuff openly and unwrapped alongside heavy traffic roads which are apparently contaminated with air pollutants.

Even though there are a good number of reports on the adverse effects of air pollution on human health and the environment, no such studies have been carried out around Okrika to substantiate these

findings and also to assess its air quality. This work is therefore aimed at assessing the air quality around Okrika to determine the levels of carbon monoxide (CO), sulphur dioxide (SO_2), nitrogen dioxide (NO_2), suspended particulate matter (SPM), volatile organic carbons, Ammonia (NH_3) and Hydrogen sulphide (H_2S) around the area.

MATERIALS AND METHODS

The sampling equipments used are portable digital hand held air monitors to measure the air pollutants. These monitors include: An industrial scientific corporation ITX Multi gas monitor for VOC, NO_2, SO_2, CO, NH_3. H_2S; Aerosol mass monitor by MET One instrument INC for SPM; Digital Cole Parmer Combination (Hydrothermo-anemometer) by Extech for wind speed, temperature and Relative Humidity and A Cole-Parmer Extec Model 407736 sound level meter for noise levels in the area. .

Ten stations including a control station were selected during reconnaissance between refinery and Okrika main town. The stations and their geographical positions are shown in Table 1 and Fig. 1. Air quality measurements were made at ten stations within the study area using digital hand held air samplers.

Ambient air quality measurements in the area were made twice during the day time, representing the rainy (June, 2010) and dry (February 2010) seasons. Measurements were not made at night due to security reasons. At each station measurements were repeated.

Seven potential air pollutants were monitored in the study area. These include: Suspended particular matter (PM_1, $PM_{2.5}$, PM_7, PM_{10}, TSP) Carbon (II) Oxide (CO), Nitrogen (iv) Oxide (NO_2), Sulphur (IV) oxide (SO_2), methane (CH_4), volatile organic compound (VOC), Hydrogen Sulphide (H_2S), Ammonia (NH_3), relative humidity, ambient temperature, wind speed and wind direction.

Table 1: Identification of sampling stations with geographical coordinates

Station	Name	Geographical Co-ordinates
1.	Refinery	N 04° 45′ 9.42″ E 007° 05′ 56.58″
2.	Local Govt. council	N 04° 45′ 9.36″ E 007° 05′ 56.76″
3.	Secondary School	N 04° 44′ 37.98″ E 007° 05′ 52.44″
4.	George Ama	N 04° 45′ 23.16″ E 007° 04′ 38.76″
5.	Kalio Ama	N 04° 45′ 53.7″ E 007° 05′ 51.12″
6.	A.T.C	N 04° 44′ 32.94″ E 007° 04′ 38.94″
7.	Ogoloma	N 547′ 04° 44′ 32.82″ E 650′ 007° 04′ 39″
8.	Ibaka	N 04° 44′ 34.86″ E 007° 05′ 15.6″
9.	Ogbogbo	N 672′ 04° 44′ 40.32″ E 925′ 007° 04′ 55.5″
10.	Kiri Ama (control)	

RESULTS AND DISCUSSION

The results of air pollutants and noise measured around Okrika are presented in Tables 2 – 5. The concentrations of PM_1, 0.001 mg/m^3 did not vary in the Dry season. The mean concentrations in the Dry season were higher than the rainy season concentration in all the stations. (Tables 2 and 3). The concentrations of $PM_{2.5}$ varied from 0.001 mg/m^3 at station 10 to 0.017 mg/m^3 at station 9 in the rainy season and 0.008 mg/m^3 at station 6 to 0.071 mg/m^3 at station 1 in the Dry season. The mean concentrations in the Dry season were higher than the rainy season values. The concentrations of PM_7 in the rainy season varied between 0.004mg/m^3 at station 6 and 0.077mg/m^3 at station 8 and between 0.025mg/m^3 at station 10 and 0. 437mg/m^3 at station 3 in the Dry season. The Dry season values were generally higher than the rainy season values. The concentrations of PM_{10} ranged from 0.010mg/m^3 at station 10 to 0.092mg/m^3 at station 9 in the rainy season and 0.032mg/m^3 at station to 0.468 mg/m^3 at station 3 in the Dry season. The Dry concentrations were higher than the rainy season concentrations. The TSP concentration in the rainy season varied from 0.012mg/m^3 at station 10 to 0.128mg/m^3 at station 1 and 0.024mg/m^3 at station 10 to 0.646mg/m^3 at station 3 in the Dry season. The Dry season concentrations are higher than rainy season concentrations. The concentrations of NO_2 in the area were constant, 0.09ppm except at the control station (10), and 0.02ppm in the rainy season but varied from 0.02ppm to 2.0ppm at station 1 in the Dry season. The values of SO_2 in the rainy season varied between 0.026ppm at station 10 and 0.2ppm at station 1 while in the Dry season it varied between 0.03ppm at station 10 and 2.0ppm at station 2. The mean concentrations in by season are higher than those in the rainy season. Table 4 showed that the Relative humidity varied from 41.8% to 59.9%, Temperature between 36.7% and 38.6°C, wind speed from 0.9m/s to 1.5m/s with prevailing North-East winds in the Dry season while in the Rainy season the Relative humidity varied from 62.5% to 70.1%, Temperature between 26.0% and 29.5°C, wind speed from 0.2m/s to 1.9m/s with prevailing South-West winds.

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Table 2: Mean Concentrations of air pollutants measured around Okrika communities (Dry season)

Station	Suspended particulate matter (mg/m^3)					Gases (ppm)						
	PM_1	$PM_{2.5}$	PM_7	PM_{10}	TSP	NO_2	SO_2	CH_4	H_2S	CO	NH_3	VO µg/m^3
1	0.007	0.034	0.247	0.324	0.412	1.7	0.2	2	0.2	9.3	2.7	4.1
2	0.004	0.019	0.047	0.061	0.07	0.03	0.8	1	0.2	10.3	1.0	5.2
3	0.003	0.021	0.286	0.378	0.503	0.1	1.4	1.7	0.1	9.7	1.7	3.3
4	0.005	0.032	0.142	0.187	0.246	0.1	0.2	2.3	0.2	8.7	1.3	3.4
5	0.004	0.024	0.076	0.089	0.105	0.2	0.3	1.7	0.2	12.7	1.3	4.7
6	0.004	0.015	0.096	0.103	0.110	0.2	0.2	2.3	0.2	10.7	2	5
7	0.004	0.017	0.046	0.065	0.072	0.1	0.2	1.7	0.1	1.0	1.3	0.1
8	0.004	0.030	0.059	0.070	0.078	0.2	0.8	1	0.2	2.3	1.7	0.2
9	0.004	0.036	0.057	0.072	0.076	0.1	0.2	3	0.2	1.7	1.7	0.1
10	0.002	0.010	0.025	0.032	0.024	0.025	0.03	0.20	0.08	0.50	0.07	0.10
S.E.±	0.001	0.009	0.089	0.120	0.1637	0.505	0.429	0.798	0.052	4.714	0.685	2.232

Table 3: Mean Concentrations of air pollutants measured around Okrika communities (Rainy season)

Sta.	Suspended particulate matter (mg/m^3)					Gases (ppm)						
	PM_1	$PM_{2.5}$	PM_7	PM_{10}	TSP	NO_2	SO_2	H_2S	CO	NH_3	CH_4	VOC µg/m^3
1	0.0003	0.006	0.043	0.055	0.071	0.1	0.1	0.1	4.3	1.7	2.7	7.0
2	0.0003	0.0037	0.015	0.018	0.020	0.1	0.1	0.1	0.1	0.1	0.1	0.1
3	0.001	0.0027	0.016	0.022	0.027	0.1	0.03	0.1	0.7	0.1	0.1	0.3
4	0.001	0.0037	0.016	0.020	0.023	0.1	0.1	0.1	2.3	0.1	0.5	0.2
5	0.001	0.008	0.047	0.066	0.093	0.1	0.1	0.1	2.3	0.1	0.1	0.1
6	0.001	0.002	0.023	0.031	0.044	0.1	0.1	0.1	2.7	0.1	0.5	0.03
7	0.001	0.006	0.030	0.042	0.053	0.1	0.1	0.1	1.0	0.1	0.0	0.1
8	0.001	0.006	0.042	0.054	0.083	0.1	0.1	0.1	2.3	0.1	0.1	0.2
9	0.001	0.008	0.043	0.058	0.081	0.1	0.1	0.1	1.7	0.1	0.3	0.1
10	0.001	0.001	0.010	0.010	0.012	0.02	0.026	0.05	0.1	0.0	0.06	0.04
S.E.±	0.0003	0.002	0.014	0.019	0.029	0.025	0.030	0.015	1.309	0.510	0.806	2.174

Table 5 showed that the mean levels of noise ranged from 58.8 ± 1.74 dB(A) at control (station 10) to 83.8 ± 4.25 dB(A) at station 9 in the rainy season and 55.5 ± 0.83 dB(A) at control to 82.7 ± 3.42 dB(A) at station 9 in the dry season.

The concentrations of pollutants in the dry season were found to be higher than the concentrations in the rainy season. This could be attributed to rainfall during the rainy season. This is in agreement with the fact that pollutant dispersion is highest in the dry season and lowest in the rainy season (Bhatia, 2002). Also heavy rainfalls scavenge the atmosphere of pollutants emitted from natural and anthropogenic sources (NADP, 1982). Statistical analysis showed that the difference between the dry and rainy season concentrations was not significant in the case of TSP ($P<0.05$) but was significant ($P<0.05$) in other pollutants with correlation coefficient r = -0.1084 (TSP), 0.0001 (PM_1), 0.0215 ($PM_{2.5}$), 0.0161 (PM_7), -0.0062 (PM_{10}), 0.1989 (NO_2), 0.1617 (SO_2), 0.4218 (CH_4), 0.3918 (H_2S), 0.2141 (CO), 0.5806 (NH_3) and 0.298 (VOC). It is observed that all the gaseous pollutants were highest at station 1 (Refinery) in the rainy season while NO_2, H_2S and NH_3 were highest in the dry season. TSP was highest at station 6 (ATC) in the rainy season and station 3 (Okrika Grammar School) in the dry season.

In the dry season TSP and SO_2 were highest at station 3, NO_2 and NH_3 at station 1, CO at station 5 (Kalio Ama), CH_4 at station 9 (Ogbogbo) and VOC at station 2 (Local Government Secretariat). The concentrations of the pollutant were compared with permissible limits recommended by the Federal Ministry of Environment (1991). The concentrations of TSP in all the stations were below the permissible limit of 100mg/m^3 and therefore do not pose serious environmental problems. The concentrations NO_2 in all the stations except stations 2 and 10 exceeded the permissible limit of 0.04ppm and therefore pose environmental concern. The concentrations of SO_2,

H_2S and VOC in all the stations exceeded the permissible limit of 0.01ppm (SO_2 and H_2S) and 0.05ppm (VOC). These levels of pollutants call for serious environmental concern. The concentrations of NH_3 in all the stations except the control (station 10) were above the permissible limit of 0.2ppm. This also calls for concern in the area. The concentrations of CO at stations 2, 5 and 6 exceeded permissible limit of 10ppm and therefore pose some concern in the environment.

Table 4: Meteorological parameters measured around Okrika communities (Dry and Rainy seasons)

station	Temp. (°C)		Relative Humidity (%)		Wind Direction and Speed (m/s)			
	Dry	Rainy	Dry	Rainy	Dry	Dry	Rainy	Rainy
1	37.0	28.5	59.9	67.4	NE	1.4	SW	1.0
2	38.4	26.0	57.9	65.0	NE	1.5	SW	0.9
3	36.8	27.8	51.4	62.5	NE	1.2	SW	1.6
4	38.6	29.5	49.2	62.8	NE	0.9	SW	0.2
5	37.3	29.0	47.7	66.4	SE	1.0	SW	0.5
6	38.4	28.5	47.6	65.0	SE	1.0	SW	0.2
7	38.2	28.9	45.0	63.5	NE	1.4	SW	0.4
8	36.7	26.3	41.8	70.1	NE	1.5	SW	0.1
9	37.6	27.0	45.6	66.5	NE	1.0	SW	1.9
10	36.2	26.4	45.0	68.8	NE	1.2	SW	0.5

SW – South-West SE – South East NE – North East

Table 5: Mean levels of noise measured around Okrika communities (Rainy and Dry Seasons)

Stations	Noise dB(A)	
	Rainy	Dry
1	73.5 ± 2.65	71.2 ± 2.75
2	69.6 ± 5.69	69.0 ± 7.69
3	75.1 ± 8.24	68.6 ± 2.55
4	75.5 ± 5.48	66.4 ± 7.76
5	67.4 ± 5.63	70.3 ± 1.95
6	74.2 ± 11.54	61.1 ± 5.31
7	76.1 ± 4.25	55.0 ± 1.9
8	61.2 ± 1.88	61.8 ± 1.82
9	83.8 ± 4.25	82.7 ± 3.42
10	58.8 ± 1.74	55.5 ± 0.83

The levels of CO, CH_4 and VOC were high as a result of the automobile and industrial activities around the area. Emissions from the refinery influenced the levels of the pollutants. This is because during reversals of the wind direction, pollutants are transported to the communities and thereby call for serious concern. The least levels of pollutants were measured at station 10 (control) in both seasons. Since both the control and the communities in the study area are rural communities the activities of the major industries such as the Port Harcourt refinery had negative impact on the quality of air in the study area. In addition to the industrial activities, emissions from anthropogenic, domestic and automobile sources contributed to the levels of pollutants measured in the area.

Motor vehicles are a major source of air pollution in urban areas accounting for approximately 48% CO, 32% NOx and 59% VOC in the amount and have adverse effects on the environment and humans (Park, 2005, Corson, 2006, Ideriah, 2008). The study area has only one single, narrow motorable road and surrounded by creeks where outboard engine boats regularly emit pollutants into the communities depending on the prevailing wind direction. The activities on this road and creeks also contributed to the levels of pollutants measured in the area.

Most effects of TSP (or SPM) on human health result from inhalation, although other routes of uptake such as the alimentary tract (children ingesting dust, food contamination, etc) may be of interest in certain cases, for example lead and some highly toxic organic compounds. Suspended Particulate Matter may be chemically inert but can absorb chemically active materials. The effects of SPM depend on its chemical composition and physical characteristics. (Concawe, 1999). It can soil painted surfaces, corrode metals, reduce visibility, aggravate respiratory (bronchi) and cardiovascular diseases and cause premature mortality. Settling aerosols containing hydrocarbon vapours can also stain materials. Suspended particulate matter also

contributes to green house effect in the atmosphere by absorbing infra red radiation from the earth. Continuous emission of SPM reduces the general aesthetics of the environment. The visible impacts in the study area include settling of dusts and soot particle on roofs, clothes and leaves. This could lead to economic loss and blocking of stomata which can result in low food production.

Respirable particulate matter may cause effects by three different mechanisms (UNEP/WHO, 1994): a direct mechanical (irritation) effect on the respiratory tract; a direct (systemic) toxic effect; and an indirect effect as carrier of toxic compounds. Exposure to respirable particles may result in any of the following: pulmonary function changes, changes in the defense capacity of the lung, and occurrence of respiratory disorders; aggravation of existing respiratory and cardiovascular disease; increased susceptibility to respiratory infection; morphological changes of the respiratory tract; carcinogenesis; and mortality (UNEP/WHO, 1994). Asthmatics and patients with chronic obstructive pulmonary disease (COPD) are said by WHO to be "clearly more susceptive" for reductions in lung function, increased airway responsiveness, and symptoms than are healthy persons.

The oxides of nitrogen (NOx) are mainly nitrogen monoxide (NO), dinitrogen oxide (N_2O) and nitrogen dioxide (NO_2). All these are formed in all types of combustion talking place at high temperature.

$$N_2 + 2O_2 \longrightarrow 2NO_2$$

Nitrogen dioxide is one of the most active photochemical species found in a polluted atmosphere and is an essential participant in the smog – formation process. In NO_2 polluted air, O_3 which is an eye irritant could be produced as a secondary pollutant.
The levels of Nitrogen dioxide obtained in this study can combine with sulphur dioxide and water vapour to form acid rain. In combination with hydrocarbon in the atmosphere oxide of nitrogen may form photochemical oxidants, which irritate the eyes and respiratory tracts and impair human health.

The highest VOC level measured was 7.0µg/m^3 during the rainy season. This level of pollution could stain materials. In particular, ethylene can inhibit plant growth while polynuclear aromatic hydrocarbons are carcinogenic.

Volatile organic compounds, nitrogen oxides, and sulphur dioxide are released by mobile sources and by facilities such as furniture manufacturing and finishing plants, natural gas and coal-fired power plants, and pulp and paper mills. Volatile organic compounds and nitrogen oxides, once emitted, undergo chemical transformation in the atmosphere in the presence of sunlight to form ozone. Sulphur dioxide and nitrogen oxides emitted as a result of fossil fuel combustion undergo chemical transformation in the atmosphere and occur as sulphur, nitrate, and hydrogen ions when dissolved in precipitation.

Carbon monoxide has not been observed to cause adverse impacts on vegetation at exposure concentrations typical of the ambient environment. It is the high affinity of CO for haemoglobin and other important haem containing proteins (eg. cytochromes) that is the key health issue. Carbon monoxide is a poisonous gas having a lifetime of two to four months in the atmosphere. The levels of CO measured in this study are due mainly to combustion of carbon-containing fuels including fish smoking with firewood. Carbon monoxide (CO) is a product of incomplete combustion of organic materials. It is an odourless and colourless gas which has a higher affinity for blood oxygen. The toxic effects of CO on human beings and animals arise from its irreversible combination with haemoglobin (Hb) in the blood, affecting its oxygen-carrying capacity and result to death.

$$Hb + O_2 \longrightarrow HbO_2$$
$$HbO_2 + CO \longrightarrow HbCO + O_2$$

Carboxyhaemoglobin (COHb) complex reduces the oxygen carrying capacity of the blood cells so that less oxygen is available to the body cells and organs, especially the brain, leading to various physical disabilities. Also HbCO reduces the dissociation of Oxyhaemoglobin (HbO_2) into haemoglobin and oxygen. Carbon monoxide ties up about 220 times more Hb than does O_2. As much as 2000mg/m^3 CO could kill instantly and 250mg/m^3 CO will cause loss of consciousness. The upper limit of CO for industrial exposure to healthy workers is 100mg/m^3. At this level, many people experience dizziness, headache and lassitude. An amount, as low as 10mg/m^3 has effect on the central nervous system. (Concawe, 1999).

Hydrogen sulphide emissions result in damage to human health. It also causes irritation of the respiratory tract and damage to the central nervous system. At high concentrations it destroys immature plant tissue (Manahan, 1979). The major source of hydrogen sulphide is the microbial decay of organic

matter and the reduction of sulphate ion (Manahan, 1979).

$SO_4^{2-} + 2(CH_2O) + 2H^+ \longrightarrow H_2S + 2CO_2 + 2H_2O$.

Since the fuel burnt in the area contain low level of sulphur and the area is surrounded by rivers and swamps the levels of H_2S measured in the study area are mainly contributed by mudflats, riverbanks and tidal marsh soils (Cope and Spedding, 1982). Hydrogen Sulphide at levels well above ambient concentrations irritate respiratory tract and damage central nervous system (Manahan, 1979). Hydrogen Sulphide could cause death at levels as low as 0.25mg/m^3. The gas has the odour of rotten egg, and can be perceived at a low concentration. Higher concentrations above 0.25mg/m^3 have the ability of deadening the odour cells of the olfactory lobes, so that the victim may not be sensitive to the impending danger of death. Hydrogen Sulphide can be oxidized by atmospheric molecular oxygen (O_2) and Ozone (O_3) in the following reactions:

$2H_2S + 3O_2 \longrightarrow 2SO_2 + 2H_2O$
$H_2S + O_3 \longrightarrow SO_2 + H_2O$

Further oxidation of SO_2 by O, O_2 and O_3 will give;
$SO_2 + O \longrightarrow SO_3$
$2SO_2 + O_2 \longrightarrow 2SO_3$
$SO_2 + O_3 \longrightarrow SO_3 + O_2$

Sulphur dioxide is a major air pollutant, primarily found in the combustion products of oil and coal. Its presence in the area could also be attributed to the activities of roadside vulcanizers. It is corrosive and an eye irritant. Inhalation of 0.2mg/m^3 SO_2 could result in death. Sulphur dioxide is the most corrosive of the sulphur oxides while SO_3 and SO_2 could react with atmospheric water vapour to produce sulphuric acid, which can be precipitated as acid rain.

$SO_2 + H_2O \longrightarrow H_2SO_3$
$H_2SO_3 + ½\ O_2 \longrightarrow H_2SO_4$
$SO_3 + H_2O \longrightarrow H_2SO_4$

Ammonia is present in the atmosphere as a result of natural, biochemical and chemical processes. Ammonia in polluted atmosphere reacts readily with acid materials such as sulphuric acid aerosol droplets to form ammonium salts.
$NH_3 + H_2SO_4 \longrightarrow NH_4HSO_4$

The high mean levels of PM_1, (0.007mg/m^3), NO_2 (1.7ppm) and NH_3 (2.7ppm) in the dry season and CO (4.3ppm), NH_3 (1.7ppm), CH_4 (2.7ppm) and VOC (7.0mg/m^3) in the rainy season as well as other pollutants measured at station 1 could mainly be attributed to emissions from tanks, valves and flare at the refinery in addition to loading and other activities of tankers, trailers and other vehicles at the refinery site and Jetty.
The highest mean level of VOC (5.2ppm) measured at station 2 in the dry season could be attributed to its proximity to the refinery Jetty where vessels are loaded and bunkery activities take place.

The highest mean level of PM_7 (0.286mg/m^3), PM_{10} (0.378mg/m^3), TSP (0.503mg/m^3) and SO_2 (1.4ppm) measured at station 3 in the dry season could be attributed to emissions from the refinery and Jetty and vehicular activities on the road as it is located at the predominant down wind of the refinery.

At station 5 the highest mean level of CO (12.7ppm) in the dry season and $PM_{2.5}$ (0.008mg/m^3), PM_7 (0.047mg/m^3), PM_{10} (0.066mg/m^3) and TSP (0.093mg/m^3) in the rainy season. This observation could be attributed to emissions from vehicular and domestic activities such as cooking and drying of fish with firewood.

The highest mean levels of $PM_{2.5}$ (0.036mg/m^3) and CH_4 (3.0ppm) in the dry season and $PM_{2.5}$ (0.008mg/m^3) in the rainy season were measured at station 9. This observation could be attributed to emission from plants, vehicles and domestic activities such as cooking and drying of fish with firewood.

It was observed that in both seasons none of the pollutants measured had highest value at stations 4,6,7,8 and 10. However appreciable levels of the pollutants were measured at these stations. This observation could be attributed to the fact that these stations are riverine communities which are distant from the refinery and low vehicular activities; pollutants in these communities are mainly influenced by emissions from outboard engine boats and domestic activities such as cooking and drying of fish with fire firewood.

Meteorological Parameters: The highest mean ambient temperature was 38.6°C (dry season) and 29.5°C (rainy season) both at station 4. The higher temperature in the dry season than the rainy season was not unexpected. The differences in ambient temperature at the stations was due to differences in the time of the day measurement was made. The observed temperature values are opposed to Alagoa and Derefaka (2002) who stated that temperature is fairly constant throughout the state with a maximum

of 30°C. The high temperature could be attributed to reduction in the moisture content of the air around the stations due to prevalence of North-East trade winds (harmattan winds), which were dry, cold and dust laden. Other factors which probably contributed to the high values were increased use of biomass fuel for cooking and drying at the study areas and gas flaring activities in the state (Uzukwu, 1998).

The mean levels of relative humidity was 59.9% (dry season) and 70.1% (rainy season). The rainy season values were generally higher than the dry season values in all the stations. This is attributed to high moisture content of the air in the area during the rainy season. The results obtained in this study are in line with the report by Alagoa and Derefaka (2002) that the month of June (rainy season) recorded a monthly mean of over 80% and the dry season month of January recorded below 65%.

With the exception of stations 3 and 9, the dry season mean values of wind speed were higher than the rainy season values. This observation does not agree with the observations of Osaisai, 2008 who reported the contrary in Yenagoa. The higher wind speeds in the dry season could cause dispersion of pollutants faster from sources to down wind locations.

The predominant wind direction, North East, in the dry season and South West in the rainy season could be responsible for the higher levels of pollutants such as particulate matter in the study area. Most of the communities are located North Westerly and South Westerly of the refinery and therefore emissions are carried by the North Easterly winds and dispersed to these communities to influence the pollutant levels in the communities.

Ambient Noise Measurement **:** The highest mean level of noise, 83.8 dB(A) in the rainy season and 82.7dB(A) in the dry season were obtained at station 9. The noise levels in the rainy season were generally higher than the levels in the dry season in all stations except at stations 5 and 8. This observation could be attributed to high wind speeds at stations 3 and 9 during the rainy season. It was observed that noise measurements were done outside the Refinery (along the road) and within the communities. The levels obtained are therefore attributed to human activities including conversations, automobiles and musical systems.

The highest level of noise measured in the study area is below the permissible limit of 90 dB(A) and therefore do not call for serious environmental and human concern.

Nose pollution is a serious public problem that can easily disrupt a vital train of thought. Prolonged exposure to a noise level of about 85 dB(A) usually results in loss of hearing (Time, 1968, SKC, 2000). NIOSH (1996) attributed hearing loss among workers to their exposure in the industries while Smoorenburg *et al*., (1990) identified prolonged equivalent daily exposures of at least 85 dB(A) as a contributing factor to increased blood pressure and hypertension. Loss of hearing due to exposure to noise can equally lead to tinnitus that is, buzzing in the ear while insomnia and tiring can also be caused by noise exposure. Occupational hearing loss is often being overlooked because it usually occurs insidiously without dramatic consequence such as bleeding, deformity, or death (Berger, 2000). However the Federal Ministry of Environment recommended 90 dB(A) as the standard noise exposure limit for Nigeria in an 8 hour working period (FMEnv, 1991). The noise does not only disturb sleep, interrupt conversation, and create stress and annoyance in the general population; it also reduces the efficiency and output of workers (Sinha and Sridharan, 1999).

Conclusion: The quality of air in the study area is poor indicating pollution as pollution the concentrations of the air pollutants such as hydrogen sulphide (H_2S), volatile organic compounds (VOC), nitrogen (iv) oxide (NO_2), sulphur (iv) oxide (SO_2) and ammonia (NH_4) exceeded permissible limits and therefore pose serious environmental and health problems in the area. The ground level concentration resulting from industrial, traffic and domestic emissions were variable according to the meteorological/weather conditions prevailing at the time.

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