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Original Research Article

Evaluation of Air Quality Profile of Selected Areas of Obio/Akpor LGA and Environs of Rivers State, Nigeria

***[1]Ugbebor, J. N. and [2]Ntesat, B.**
[1]Department of Civil and Environmental Engineering, University of Port Harcourt, Nigeria
[2]Nigerian Institution of Environmental Engineers, Rivers State Branch, Port Harcourt, Nigeria
*johnugbebor@yahoo.com

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ABSTRACT

This study investigated the quality of ambient air in four major locations in Port Harcourt and environs. The sampling points were Rumuokoro, Choba Park, Oil mill/Eleme junction and Chokocho-Umuechem junction (control). The Enerac 700 was applied to sample the air quality. A Minivol air metrics sampler was used for suspended particulate matter (SPM). A spark model 706 RC docimeter was used for noise level measurement. The objectives were to establish the concentration of nitrogen oxides (NOx), sulphur oxides (SOx), carbon monoxide (CO), and particulate matter ($PM_{2.5}$ and PM_{10}) and compare the results with air quality standards of the Federal Ministry of Environment (FMEnv) of Nigeria and National Ambient Air Quality standards (NAAQS). The results showed that NOx was 0.5ppm, 1.4ppm, 0.75ppm, and 0.13ppm respectively and exceeded the limits of FMEnv (0.06ppm) and NAAQS (0.1ppm). SOx was 1.44ppm, 1.3ppm, 1.13ppm and 0.31ppm, respectively and also exceeded the permissible limits of FMEnv (0.01ppm) and NAAQS (0.14ppm). The analysis proved that CO exceeded acceptable limits only at the Oil Mill/ Eleme junction but was stable at other sampling locations. Particulate matters of $PM_{2.5}\mu/m^3$ and $PM_{10}\mu/m^3$ had a threshold at Rumuokoro ($144.5\mu/m^3$ and $181.25\mu/m^3$), Choba Park ($79.63\mu/m^3$ and $181.65\mu/m^3$), Oil Mill/ Eleme ($228.1\mu/m^3$ and $471\mu/m^3$) and Chokocho- Umuechem junction had $71.9\mu/m^3$ for $PM_{2.5}$ and $157.2\mu/m^3$ for PM_{10} and these exceeded permissible limits of NAAQS ($35\mu/m^3$ and $150\mu/m^3$). Therefore, due to severe public health consequences, it is recommended that custodian government agencies continuously monitor air quality and checkmate various unhealthy activities that may escalate pollutants in air.

1. INTRODUCTION

Air is a mixture of gases which does not pose any problem to anyone in its natural form (Ghio *et al*., 2012). However, human activities (industrial, commercial and domestic) often cause series of air contamination.

Air quality around a location may be impacted by anthropogenic processes such as burning of fossil fuel in power generators for long periods, burning of fossil fuel by associated gas flaring from oil production facilities and vehicular emissions (Akuro, 2012). Other sources of air pollutants today are the emissions products discharged into the air from thermal plants, boilers, exhaust of internal combustion engines and furnaces of industries, and homes (Park, 2005; Barman *et al.*, 2010). With industrialization and urbanization various activities that could cause air contamination have increased thereby making air quality a very serious issue, as good or bad air affect human health positively or negatively. What one breathes in is largely a function of one's location at a particular period of time except if moving around with gas masks proves favorable (Colais *et al.*, 2012; Kavuri and Paul, 2013; Enotoriuwa *et al.*, 2016). There is the need therefore, to assess the quality of air from time to time in such places or areas to ensure environmental health (Gandini *et al.*, 2013). Today, science has made instruments possible to enable the collection of data about the present state of ambient air quality in relation to meteorological factors which are necessary tools for the formulation of emission control measure (Rao, 2002; Shukla *et al.*, 2010; Bhuyan *et al.*, 2014). A large number of air quality studies have been carried out over the years particularly in exposure assessment (Galeano and Kariuki, 2001; David *et al.*, 2004; Enotoriuwa *et al.*, 2016; Yorkor *et al.*, 2017; Ugbebor *et al.*, 2017; Ugbebor and Yorkor, 2018). The essence of such studies has gained wide recognition in various parts of the world since scientifically, man has always sort to have significant control over environmental exposures that have the potential to impact his health. Air pollution issues remain a fundamental and serious threat to healthy environment in several cities of the world (McCarthy *et al.*, 2007; Kan *et al.*, 2009).

Concentrations of the ambient air must be measured to determine whether air is suitable to breathe (i.e. meets the criteria set by National Ambient Air Quality standards) (De Nevers, 2016). Many Nigeria States including Rivers State are on the brink of environmental calamity due to air pollution occasioned by particulate emissions. This is due to illegal crude oil refining ('Kpo fire') in its suburbs, concentration of many industries, high density of traffic, poor integrity of commercial vehicles (Igoni, 2018). However, the poor enforcement of any existing air quality laws by regulators and agencies in charge, has aided the deterioration of ambient air quality in the study area (Shukla et al., 2010; Iniaghe and Tesi, 2013; Igoni, 2018). A continuous evaluation of the air quality is indispensable for the enhancement of any plan for health risk, caused by polluted air (Penard-Morand and Annesi-Maesano, 2004; Umapathy, 2011).

The purpose of this study was to determine the air quality profile by measuring the ambient air quality parameters such as Sulphur oxide (SOx), Nitrogen oxide (NOx), and particulate matter (PM_{10} and $PM_{2.5}$), carbon monoxide (CO), Ammonia (NH_3), Lead (Pb), and Ozone (O_3) in selected areas of Port Harcourt in Rivers State and this will help establish the environmental health status of the City. The results obtained were compared with international air quality standards from National Ambient Air Quality Standard (NAAQS) and Federal Ministry of Environment (FMEnv).

2. MATERIALS AND METHODS

2.1. Study Area

The study areas were selected within Port Harcourt City. A neighboring community within Rivers State, Nigeria with fewer commercial activities was chosen as control. Some major parking lots and main market spots such as Rumuokoro roundabout, Oil Mill/ Eleme market, Choba Park; and Chokocho Umuechem junction, were chosen as study locations (Table 1).

Table 1: Sampling locations and their coordinates

Sampling locations	Coordinates
Rumuokoro roundabout	N4°52'3.53"; E7°0'0.55"
Choba park	N4°53'54.96"; E6°54'23.95"
Oil Mill/Eleme junction	N4°85'5.08"; E7°06'48.26"
Control (Chokocho-Umuechem road)	N4°99'08.33"; E7°05'44.44"

Figure 1: (A) Map of Rivers State showing Obio/Akpor; (B) Sampling locations and distances (https://www.google.com.ng)

2.2. Procedure for Field Sampling

Air samplings were carried out using the Enerac 700 digital monitoring device (DMD), a high capacity sampler method to sample the air quality. The DMD gave an instantaneous reading and results in sample stations which were recorded. The instrument was fixed at a benchmark of 3 meters above the ground level using tripod standard stand cord at the specific sampling points. Sampling was done during the dry season at regular intervals for a period of 8 hours in compliance with WHO guidelines (Rao, 2002; WHO, 2017). The absorbent solution was then analyzed by ultraviolet/visible infrared spectrometer. A Minivol Airmetrics sampler was used for Suspended Particulate Matter (PM_{10} and $PM_{2.5}$). A spark model 706 RC dosimeter with accessories was used for noise level measurement. The data collected at the sampling sites included concentration of nitrogen oxides, sulphur oxides, carbon monoxide, particulate matter ($PM_{2.5}$ and PM_{10}) and noise level. The results were compared with air quality standards of the Federal Ministry of Environment (FMEnv) of Nigeria and National Ambient Air Quality standards (NAAQS). The standard analytical method used for measuring pollutants in ambient air was in 40CFR50 App A-H, which conformed to Environmental Protection Agency standards (USEPA, 2009).

2.3. Sample Collection

A total of forty-eight (48) representative samples were collected from the four (4) sampling points. In order to give effective sampling, meteorological factors of interest were considered including wind speed and direction, temperature, and humidity. It was observed that some pollution sources within sampling stations were industrial emissions, vehicular emissions, as well as food confectionaries.

2.4. Computation of Noise Level at the Sampling Locations

The combined noise level from the selected sampling locations was obtained from the following expression:

$$L = 10log_{10}\left(10^{\frac{L_1}{10}+}\,10^{\frac{L_2}{10}+}\,\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 10^{\frac{L_n}{10}+}\right)\,db \quad (1)$$

Where:

L = total (combined) noise level
L_1, L_2 …….L_n are noise levels from 1st, 2nd, ...nth source.
L_1 = mean concentration of noise level at Rumuokoro roundabout = 76.43db
L_2 = mean concentration of noise level at Choba park = 71db
L_3 = mean concentration of noise level at Oil Mill/Eleme junction = 83.1db
L_4 = mean concentration of noise level at Control (Chokocho-Umuechem) = 51.19db
L = 84.16db

3. RESULTS AND DISCUSSION

The results of the field sampling and monitoring in the selected study locations are shown in Tables 2-6. The parameters of concern included: NOx, SOx, CO, $PM_{2.5}$, PM_{10} and noise sampled at the respective sampling locations; in addition to the listed parameters, the meteorological factors were included in Tables 2-5. Table 6 illustrates the mean of all concentrations of the sampled parameters and their relative approved standards (FMEnv and NAAQS).

Table 2: Result of ambient air quality monitoring at Rumuokoro junction

18 - 05 – 2018 Coordinates from Google Earth											
Time (hr)	NOx (ppm)	SOx (ppm)	H_2S (ppm)	CO (ppm)	$PM_{2.5}$ (µg/m^3)	PM_{10} (µg/m^3)	Noise dB (A)	Wdspd (m/s)	Temp (°C)	Rel. Hum (%)	Wind direct
9:00	0	0.5	0	0.5	100	198	87.59	1	24.43	95.34	NE
10:00	0	1	0	4.5	180	280	38.9	1.54	27.52	78.56	SE
11:00	0.5	1	0	8	265	553	94.99	3.67	29.68	91.32	SW
12:00	0.5	1.5	0.5	4.33	150	120	67.52	1.9	30.23	67.65	NE
13:00	1	2	0.5	7.98	300	85	94.23	1.5	31.89	56.89	NE
14:00	1	2	0	5.78	50	77	75.77	4.67	33.74	77.43	SW
15:00	0.5	2	1	8.65	76	150	58.51	2.58	33.56	65	SE
16:00	0	1.5	1	4.34	35	67	93.98	1.5	30.89	63.89	SE
Range	0.0-1.0	0.5-2.0	0.0-1.0	0.50-8.65	50.0-300.0	67.0-553.0	38.90-94.99	1.00-4.67	24.43-33.89	56.89-95.34	
Mean	0.5±0.15	1.44±0.28	0.75±0.17	5.51±6.39	144.5±8448	181.25±23168	76.43±362.9	2.3±1.41	30.24±8.49	74.51±162.8	
FMEnv	0.06	0.01	NA	10	NA	NA					
NAAQS	0.1	0.14	NA	9	35	150					

Table 3: Result of ambient air quality monitoring at Choba park junction

19 - 05 – 2018 Coordinates from Google Earth											
Time (hr)	NOx (ppm)	SOx (ppm)	H_2S (ppm)	CO (ppm)	$PM_{2.5}$ ($\mu g/m^3$)	PM_{10} ($\mu g/m^3$)	Noise dB (A)	Wdspd (m/s)	Temp (^oC)	Rel. Hum (%)	Wind direct
9:30	0	0.5	1	0.5	186	287.56	77.62	3.87	31.41	87.52	SW
10:30	0	1	1	4.5	100	345.23	58.45	0.77	32.84	88.43	NE
11:30	1.5	1	2	8	34	333.2	67.59	2.3	30.31	81.92	NW
12:30	1	1.5	1.5	4.33	89	100	89.81	1.7	33.19	54.96	SW
13:30	1.3	0.8	0.5	7.98	67	67	69.82	0.78	28.56	66.12	NE
14:30	1.7	2	1	5.78	50	90.34	70.99	4	30.67	87.11	NW
15:30	1.4	2	1.86	8.65	66	165.1	42.63	5.08	29.89	82.01	SW
16:30	0.5	1.5	1.23	4.34	45	64.78	90.75	1.54	29	50	SE
Range	0.00-1.70	0.50-2.00	0.50-2.00	0.50-8.65	45.00-186	64.78-345.23	42.63-90.75	0.77-5.08	28.56-33.19	50.00-88.43	
Mean	1.4± 0.40	1.3 ± 0.27	1.26 ±0.22	5.51± 6.39	79.63 ± 2040.23	181.65± 12878.01	71 ± 220.38	2.51± 2.29	30.73 ±2.44	74.76 ±210.72	
FMEnv	0.06	0.01	NA	10	NA	NA					
NAAQS	0.1	0.14	NA	9	35	150					

Table 4: Result of ambient air quality monitoring at Oil Mill/Eleme junction

20 - 05 – 2018 E7^o 03' 47.388" and N4^o 51' 17.976"											
Time (hr)	NOx (ppm)	SOx (ppm)	H_2S (ppm)	CO (ppm)	$PM_{2.5}$ ($\mu g/m^3$)	PM_{10} ($\mu g/m^3$)	Noise dB (A)	Wds pd (m/s)	Temp (^oC)	Rel. Hum (%)	Wind direct
9:10	0	1	0	7	230.5	195.88	68.19	2.5	30.13	85.5	SW
10:10	0	0	0	8	359.34	278.09	74.1	1.8	32.78	89.16	NE
11:10	0.5	1.5	1	26	25.8	863.2	92.79	2.65	28.45	69.48	SE
12:10	1.5	1	0.5	28.67	189	640	78.69	1.6	31.56	98.89	NE
13:10	1	1.5	0.5	13.5	598.5	999	89.56	2.55	34.5	61.13	NW
14:10	1	2.5	1	9.23	200.8	621	89.13	1.61	29.5	84.6	SE
15:10	1.5	1.5	1.5	10.65	125	242.5	88.72	3.62	33.79	72	NE
16:10	0.5	1	0.5	15.5	95.83	88.39	83.62	2.2	30.19	54.7	NW
Range	0.00-1.50	0.00-2.50	0.00-1.50	7.00-28.67	25.80-598.50	88.39-99.9	68.19 - 92.79	1.61-3.62	28.45-34.50	54.70-98.89	
Mean	0.75± 0.31	1.13± 0.44	0.63± 0.23	14.82 ± 59.42	228.1± 28218.78	471± 98996.42	83.1± 65.82	2.31 ± 0.40	31.36 ± 4.08	76.93 ± 198.46	
FMEnv	0.06	0.01	NA	10	NA	NA					
NAAQS	0.1	0.14	NA	9	35	150					

Table 5: Result of Ambient Air quality monitoring at Chokocho-Umuechem (Control)

21 - 05 – 2018 $E7^0$ 05'4.444" and $N4^0$ 99'0833"

Time (hr)	NOx (ppm)	SOx (ppm)	H_2S (ppm)	CO (ppm)	$PM_{2.5}$ ($\mu g/m^3$)	PM_{10} ($\mu g/m^3$)	Noise dB (A)	Wdspd (m/s)	Temp (^oC)	Rel. Hum (%)	Wind direct
9:50	0	0.5	0	0	91	332	34.99	0.5	29.33	83.44	SE
10:50	0	0	0	0	101	195.99	49.12	1.04	28.67	69.43	NW
11:50	0.5	0	0	1	49	341	69.05	1.67	31.78	88.56	NE
12:50	0	0.5	0	0.03	88	101	77.22	1.7	30.45	77.45	NE
13:50	0	1	0.5	2	66	79	30.63	2	34.9	69.67	SE
14:50	0.5	0	0	0.12	80.2	81.5	58.55	0.78	31.24	89.56	SE
15:50	0	0	1	0	54.5	60.68	66.71	1.43	27.56	70	NE
16:50	0	0.5	0.5	0.01	45.5	67	71.25	1	29.88	67.9	NW
Range	0.00-0.5	0.00-1.00	0.00-1.00	0.00-2.00	45.50-101.00	60.68-341.00	30.63-77.22	0.50-2.00	27.56-34.90	67.90-89.56	
Mean	0.13± 0.05	0.31± 0.12	0.19± 0.13	0.4± 0.47	71.9± 387.33	157.2± 12287.30	57.19± 261.93	1.3± 0.23	30.4± 4.41	77± 71.99	
FMEnv	0.06	0.01	NA	10	NA	NA					
NAAQS	0.1	0.14	NA	9	35	150					

Table 6: Mean concentrations at various sampling stations

Parameters	Control	Rumuokoro	Choba	Oil mill/Eleme	FMEnv	NAAQS
NOx (ppm)	0.13	0.5	1.4	0.75	0.06	0.1
SOx (ppm)	0.31	1.44	1.3	1.13	0.01	0.14
CO (ppm)	0.4	5.51	5.51	14.82	10	9
PM2.5 ($\mu g/m^3$)	71.9	144.5	79.63	228.1	NA	35
PM10 ($\mu g/m^3$)	157.2	181.25	181.65	471	NA	150
Noise dB (A)	57.19	76.43	71	83.1	-	-
Wdspd (m/s)	1.3	2.3	2.51	2.31	-	-
Temp (^oC)	30.4	30.24	30.73	31.36	-	-
Rel. Hum (%)	77	74.51	74.76	76.93	-	-

Wdspd= Wind speed; Temp= Temperature; Rel. Hum= Relative Humidity

Table 2-6 showed the average measurement for the concentration of NOx to be at a disturbing rate of 0.5ppm (Rumuokoro), 1.44ppm(Choba) and 0.75ppm (Oil mill/Eleme junction) and 0.13ppm (Control-Chokocho-Umuechem) against FMEnv and NAAQS that are 0.06ppm and 0.1ppm and SOx which had a rate of 1.44ppm (Rumuokoro), 1.3ppm (Choba road junction), 1.13ppm (Oil mill/ Eleme junction), 0.31ppm (Control-Chokocho-Umuechem) respectively as against the permissible limits of 0.01ppm (FMEnv) and 0.14ppm (NAAQS). The health implications of these abnormal thresholds according to FMEnv and NAAQS include eye irritation, breathing difficulties, increased respiratory diseases, damage to plants and odor. In this light, CO was 14.82ppm only at Oil mill/Eleme junction while the rest sampled locations remained

within the benchmarks of FMEnv and NAAQS (10ppm and 9ppm) respectively. The implication of high CO threshold to persons with long exposure to this air quality conditions include chronic cardiovascular, nervous, and pulmonary systems breakdown. The mean concentration of the particulate matter ($PM_{2.5}$) for the four (4) stations were 144.5µg/m^3 (Rumuokoro), 79.63µg/m^3 (Choba), 228.1µg/m^3 (Oil mill/ Eleme junction), and control 79.1µg/m^{3}respectively. While PM_{10} for the four (4) stations were181.25µg/m^3 (Rumuokoro), 181.65µg/m^3 (Choba), and 471µg/m^3 (Oil mill/Eleme junction) and control 157.2µg/m^{3}respectively; $PM_{2.5}$ and PM_{10} exceeded the NAAQS recommended level of 35µg/m^3 and 150µg/m^{3}respectively.

It is important to note that $PM_{2.5}$ and PM_{10} was of interest in this study because it was among the criteria pollutants. The highest concentration of PM_{10} was recorded at Oil mill/Eleme junction. This was not unconnected with the huge traffic activities going on around the area, coupled with the Oil mill market. The implication of these high particulate matter thresholds; indicated that long exposure may result to challenging health issues such as eye and throat irritation which may aggravate lung illnesses, accelerate chemical reactions and obscured vision. The lowest recorded mean concentrations were at Chokocho-Umueche road the control station, where there was fewer commercial activities. However, the noise index level was at high level of 84.16db as evaluated using the standard model in Equation (1) (Barber, 1992; Leton, 2007) and this may result in distracting and gradual deafening may begin to occur with extended long exposure to person(s) who constantly spend close to six (6) to eight (8) hours on daily bases at the selected sampled areas considering that they are densely populated and a high business environment.

4. CONCLUSION

The study examined the qualities of ambient air in the four (4) major locations in Port Harcourt City and environs. A total of 6 parameters were analyzed out of which two (2) were concentration of suspended particulate matters measured during the field sampling, and four (4) concentrations of gaseous pollutants. The standard sampling methods and instruments were used to carry out the field sampling of parameters. The results of the analysis for gaseous pollutants showed that nitrogen oxide (NOx) were 0.5ppm, 1.4ppm, 0.75ppm, and 0.13ppm respectively which exceeded the limits of FMEnv (0.06ppm) and NAAQS (0.1ppm) standard. Sulphur oxide (Sox) was 1.44ppm, 1.3ppm, 1.13ppm and 0.31ppm, respectively which also exceeded the permissible limits of FMEnv (0.01ppm) and NAAQS (0.1ppm). The analysis proved that CO exceeded acceptable limits only at the Oil Mill/ Eleme junction with a mean concentration of 14.83ppm, but remaining stable at all other sampling locations. The particulate matters of $PM_{2.5}$µ/m^3 and PM_{10} µ/m^3 had a threshold at Rumuokoro (144.5µg/m^3 and 181.25µg/m^3), Choba Park (79.63µg/m^3 and 181.65µg/m^3), Oil Mill/Eleme junction (228.1µg/m^3 and 471µg/m^3) and Chokocho-Umuechem road junction (71.9µg/m^3 and 151.2µg/m^3). Investigation showed that most of the parameters analyzed within Rumuokoro, Choba Park and Oil Mill/Eleme junction were contributed to the levels of air pollution from these locations. The mean concentrations of Nitrogen oxide (NOx), Sulphur oxide and Carbon monoxide (CO) were as a result of burning of fossil fuel from various carbon driven engines. The concentrations of these sampled parameters were above the FMEnv and NAAQS limits were indications that the public may suffer health risk in study areas. The custodian government agencies of Rivers State should put mechanisms in place to ensure regular monitoring of ambient air quality in the selected areas in Port Harcourt remarkably as activities increase, to promote early warning of air pollution and ensure the effectiveness of engineered air pollution control blueprint. The government should also speed up natural dispersion and scavenging, such as trees planting and activate the use of diverse energy sources other than conventional fossil fuel which increases the risk of air pollution.

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6. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

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