



## Monitoring and health risk of ambient air pollutants in moderately industrialized zones of Port Harcourt, Nigeria

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### Abstract

The aim of this research work was to investigate the levels and possible health risk due to the presence of ambient air pollutants in the atmospheric air of moderate industrial areas (Bua factory, Flourmill and macoba areas) of Port Harcourt metropolis (Industry road). The study deployed standard methods and protocols to examine and monitor the parameters in the air of the study zones. The following; CO<sub>2</sub>, NO<sub>2</sub>, SO<sub>2</sub>, CO, O<sub>3</sub>, CH<sub>4</sub>, NH<sub>3</sub>, and particulate matters were determined. The results revealed that CO, SO<sub>2</sub>, NO<sub>2</sub>, O<sub>3</sub>, and NH<sub>3</sub> were not among the detected pollutants in all the zones. The others detected were thus: Bua: PM<sub>2.5</sub>; 32.30±1.60 pg/m<sup>3</sup>, PM<sub>10</sub>; 36.55±1.15 pg/m<sup>3</sup>, VOC; 0.065±0.010 ppm. Flourmill: PM<sub>2.5</sub>; 23.15±2.650 pg/m<sup>3</sup>, PM<sub>10</sub>; 43.45±0.650 pg/m<sup>3</sup>, VOC; 0.195±0.020 ppm. Macoba: PM<sub>2.5</sub>; 40.80±0.59 pg/m<sup>3</sup>, PM<sub>10</sub>; 57.65±6.71 pg/m<sup>3</sup>, VOC; 0.080±0.010 ppm. The health risk analysis indicated low risk due to hydrogen sulphide and sulphur (IV) oxide presences. The levels of the pollutants were not too high but continuous inhalation may be injurious to the immediate inhabitants of the area. It is recommended that strict monitoring of the area should be encouraged.

**Keywords:** ambient air contaminants, particulate matter, relative humidity, noise level etc

### Introduction

The inhabitants of Port Harcourt are beyond two million which allows room for a lot of anthropological venture at sublime measure. It is the seat of government of Rivers State, and the commercial, manufacturing and mining hub of the Niger delta region of Nigeria. It is one of the various metropolitan and overpopulated town in Nigeria. The city is extremely metropolitan with completely developed road matrix which helps the movement of vehicular traffic that exert influence on the measure of air pollution within the town (Adoki, 2012) <sup>[1]</sup>. Air pollution is one of the foremost environmental difficult situations challenging the city of Port Harcourt still statistics concerning this is very limited as not many studies has been investigated attributed to shortage of equipment and indifferent frame of mind on the part of the administrators. Discounting from statistics gathered by a handful of person and corporate institution at separate locality, within Port Harcourt there is no full-scale and verifiable database on the dimensions of the risk and its deleterious consequence on the resident and ecosystems within the city. It has been documented that the ecosystem within the Port Harcourt environment has been impacted by xenophobic materials discharging from both man and his activities. Likewise, the existing connection of meteorological stations is not promptly giving out this information to the citizens for citation and educational goal. Port Harcourt is Nigeria's hydrocarbon business capital with numerous of the international oil establishment having their workplace and functioning base within Trans Amadi axis of the city. The functioning of these industries particularly the upstream and downstream petroleum quarter in addition to a diversity of other anthropogenically connected undertaking as well as biofuels ignition, debris burning and traffic discharge unloose a plethora of material such as explosive organics, oxides of carbon, nitrogen, sulphur, particulate matter, heavy metals and other toxin at proportion that predominantly surpass both the state and worldwide recommendation. Aside from compromising the standard of the atmosphere most of the air pollution in Port Harcourt is noticed to give rise to the emergence of acid rain, contamination of water bodies, land pollution, death of plants and wild life and correspondingly play a part to the global warming. The paramount source of air pollution within the city is vehicular cause, with emission from it playing a crucial part to the measure of pollutants in the air. Some pollutants stay only in the environment for a short time, while others stay long (WHO, 2003) <sup>[13]</sup>. The duration of the persistence of pollutants is normally influenced by the properties of the compounds in the medium in which they are distributed and the climatic conditions (Wonodi & Ekpete 2021) <sup>[15]</sup>. The other causes of pollution within Port Harcourt city is gas flaring. There is a significant matter within the city which has to do with black soot in the air within the city. The source has not been substantiated nonetheless is suspected to have emanated from illegal crude oil refining action within the creeks around the city. This has

negatively influenced the standard of air within the city. There was an assertion that about 70% of associated gas manufactured yearly is been squandered via flaring. The Energetic Solution Conference approximate that the Niger Delta area has about 123 gas flaring location (Khalda, 2012) <sup>[9]</sup>. Preponderance of these flared gases unleash pollutants such as NO<sub>2</sub>, SO<sub>2</sub>, CO, H<sub>2</sub>S, CH<sub>4</sub> and volatile organic. Gas flaring and oil spill has immediate and unintended aftereffect on man and the environment. Flared gases shatter the innate ecosystem and also have a handful of health consequences. To give an instance, the exhaustion of liquefy oxygen by pathogens living on the spilled-over aromatic hydrocarbons engender death of aquatic organism in water. Some of the well-being difficulty that may become apparent incorporates respiration difficulty, epidermis abrasion and cancers etc. Flares and spills as well adulterate fresh unprocessed water bodies. In addition, subjection to flared gas can complicate asthma, long-standing bronchitis and leukaemia. This research was therefore ventured to investigate the level of atmospheric air pollutants and the possible health risk in moderately industrialized zones of Port Harcourt and its vicinity and was done using standard air quality monitoring instruments and procedures.

## Materials and Methods

### Study Area

The study location of Port Harcourt is a multi-ethnic city and has been a centre of manufacturing and other anthropogenic activities. It is the capital and economic nerve centre of Rivers State in Nigeria. It is the second most industrialized city in Nigeria outside Lagos city. Port Harcourt and its environment comprise of different local government; Port Harcourt City Local govt, Obio/akpor Local govt, Oyigbo local government area, Okrika local govt, Eleme local govt and Ikwerre local govt areas. The city covers about 370 km<sup>2</sup> (147 sq mile) in land area and water area, while the cosmopolitan area of the city is about 1900 km<sup>2</sup>. Industry road axis of Port Harcourt is a major moderate industrial location with major installations like Port Harcourt Flourmill, Bua Cement Industry, Macoba Industry, Gas refilling plants and NPA ports where crude oil and its allied activities are carried out.

**Table 1:** Location coordinates of the sample locations from the study area

Location	Latitude	Longitude
Control	N4°48'19.67272", 4.805470	E7°1'49.6632", 7.006754
Bua Factory	N4°46'28.736044", 4.774623	E7°0'45.26568", 7.012611
Flourmill	N4°45'58.06188", 4.766128	E7°0'46.08504", 7.012801
Macoba	N4°45'32.17284", 4.758937	E7°0'31.80168", 7.008834

### Measurement of Air Quality Parameters

#### Extech Anemometer

A multi-parameter digital anemometer Model No. 45170 was used to measure the wind speed, and direction, relative humidity, pressure, and temperature.

#### Noise Meter

Sound Pressure Level Meter with the model TES1352H was used to measure the noise level at each point in decibels.

#### TESTO Gas Analyser

A portable gaseous emission analyzer, the TESTO 350-XL, from Testo Inc. (Testo, 2009), collects and stores data independently for up to 48 hours. It measures O<sub>2</sub>, CO, NO<sub>x</sub>, NO, NO<sub>2</sub>, SO<sub>2</sub>, HC, and H<sub>2</sub>S.

#### Total Suspended Particulate Matter (TSPM) and Particulate matter

A Mini Volume instrument, Aerosol gas monitor was used to measure Total Suspended Particulate Matters. Mini-Volume Portable Air Sampler manufactured by Air metrics is a portable ambient air sampler for particulate (PM<sub>10</sub> and PM<sub>2.5</sub>).

#### Frequency of Sample Collection

The monitoring involved an hourly sampling technique where samples were monitored at each location for a period of six hours in a day from and the average taken for each location. This was repeated for a done period of three months at three days intervals (Adoki, 2012) <sup>[11]</sup>.

#### Data Analysis/Air Quality Index (AQI)

The collected data were subjected to SPSS and excel spread sheets for mean, standard deviation and graphical analysis. The AQI for criteria pollutants, is a calculation set by USEPA for checking the quality of the atmospheric air. It expresses the level of cleanness and pollution of the atmospheric air. The ambient air pollutants are classified into categories ranging from very good to very poor. From (0 – 15) AQI rating is A which is very good, (16 – 31) AQI is B which is good, (32 – 49) AQI is C which is moderate, (50 – 99) AQI is D which is poor and (100 and above) AQI is E is very poor, showing critical values.

$$\text{AQI contaminant} = x = \frac{\text{Conc.of Pollutant}}{\text{Standard limit}} \times 100 \dots \dots \dots (1)$$

### Health Risk Estimation

#### Hazard Quotient (non-carcinogenic Risk)

The non-carcinogenic health risk due to the inhalation of contaminants (H<sub>2</sub>S, and SO<sub>2</sub>) were estimated using equation (2) (EPA, 2009):

$$\text{Hazard Quotient (HQ)} = \text{EC/MRL} \dots \dots \dots (2)$$

Where EC = exposure concentration ( $\mu\text{g}/\text{m}^3$ ) and MRL= minimal risk level ( $\mu\text{g}/\text{m}^3$ ).

For acute exposures (exposure for 24 hours or less), MRLs of H<sub>2</sub>S, and SO<sub>2</sub> are 0.07 ppm (98  $\mu\text{g}/\text{m}^3$ ) (ATSDR, 2014), and 0.01 ppm (26.2  $\mu\text{g}/\text{m}^3$ ) (ATSDR, 1998), respectively.

### Results and Discussions

The amount of pollution of the atmospheric air from the selected moderate industrial areas of Port Harcourt is presented in table 2.

**Table 2:** Mean values of pollutants in ambient air in selected areas of Port Harcourt

Parameter	Bua factory	Flourmill	Macoba	WHO
PM <sub>2.5</sub>	32.30±1.600	23.15±2.650	13.50±0.090	35.00
PM <sub>10</sub>	36.55±1.150	43.45±0.650	26.90±6.700	150-230
CO <sub>2</sub>	750.0±0.010	800.0±0.010	600.0±0.000	-
CO	ND	ND	ND	0.01
SO <sub>2</sub>	ND	ND	ND	0.1-0.15
NO <sub>2</sub>	ND	ND	ND	0.15
VOC	0.065±0.010	0.195±0.020	0.080±0.010	
CH <sub>4</sub>	1.250±0.250	1.250±0.250	1.350±0.150	
NH <sub>3</sub>	ND	ND	ND	
H <sub>2</sub> S	ND	ND	ND	0.15
O <sub>3</sub>	ND	ND	ND	
O <sub>2</sub>	20.90±0.000	20.90±0.000	20.90±0.000	21.00
Relative Humidity	63.95±0.050	62.65±0.450	57.20±0.400	
Wind Speed	1.050±0.150	1.500±0.250	2.100±0.100	
Noise	77.70±2.500	66.10±2.200	63.660±3.72	80-100
Temperature	34.30±0.700	35.25±0.150	34.05±0.150	
Pressure	1012±0.000	1011±0.000	1013±0.000	
Altitude	10.50±0.500	11.50±0.500	16.00±0.000	
AQI	83.00±3.000	86.00±1.000	56.50±0.100	

DPR, 1991.

Table 2 present the average value of air pollutants in the selected areas of the moderate industrialized zones of Port Harcourt and its environment. The table shows that the following pollutants; CO, SO<sub>2</sub>, NO<sub>2</sub>, O<sub>3</sub>, and NH<sub>3</sub> were not detected. The results of Bua factory area were thus; PM<sub>2.5</sub>; 32.30±1.60  $\mu\text{g}/\text{m}^3$ , PM<sub>10</sub>; 36.55±1.15  $\mu\text{g}/\text{m}^3$ , VOC; 0.065±0.010 ppm, CH<sub>4</sub>; 1.250±0.25 ppm. These results indicates levels of impact is of closer sources but is minimal and was all below the permissible limit. Flourmill area of Port Harcourt had the following results; PM<sub>2.5</sub>; 23.15±2.650  $\mu\text{g}/\text{m}^3$ , PM<sub>10</sub>; 43.45±0.650  $\mu\text{g}/\text{m}^3$ , VOC; 0.195±0.020 ppm, CH<sub>4</sub>; 1.250±0.250 ppm. These mean results were all below the standards by USEPA and DPR for the presence of pollutants in ambient air. Though the flourmills have been in the said area for a long time but have not been operational which could be the cause of the low level of pollutants. Secondly, the low traffic may also be caused by less number of vehicles within the area since the major road is not a major route for commercial drivers. Macoba was thus; PM<sub>2.5</sub>; 40.80±0.59  $\mu\text{g}/\text{m}^3$ , PM<sub>10</sub>; 57.65±6.71  $\mu\text{g}/\text{m}^3$ , VOC; 0.080±0.010 ppm, CH<sub>4</sub>; 1.350±0.150 ppm. The presence of methane at higher amount compare to other areas in the industrialized zone may not be far from the fact that reclamation road where Macoba is situated has pipelines which transport crude to oil facilities within the area which may have triggered the high amount. The only pollutant higher than the permissible limit was PM<sub>2.5</sub>. Exposures to particulate matters have direct effect on the lungs and chest, and also affect respiratory system. The particulate matter was lower than reports by Obanya *et al.* (2018) <sup>[11]</sup>, on the level of air pollutants around residential areas and transportation sector locations of Lagos mainland with their values ranging from 43.3 to 127.2  $\mu\text{g}/\text{m}^3$  (Widiana *et al.* 2017) <sup>[14]</sup>. The findings from this work reveal that human activities within the study region had a moderate effect on the level of pollution of the ambient atmospheric air. The lower effect is due to the operational status of the industries within the area, while the elevated level of methane is sequel to pipeline transporting oil and gas within the region (Masitah *et al.*, 2007) <sup>[10]</sup>.

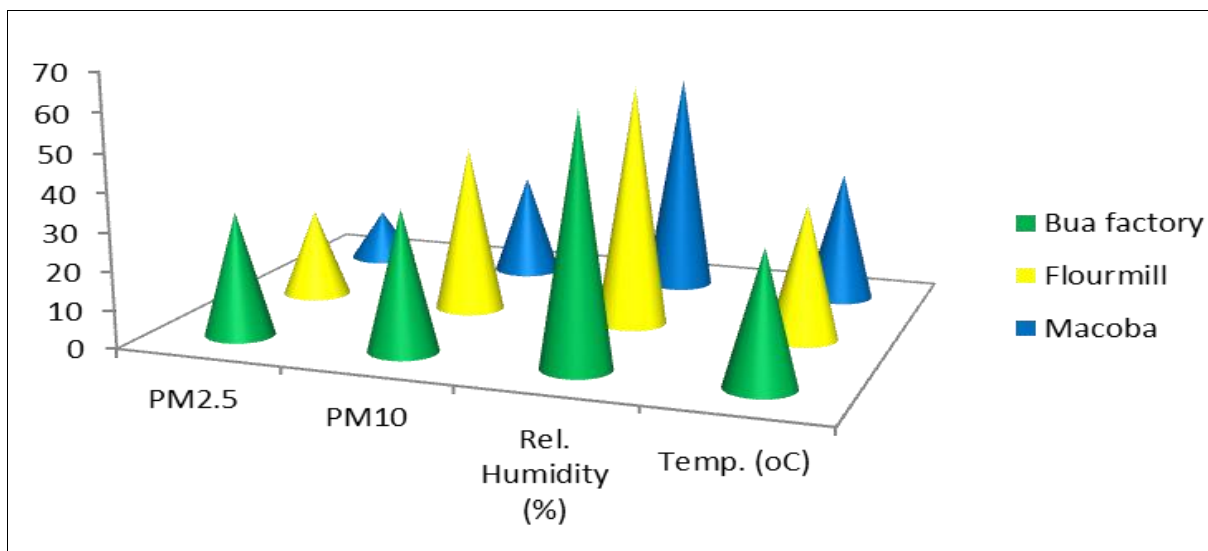


Fig 1: Variation of some of the parameters across the three zones

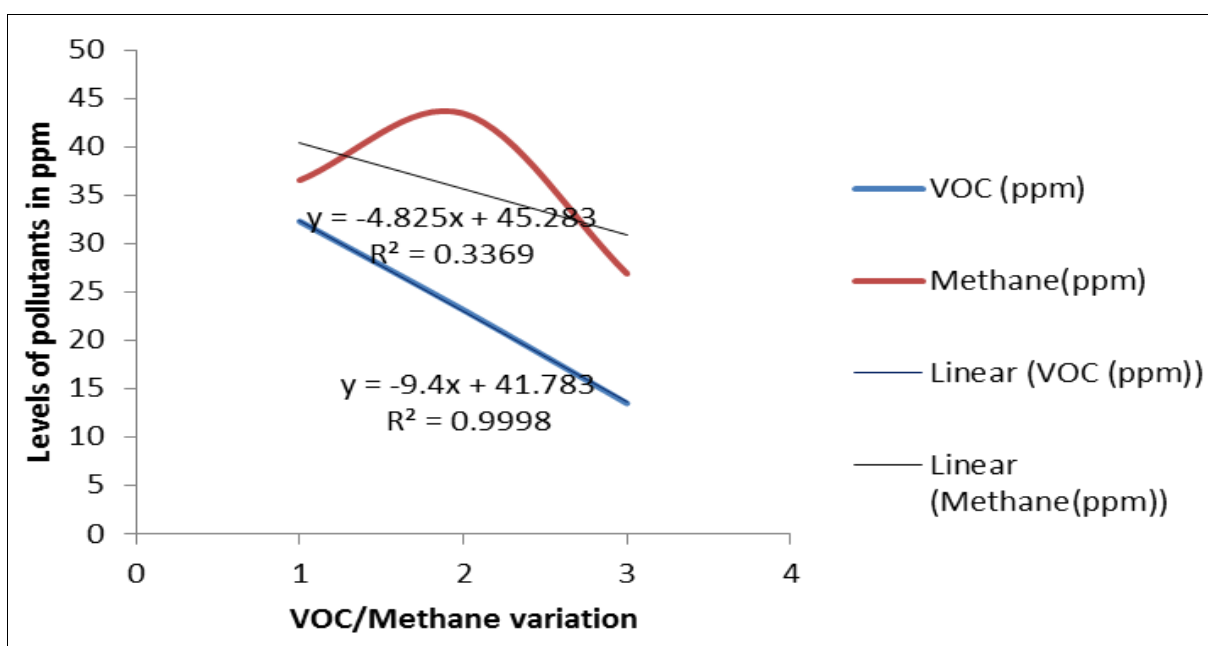


Fig 2: Line graph of the VOC and methane in the study

Figure 2 represent the regression analysis of VOC and methane, with the  $R^2$  for VOC equal to 0.3369 indicating that the variation of the samples is about 33.69% from the individual variation of the locations sampled. The  $R^2$  value for methane was 0.9998 which indicated that 99.98% variation of the methane samples emanate from variation in the individual samples from the locations. This shows that the variation correlated very well.

Table 3: Non carcinogenic risk due to presence of air pollutants

Parameter	Pabod	Slaughter	Mothercat
SO <sub>2</sub>	-	-	-
H <sub>2</sub> S	-	-	-
Total	-	-	-

Table 3 revealed that none of the pollutants of interest were detected due its low concentration at the less industrialized zone of the city of Port Harcourt, Rivers State. It can be conclude that the priority pollutants were not of risk within the less industrialized zone. There was no detection of sulphur (IV) oxide and Hydrogen sulphide. It can also be attributed to low input from vehicular emission since the area is less busy compared to the more industrialized zone of the study area. The industry road and reclamation road area of Port Harcourt is more of oil servicing activities as compared to gas flaring and generator emissions.

**Table 4:** Air quality index estimation across the study area

Parameter	Bua	Flourmill	Macoba
PM <sub>2.5</sub>	D	D	C
PM <sub>10</sub>	B	B	A

The AQI of the zone was fairly moderate as PM<sub>2.5</sub> and PM<sub>10</sub> had poor (D) and good (B) rating at Bua, poor (D) and good (B) rating at Flourmills, and moderate (C) and very good (A) rating at the Macoba areas respectively. Studies has established that the amount of suspended particulate matter in the environment especially in the industrial zones are usually high due to wind-blown dust from the roads, emissions from machineries in the industry, industrial vehicles etc (Akuro, 2012) <sup>[4]</sup>. Particulate matter impairs visibility, adversely affects ecosystem processes, and damages and/or soils structures and property. It causes variable climate impacts depending on particle type. Most particles are reflective and lead to net cooling, while some (especially black carbon) absorb energy and lead to warming. Other impacts include changing the timing and location of traditional rainfall patterns (USEPA, 2007) <sup>[12]</sup>. Most cities around the world like Lagos are experiencing high levels of visibility degradation due to high emission intensity and adverse meteorology (Jimoda, 2012) <sup>[8]</sup>. Inhabitants within these two zones need to reduce their resident time within the industrial points as not to have a greater inhalation of oxygen with other air pollutants which may be detrimental to them.

### Conclusion

This research had provided information regarding the air pollutants distribution pattern in the study area, as all the ambient air pollutants investigated were detected except NO<sub>2</sub>, SO<sub>2</sub>, NH<sub>3</sub>, O<sub>3</sub>, CO and H<sub>2</sub>S. The risk due to some of the pollutants were low and except for the PM. Periodic risk assessment of the environments should be carried out from time to time to determine the levels of air pollutants and extent of pollution.

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