



Evaluation of the levels and associated health risk of air pollutants in selected industrial zones in Port Harcourt, Nigeria

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Abstract

This study investigated the levels and health risk of ambient air pollutants in selected industrialized (Pabod, Mothercat and Slaughter) zones of Port Harcourt City, Nigeria. Standard air pollution monitoring equipment were employed. It involved the determination of the levels of CO₂, NO₂, SO₂, CO, O₃, CH₄, NH₃, VOC, relative humidity, noise level and particulate matters. Results of the study revealed that SO₂, NO₂, O₃, and NH₃ were not detected. The mean of PM_{2.5} was 28.95±5.050 µg/m³ for Pabod area, Slaughter; 81.55±4.650 µg/m³; Mothercat; 40.80±0.650 µg/m³. PM₁₀ was 158.3±17.80 µg/m³ for the Slaughter, Mothercat; 57.65±0.650 µg/m³, Pabod; 42.50±3.800 µg/m³. CO was 0.300±0.100 ppm for Pabod, and 1.10±0.10 ppm for slaughter. VOC, Pabod; 0.065±0.01 µg/m³, Slaughter; 0.175±0.030 ppm, mothercat; 0.050±0.01 ppm. Relative humidity was low across the three areas sampled. The noise level was highest in slaughter. The non-carcinogenic risks linked with the contact to H₂S in Pabod had 3.751 which is a high risk. The AQI indicated poor quality especially for slaughter and pabod areas. It is therefore recommended that periodic risk assessment of these areas be carried out from time to time to determine the levels of air pollutants.

Keywords: air quality index, air pollutants, health risk, non-carcinogenic, industrial areas, Port Harcourt

Introduction

The environment is a sizeable sinkhole that soaks up all things that is disposed to it and delivers it in a distinct form that can be beneficial or detrimental. The detrimental form is recognized as environmental pollutants. These pollutants are chemical material, physical substances namely hotness, sound and organic substances. When unleashed into the environment, they damage the standard stable operation of biological component (flora and fauna) and other environmental component located there, as stated by the World Health Organization (Wonodi & Ekpete, 2021) [31]. The environmental firmness, acceptability for good of man is conditional on the standard of the atmospheric air which is termed "ambient air" as a result of its unmixed or clean nature (WHO, 2016) [29]. Akinfolarin *et al.* (2017) [4], acknowledged that air is a paramount component for human survival since we all live by inhaling oxygen which is a vital element of air. Nonetheless, human occupation has affected the good standard of the air we are intended to inhale with unpleasant materials such as particulate matter (PM), Sulphur oxides, Nitrogen oxides, Carbon (ii) oxide (CO), methane (CH₄), Hydrogen sulphide (H₂S) (Ibe *et al.*, 2017) [12]. The condition of the atmosphere been damaged by non-existing substances has become a worldwide matter that require to be attended to by all (Munir *et al.*, 2017). This is prompted by mechanization and urbanization which has generated elevated concentration of anthropoid population in cities with practicable economic possibilities such as commercial cities (Koop & Van Leewen, 2017).

It has been documented that those human ventures in commercial cities; like those from miniature and medium sized industries namely dyes, fertilizer, ceramics, glass and textile industries, to sales of electronics and household items, abattoir services, auto repairs, hotel and restaurants, shopping malls and freelance street side trading have a significant impact on air standard (Ezejiolor *et al.*, 2013) [11]. In West Africa, commercialized hub in cities like Accra, Dakkar, Abidjan, Cotonou, Kano, Zaria, Aba and Port Harcourt are the mainstay of national economic advancement and evolution (Satope & Akanbi, 2014) [24]. In these cities and others within the Niger Delta region of Nigeria, swift evolution in vehicular movement, sweltering of animals with tyres and burning of huge metropolitan debris generated in these regions has led to the existence of particulate matter in ambient air (Njoku *et al.*, 2016; Nwokocha *et al.*, 2015) [18, 19].

In Nigeria some of the cities bedevilled with these complaints of reduced air standard are Port Harcourt in Rivers State and Aba in Abia State (Umunnakwe & Njoku, 2017; Taiwo *et al.*, 2015) [26, 23].

The challenges of gas flaring are one that cannot be debated without referring to Nigeria, who has been described as the prime natural gas flarer on the globe both completely and commensurably. Cedigaz (2000) [7], performed a juxtaposition of concentrations of atmospheric air pollutants in the domain of Lagos State and concluded that pollutant concentrations are uppermost in the Niger Delta and asserted that some of the greenhouse gases (such as methane and carbon dioxide) released or flared have a hand in universal warming. Furthermore, gas flare area

around all over the area give rise to enormous hotness thus giving rise to heat pollution (Orubu, 2002) [22]. Ogbuigwe (1998) [20] maintained that heat generated at flare areas could be as elevated as 1,600°C. Heat as elevated as 400°C at a mean distance of 43.8m from flare sites in Isoko, Delta State have been reported by Alakpodia (1995) [6] who had as well manifested that such flares have gloomy impact on plants development, animal life and environment-friendly balance in the Niger Delta region. Nonetheless, sensitive gases and aerosols are frequently connected with detrimental human well-being effect. For instance, vulnerability to O₃ and particulate matter (PM, pointing out to any solid or liquid suspended in the air) has been connected to heart ailment, respiratory ailment, and untimely death. Actually, disclosure to health-inimical air pollutants namely PM and O₃ is a major contributor to the universal concern of ill health and give rise to millions of untimely deaths each year, as stated by research carried out by the Institute for Health Metrics and Evaluation (IHME). IHME categorized disclosure to atmospheric PM as the 5th paramount risk component for death globally. Household air pollution is rated 10th and disclosure to atmospheric O₃ is rated 33rd. Exposure to air pollution is plainly inimical to human well-being.

This study was aimed at evaluating the levels and associated health risk in ambient air quality of selected industrial zones in Port Harcourt metropolis, the work employed standard air quality monitoring methods to assess these pollutants.

Materials and Methods

Study Area

Port Harcourt is a cosmopolitan city with people from different walks of life, ethnicity and religion, engaging in numerous human activities. It is the capital of Rivers State, Nigeria. It lies along the bonny river and is located in the oil rich Niger Delta region of Nigeria. The area of study (Port Harcourt) covers an area of 369 km² (142 sq mile) and the water is 9 km². The geographical coordinates of the study area are 4° 49' 27'' N and 7° 2' 1'' E. The city has volumes of traffic due to regular vehicular movement, mining and industries. These areas are usually busy all through the day as a result of human activities. Table 1 present the location coordinates of the study.

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

Location	Latitude	Longitude
Control	N4°48'19.67272''	E7°1'49.6632''
Pabod	N4°49'35.02308''	E7°2'18.5784''
Slaughter	N4°48'43.11648''	E7°2'36.09708''
Mothercat	N4°48'19.69272''	E7°1'40.28448''

Sampling Equipment

The monitoring of the pollutants was with standard equipment known as portable digital hand held air monitors. PM_{2.5} and PM₁₀ determined with Kanomax 3900 particle counter, others were aeroqual environmental gas monitor equipped with infrared sensor used to assess CO, NO₂, and SO₂. The VOCs and O₃ was with Aerocet 531 particle mass monitor, while the wind speed and direction, temperature, and relative humidity was done using digital hand held cole – parmer combination Anemometer. The sampling was carried at individual sampling points for 3 days on 24 hours interval. The instrument was placed at a height 1.5m above the ground level to ensure accurate capturing of the data.

Data Analysis

The major data analysis especially mean, standard deviation, correlation was carried out using excel spreadsheet and SPSS.

Table 2: Air quality index for criteria pollutants

AQI Category	AQI rating	PM ₁₀ µg/m ³	CO (ppm)	NO ₂ (ppm)	SO ₂ (ppm)
Very good (0 -15)	A	0 – 15	0 -2	0 – 0.02	0 – 0.002
Good (16 -31)	B	51 – 75	2.1 – 4.0	0.02 – 0.03	0.02 – 0.03
Moderate (32 – 49)	C	76 – 100	4.1 – 6.0	0.03 – 0.04	0.03 – 0.04
Poor (50 – 99)	D	101 – 150	6.1 – 9.0	0.04 – 0.06	0.03 – 0.04
Very Poor(100 or over)	E	>150	>9.0	>0.06	>0.06

Source: USEPA 2000

Table 2 shows the AQI for criteria pollutants. This is the rating set by USEPA for determining ambient air quality. The AQI is an index for air quality daily report. It tells how clean and polluted our air is, and what associated health effects might be of concern for us. 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.

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

Health Risk Assessment

Carcinogenic Risk Assessment

Carcinogenic risks (hazard quotient) induced by the inhalation of H₂S, and SO₂ was evaluated by using equation (3) deduced from equation (2), (EPA, 2009):

$$\text{Carcinogenic risk (HQ)} = \text{EC/MRL} \dots \dots \dots (3.2)$$

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 lasting 24 hours or less),

EC = CA (EPA, 2009), where CA = contaminant concentration in air ($\mu\text{g}/\text{m}^3$).

Hence, equations (1) become

$$\text{HQ} = \text{CA/MRL} \dots \dots \dots (3)$$

MRLs of H₂S, and SO₂ 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

Levels of ambient air quality of selected high industrial zones of Port Harcourt

The mean and variations of the pollutants based on the areas are depicted the tables below.

Table 3: Mean values of pollutants in ambient air of High Industrial area

Parameter	Pabod	Slaughter	Mothercat	Standard limit
PM _{2.5}	28.95±5.050	81.55±4.650	40.80±0.400	35.00
PM ₁₀	42.50±3.800	158.3±17.80	57.65±0.650	150-230
CO ₂	950.0±100.0	750.0±10.00	700.0±0.010	-
CO	0.300±0.100	1.100±0.100	ND	0.01
SO ₂	ND	ND	ND	01-0.15
NO ₂	ND	ND	ND	0.15
VOC	0.065±0.010	0.175±0.030	0.050±0.010	-
CH ₄	ND	0.850±0.150	0.750±0.150	-
NH ₃	ND	ND	ND	-
H ₂ S	0.250±0.050	ND	ND	0.150
O ₃	ND	ND	ND	-
O ₂	20.90±0.000	20.90±0.000	20.90±0.000	21.00
Relative Humidity	76.10±0.100	76.35±0.950	66.95±0.450	-
Wind Speed	2.100±0.100	2.250±0.045	1.350±0.150	-
Noise	78.10±1.900	81.05±0.350	65.65±0.550	80-100
Temperature	31.35±0.350	34.55±0.350	34.44±0.400	-
Pressure	1012±0.000	1012±0.000	1012±0.000	-
Altitude	12.50±0.010	8.500±0.010	8.000±0.500	-
AQI	80.50±0.500	126.0±0.100	88.50±0.200	-

DPR, 1991; DPR, 2002.

Table 3 presents the mean of air pollutants in the respective areas of the study. The results revealed that SO₂, NO₂, O₃, and NH₃ were not detected. The PM_{2.5} had higher mean than the permissible limit of 35 $\mu\text{g}/\text{m}^3$ except for Pabod with 28.95±5.050 $\mu\text{g}/\text{m}^3$. Slaughter was highest at 81.55±4.650 $\mu\text{g}/\text{m}^3$ and mothercat; 40.80±0.650 $\mu\text{g}/\text{m}^3$. These were slightly lower than reports by Adoki, (2012) ^[1] on the Niger Delta (100 $\mu\text{g}/\text{m}^3$). The mean PM₁₀: slaughter; 158.3±17.80 $\mu\text{g}/\text{m}^3$, mothercat; 57.65±0.650 $\mu\text{g}/\text{m}^3$; Pabod; 42.50±3.800 $\mu\text{g}/\text{m}^3$. This was lower than report by Okeh-Wokeh *et al.* (2020), on Rivers and Abia states, Nigeria (500 $\mu\text{g}/\text{m}^3$). The occurrence of PM₁₀ as seen could be attributed to the relative humidity, as low humidity enhances higher accumulation of particulate matter (Masitah *et al.*, 2007). CO₂ ranged from 700 to 950 ppm for the three areas. CO values were higher than the standard limit of 0.01 ppm, which includes: Mothercat was BDL, 0.300±0.100 ppm for Pabod, while Slaughter was highest at 1.10±0.10 ppm. The high level of CO may be deleterious to humans who might inhale the gas, especially those that have more resident time there, because it combine with haemoglobin by displacing oxygen to form carboxy-haemoglobin instead oxy-haemoglobin which is the carrier of blood to parts of the body, this singular action can lead to death. The VOCs values were Pabod; 0.065±0.01 $\mu\text{g}/\text{m}^3$, Slaughter; 0.175±0.030 ppm, Mothercat; 0.050±0.01 ppm. Widiana *et al.* (2017), reported higher VOC in municipal wastewater treatment plant in North Taiwan, (over 2000 ppb). Methane was detected in Slaughter (0.850±0.15 ppm), and Mothercat (0.750±0.01 ppm), the source could be from landfills, mobile combustion and waste treatment processes. The harmful effect of methane includes climate change, increase heat in the atmosphere and enhancing the abundance of tropospheric ozone. Pabod; 76.10±0.100 %, Slaughter; 76.35±0.95%, and

Mothercat; $66.95 \pm 0.450\%$ had relative humidity above 50%. This justifies the high level of pollutants in this research work. The wind speed was low which could have really affected the level of the air pollutants in the ambient air from the study area, as the pollutants had more resident time in the air. The temperature level was within the limits of the agencies and world health organisations, the pressure and altitude were also same except for Pabod which was higher in the height.

Also, the meteorological factors were also high in the area. This shows that anthropogenic activities going on in the zone like oil and gas transport, burning of car tyres by abattoir attendants, heavy car traffic contributed tremendously to the elevated levels of the pollutants in the area under consideration.

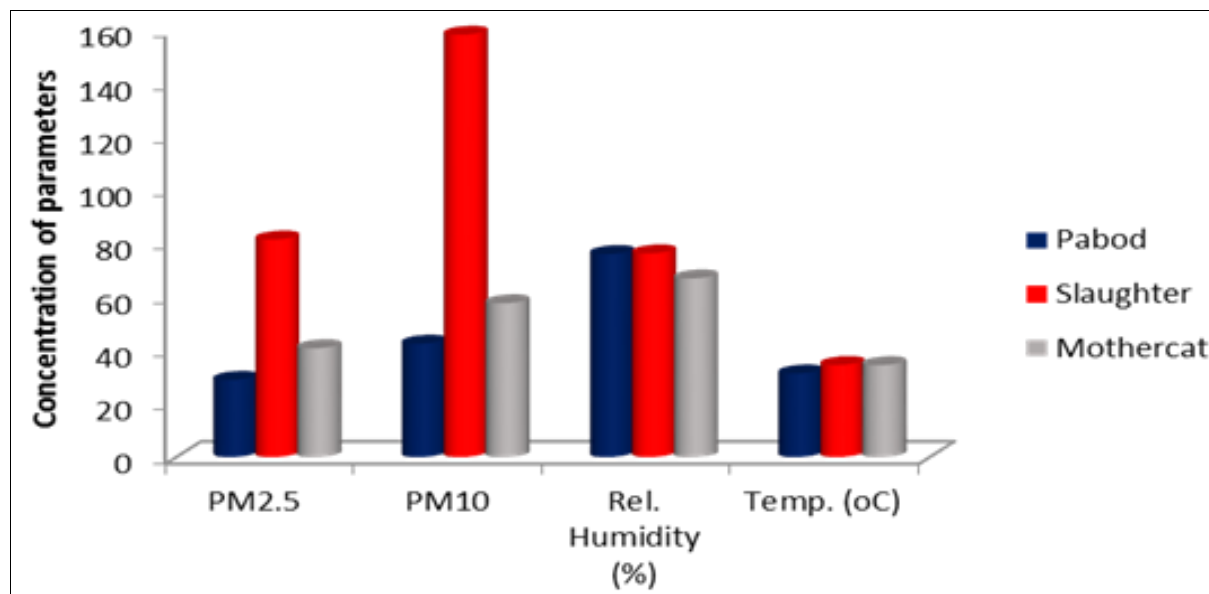


Fig 1: Spatial distribution of the PM and some meteorological parameters.

Health risk assessment of the air pollutants

The tables below show the risk assessment of the pollutants level and the air quality index.

Table 4: Non carcinogenic risk due to presence of air pollutants in the highly industrialized zone

Parameter	Pabod	Slaughter	Mothercat
SO ₂	-	-	-
H ₂ S	3.571	-	-
Total	3.571	-	-

Table 4 present the result of the non-carcinogenic risk of sulphur (IV) oxide and Hydrogen sulphide in the study. Hazard quotient (non-carcinogenic risk) values below 1.0 indicate that the pollutant under investigation is not likely to cause health impairment, whereas HQ values above 1.0 indicate risk levels that are likely to damage health (Matookane & Diab, 2003; Kitwattanavong *et al.*, 2013) [16, 13]. The individual HQ values showed that H₂S were all higher than 1 in Pabod. This shows that the presence of hydrogen sulphide within the Pabod region of Port Harcourt may be of threat, therefore there is need to curtail its source to the natural environment. It is necessary to state that hydrogen sulphide is dangerous to human health therefore its continuous inhalation could lead to health challenges.

Table 5: Air quality index estimation across the study area

Parameter	Pabod	Slaughter	Mothercat
PM _{2.5}	D	E	E
PM ₁₀	B	E	C
CO	E	E	-
H ₂ S	E	-	-

In terms of Air Quality Index (AQI) rating, the air quality for PM_{2.5}, PM₁₀, CO and H₂S across all the sampling locations in the Pabod, Slaughter, Mothercat area were all very poor (E) except for PM_{2.5} and PM₁₀ at Pabod that were D and B which means poor and good. PM₁₀ had values that indicated AQI of very poor. The indexing means the volume of traffic within the study area is high. This study have established that the amount of suspended particulate matter is high, which scholars attributes to wind-blown dust from the roads, emissions from machineries in the industry, industrial vehicles etc (Akuro, 2012) [5]. Ukpebor and Okolo, (2002) [25], also confirmed that particulate matter finds its course to the air through numerous sources which are mainly of

anthropogenic origin, with vehicular emission been a major source. Other impacts include changing the timing and location of traditional rainfall patterns (USEPA, 2007) [27]. Other pollutants were very poor in index showing the level of air borne human activities within the area of study. The index also correlated with that from the monitor which varied significantly across the different locations in the two zones sampled. It therefore shows that more need to be done on the part of government and necessary agencies to reduce the issue of air pollution especially area industrial areas.

Conclusion

CO and H₂S were exceptionally high in this study, which could be of health risk to the immediate inhabitant of the zones. The carcinogenic risks associated with the exposure to H₂S was high at Pabod indicating that the nearby residents to the zones may be at risk of developing health challenges in future owing to the inhalation of H₂S. It is recommended that industries within the study area should endeavour to reduce gas flaring, restrict release of exhaust fumes from their generators by building a confined house and also strict regulations should be enacted by the government.

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