Assessment of Some Air Quality Parameters in Port Harcourt City Metropolis, Rivers State, Nigeria

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Abstract: **This study evaluated some air parameters in industrial and non - industrial areas of Port Harcourt city. The areas were; Trans - Amadi, Diobu (Mile 3) and Rukpokwu. The ambient air qualities were assessed by using auto gas monitory equipment. The study revealed that the mean values for the months of September, October and November for each parameters were temperature 27.68±0.26^{0}C, 26.92±0.04^{0}C, and 28.55±0.35^{0}C for Diobu, 27.03±0.02 ^{0}C, 26.24±0.06 ^{0}C and 28.35±0.09 ^{0}C for Rukpokwu, 26.04±0.02 ^{0}C, 25.31±0.03 ^{0}C and 27.38±0.21 ^{0}C for Trans-Amadi. Relative humidity were 91.87±0.10 %, 98.65±0.05 % and 86.28±0.16 % for Trans-Amadi, 91.27±0.16 % 91.26±0.12 % and 75.34±0.27 % for Rukpokwu, 87.15±0.69 %, 91.20±0.38 % and 74.79±0.20 % for Diobu. Wind speed were 0.52±0.11 m/s, 0.45±0.06 m/s, and 0.49±0.03 m/s for Diobu, 0.46±0.3 m/s, 0.48±0.18 m/s and 0.56±0.15 m/s for Trans-Amadi, 0.41±0.08 m/s, 0.42±0.11 m/s and 0.42±0.11 m/s and 0.42±0.04 m/s for Rukpokwu. Suspended particulate matters (SPM) were 42.19±1.06 µg/m^3, 40.68±3.02 µg/m^3 and 42.93±2.19 µg/m^3 for Trans-Amadi, 38.30±3.07 µg/m^3, 37.23±1.18 µg/m^3 and 38.36±0.84 µg/m^3 for Diobu, 33.62±0.12 µg/m^3, 30.68±0.25 µg/m^3 and 33.64±0.09 µg/m^3 for Rukpokwu at the various months. While, gaseous emissions parameters such as SO_2, CO, NO_2, H_2S, VOC, CH_4, O_3 and NH_3 mean values were below DPR and FMEnv recommended limits except NH_3 which was not detected. The results of student t-test and ANOVA, showed no significant difference between the locations and within the months of the study. The results showed that all the parameters examined were within DPR and FMEnv guidelines for ambient air quality.**

Key Words: **Anthropogenic, Air, pollutants, gas monitor ambient.**

I. INTRODUCTION

Air pollution is the introduction of chemicals, particulate matter or biological materials that causes harm and discomfort to human and other living organisms (Bhatia, 2009). These air pollutants are of two categories; primary air pollutants and secondary air pollutants. The main sources of air pollution are natural and anthropogenic (USEPA, 2006; Narayanan, 2009). Air contamination is a major environmental problem that has bedeviled both industrial and non-industrial area of the world. Air pollution has been linked to increased morbidity and mortality rates. The earth's atmosphere protects life on earth by absorbing ultraviolet solar radiation, warming the surface through heat retention (greenhouse effect), and reducing temperature between day and night. The atmosphere is divided into four major layers, viz., troposphere, stratosphere, mesosphere, thermosphere and exosphere (Tim, 2017). The troposphere is the lowest portion of earth's atmosphere, extending up to 10km at the poles and 16km at the equator. It is the layer where we live and is the layer in which most atmospheric weather occurs (Horsfall and Spiff, 2013). This layer is of great interest in pollution control since it is the layer in which most living things exist and also the air we breathe. Air pollution is the presence of impurities and could occur outside the home, offices or enclosed places in both industrial and non-industrial areas of the environment at different concentrations. The most common air pollutants are sulfur oxides (SO_x), nitrogen oxides (NO_x), carbon monoxide (CO), volatile organic compounds (VOCs), particulate matter (PM), toxic metals, radioactive pollutants, photochemical smog and fog, ash from volcanic eruption, etc. (Lutgens and Edward, 2000). Air pollutants can be in the form of solid particles, liquid droplets or gases and most of them occurs due to man's activities such as the utilization of natural resources for rapid industrialization and urbanization. Other sources of anthropogenic activities includes; traffic (vehicle exhaust), oil and gas production, power plants and generating sets, cooking, burning of coal, wool, crop waste, forest fires, open burning of municipal waste and agricultural residues (Akanni, 2010; Komolfe *et al*., 2014). The increasing development of human activities has given rise to a significant increase in atmospheric pollutants which may have an impact on human health (Atash, 2007). These pollutants have resulted to several form of cancer; lungs, skins, prostrates, etc., difficulties in breathing, bronchitis and aggravation of asthma, cardio-respiratory disorders, pulmonary edema, eye disorders and skin disorders (Franchini and Mannucci, 2007).Due to the adverse effects associated with air pollution, environmental regulatory agencies were set up, these include World Health Organization (WHO), World Metrological Organization (WMO), Global Environmental Monitoring System (GEMS) and United States Environmental Protection Agency (USEPA) (Horsfall and Spiff, 2013). These agencies help to regulate and mitigate the pollutions of the air and its environment. However, the situation in Nigeria seems degenerating. Hence, in December 1988, as part of the emerging coordinated approach to environmental issues, the Federal Environmental Protection Agency (FEPA) now Federal Ministry of Environment (FMEnv) and Department of Petroleum Resources (DPR) was formed to assist in the mitigation and regulation of pollutions. Recently, there was out break of soot in many parts of Port Harcourt City which many inhabitants suggested the source might emanate from burning of tyres used for roasting of animals, other suggested it emanates from illegal or artisanal oil refining. Therefore, due to many

anthropogenic activities taking place in Port Harcourt, it becomes necessary to evaluate some ambient air quality in part of Port Harcourt City to ascertain the levels of some air pollutants.

II. MATERIALS AND METHODS

The materials and equipment used were auto digital gas meters: Kestrel weather tracker; for temperature (^oC), relative humidity (%), wind speed (m/s) MX6 IBird; for SPM ($\mu g/m^3$), Kanomax; for CO (ppm), SO_2 (ppm), NO_2 (ppm), VOC (ppm), H_2S (ppm), O_3 (ppm), CH_3 (ppm), NH_3 (ppm); and Extech sound levels for noise (dBA)

All the meters were properly pre-calibrated before usage for quality assurance. Specific meters were used for specific parameter measurement such as temperature, wind speed, SPM, CO etc Kestred weather tracker can measure, temperature, humidity and wind spread (WS), it contain many sensors in it. The various sensors were selected and allowed to read and record the parameter of interest. It was used to determine temperature in degree Celsius (^OC), wind speed in meter per seconds (m/s) and relative humidity in percentage (%).

Mx6 iBird portable gas is a portable gas monitor for SPM (suspended particulate matter), and is measured in micro gram per meters square ($\mu g/m^3$), the meter has an already installed sensor for SPM. The button on the meter was clicked to power on the meter and allowed to initialized for five (5) minutes, it auto read and the stabled value(s) of the reading(s) was recorded.

Kanomax is a portable gas monitor with lots of sensors which can be changed when in use. These sensors were changed and repacked immediately before installing the next available sensor for the parameter to be analyzed, after the reinstallation, the meter was powered on and the meter initializes for three (3) minutes and auto read, then the most stable value(s) of the reading(s) was recorded, after which it was shut down. The next sensor was reinstalled, and the process was repeated for the other parameter.

Extech sound level is a potable meter used to determine noise sound level. The noise meter was pre-calibrated before use. The sensor was directed upwards and the reading(s) were taken at the most stabled value(s). It is measured in decibels (dBA).

Study area

Port Harcourt is the capital of Rivers States, South-South Nigeria. It lies along the Bonny Rivers, 66km upstream from the Gulf of Guinea and has an estimated population of 1,865,000 inhabitants. Its coordinates is $4^o49'27"N$, $7^o2'1"E$ and 4.82417^oN, 7.03361^oE. Port Harcourt City experiences lengthy rainy season and very short dry season. Rain falls virtually throughout the year with a very short break in August and longer break from December to January. The sample locations were within the Port Harcourt City, which were Trans-Amadi industrial area; Diobu and Rukpokwu are non-industrial area. Diobu (Mile 3) is densely while Rukpukwu is moderately populated. The coordinates of the locations were as follows; Trans-Amadi is $4^o48'45"N$, $7^o 02'15"E$ Diobu (mile 3)is $4^o 48'09"N$, $6^o 59'24"E$ and Rukpokwu $N4^o 54'19"$, $6^o 59'59"E$.

Sampling Design

Sampling design used for choosing the sample locations and points was the purposive sampling method. Purposive sampling methods are a type of non-probability sampling technique which relies on the decision of the researcher when it comes to selecting the locations (e.g. people, cases/organizations, events, pieces of data) that are to be studied (Nwaogazie, 2011). The sampled areas were classified into industrial and non-industrial areas, all in Port Harcourt City and the sample locations were Trans-Amadi, Diobu and Rukpokwu. These locations were chosen for the study considering the human activities in the areas. The industrial area was Trans-Amadi and non-industrial areas were Diobu and Rukpokwu. The study was carried out for three months at the same point at each location. The sampling was done between 7.30am-9.30am (rush hours). Measurement was taken after keeping the equipment steady for about three to five (3-5) minutes. The gas monitor/meter was lifted above head level and the average readings over a period of three-five (3-5) minutes were taken.

Methods of Data Analysis

Students t-test and Analysis of Variance (ANOVA) were used for the analysis of the results.

III. RESULTS AND DISCUSSION

Results: The results from the three locations are presented in the Tables 1 to3 while fig 1 to 3 shows the variation of each parameters for the months of September, October and November with DPR and FMEnv limit.

Table 1: The mean value of air quality parameters for the month of September 2019

Parameters	Trans-Amadi	Diobu (Mile 3)	Rukpokwu	Equipment Detection limits	DPR limits (2002)	FMEnv Limits (1999)
	Mean±Std.Dev	Mean±Std.Dev	Mean±Std.Dev			
SO_2(ppm)	0.35±0.13	0.33±0.09	0.29±0.04	0-100	100-150	26-260
CO(ppm)	1.38±0.07	1.23±0.12	1.19±0.05	0-100	10.0	11-22
NO_2(ppm)	0.0404±0.0496	0.0390±0.0171	0.0240±0.0128	0-1	0.04-0.06	0.29
H_2S(ppm)	0.05±0.02	0.04±0.03	0.01±0.01	0-10	-	-

NH_3(ppm)	ND	ND	ND	0-100	-	-
VOC(ppm)	109.30±16.79	88.70±10.06	64.34±4.61.	0-500	-	160
CH_4(ppm)	11.87±1.39	10.22±3.36	08.53±0.68	0-10,000	-	-
O_3(ppm)	0.15±0.06	0.12±0.06	0.09±0.04	1-10	-	-
SPM(µg/m^3)	42.19±1.06	38.30±3.07	33.62±0.12	0.10	150-230	260
NOISE(dB)	70.98±5.46	85.79±8.95	84.12±0.04	1.0	80-100	90

NOTE:

a) Each value are mean of triplicate determination
b) ND – Not Detected
c) Std.Dev – Standard Deviation

Table 2: The mean value of air quality parameters for the month of October 2019

Parameters	**Trans-Amadi**	**Diobu (Mile 3)**	**Rukpokwu**	**Equipment Detection limits**	**DPR limits (2002)**	**FMEnv Limits (1999)**
	Mean ±Std.Dev	**Mean±Std.Dev**	**Mean±Std.Dev**			
SO_2(ppm)	0.32±0.20	0.32±0.02	0.30±0.02	0-100	100-150	26-260
CO(ppm)	1.41±0.34	1.21±0.51	1.19±0.05	0-100	10.0	11-22
NO_2(ppm)	0.1026±0.0515	0.0374±0.0182	0.0230±0.0079	0-1	0.04-0.06	0.29
H_2S(ppm)	0.05±0.03	0.04±0.02	0.02±0.01	0-10	-	-
NH_3(ppm)	ND	ND	ND	0-100	-	-
VOC(ppm)	106.91±11.49	84.67±4.32	70.64±4.79	0-500	-	160
CH_4(ppm)	11.33±5.06	09.94±2.67	08.31±2.16	0-10,000	-	-
O_3(ppm)	0.14±0.08	0.10±0.04	0.07±0.02	1-10	-	-
SPM(µg/m^3)	40.68±3.02	37.23±1.18	30.68±0.25	0.10	150-230	260
NOISE(dBA)	69.36±3.04	87.88±10.52	84.12±0.06	1.0	80-100	90

NOTE:

a) Each value are mean of triplicate determination
b) ND – Not Detected
c) Std.Dev – Standard Deviation

Table 3: The mean value of air quality parameters for the month of November 2019

Parameters	**Trans-Amadi**	**Diobu (Mile 3)**	**Rukpokwu**	**Equipment Detection limits**	**DPR limits (2002)**	**FMEnv Limits (1999)**
	Mean±Std.Dev	**Mean±Std.Dev**	**Mean±Std.Dev**			
SO_2(ppm)	0.33±0.15	0.31±0.02	0.25±0.05	0-100	100-150	26-260
CO(ppm)	1.65±0.29	1.24±0.39	1.09±0.03	0-100	10.0	11-22
NO_2(ppm)	0.1022±0.0718	0.0387±0.0917	0.0298±0.0185	0-1	0.04-0.06	0.29
H_2S(ppm)	0.04±0.02	0.06±0.05	0.03±0.01	0-10	-	-
NH_3(ppm)	ND	ND	ND	0-100	-	-
VOC(ppm)	112.57±12.96	88.19±7.15	78.70±6.52	0-500	-	160
CH_4(ppm)	11.67±6.45	10.33±2.65	08.81±3.09	0-10,000	-	-
O_3(ppm)	0.16±0.05	0.11±0.01	0.07±0.02	1-10	-	-
SPM(µg/m^3)	42.93±2.19	38.36±0.84	33.64±0.09	0.10	150-230	260
NOISE(dBA)	70.84±7.46	89.13±7.83	88.59±2.12	1.0	80-100	90

NOTE:

a) Each value are mean of triplicate determination
b) ND – Not Detected
c) Std.Dev – Standard Deviation

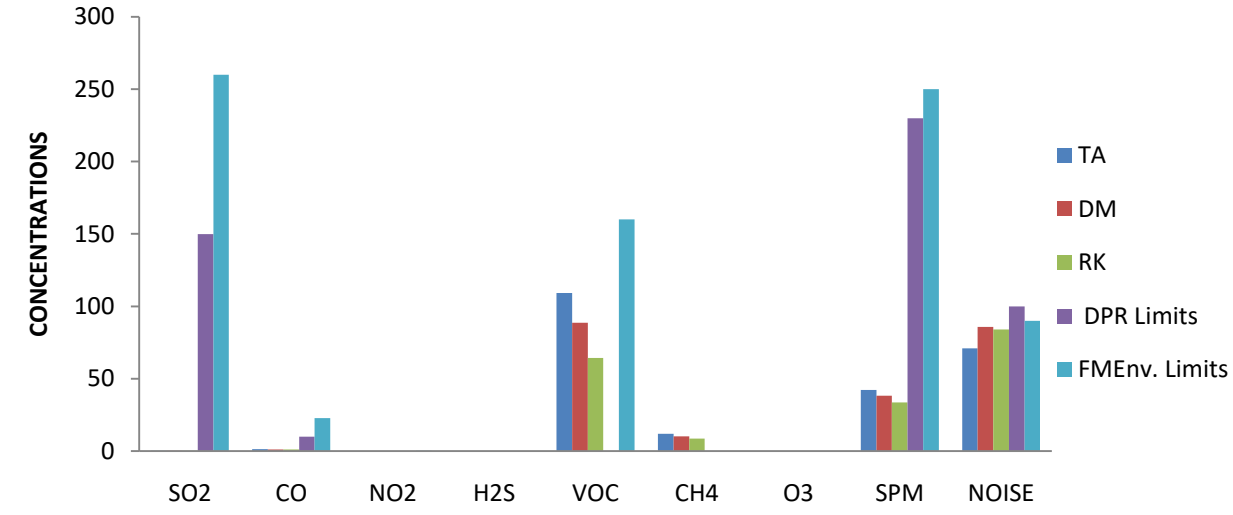

Fig. 1: Comparison of mean values of the air quality parameters at each location for the month of September.

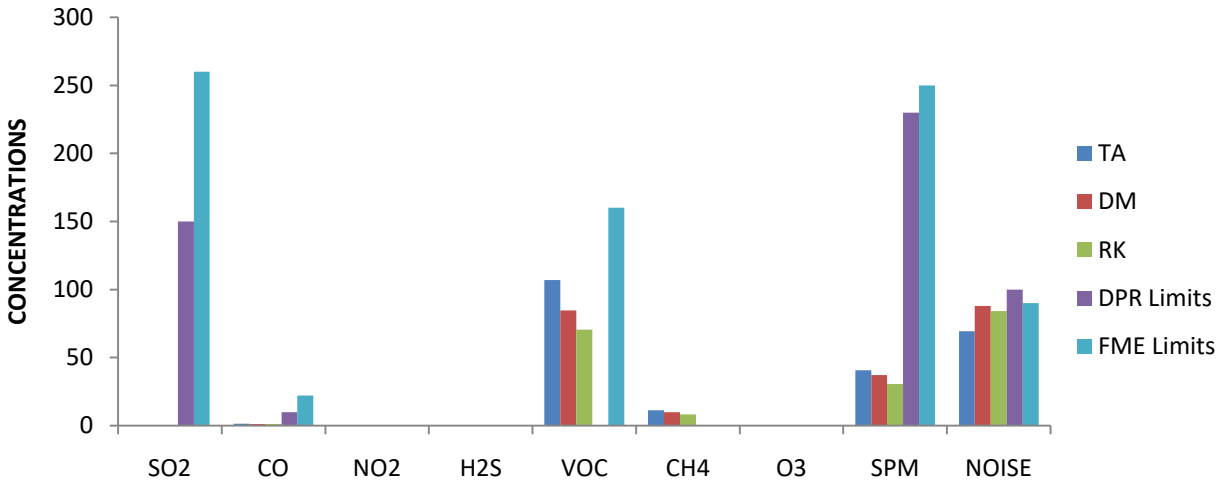

Fig. 2: Comparison of mean values of the air quality parameters of each location for the month of October

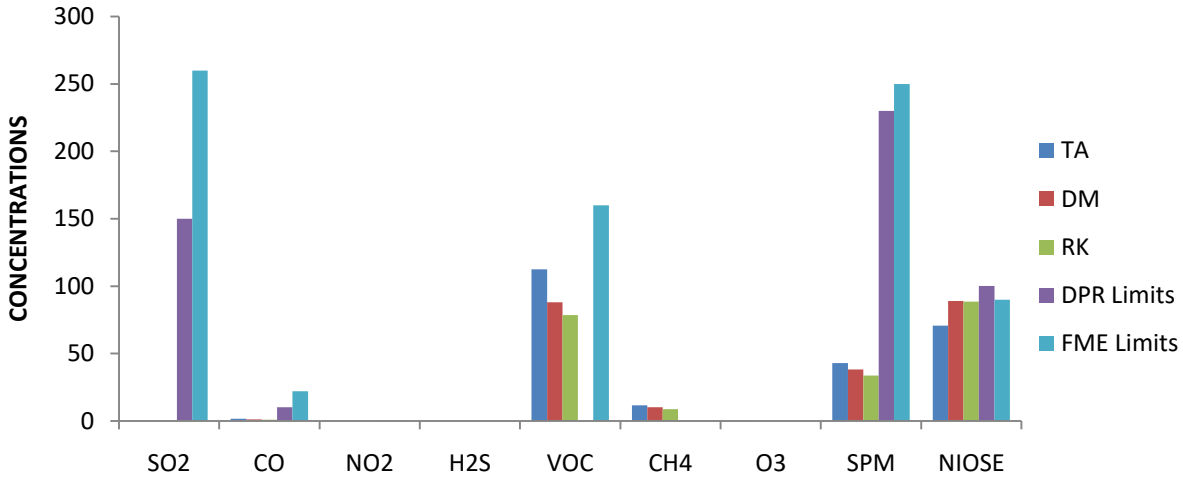

Fig. 3: Comparison of mean values of air quality parameters of each location for the month of November.

The results of the gaseous emissions and suspended particulate matters are presented in Tables 1 to 3 for the months of September, October and November respectively at each location.

Suspended particulate matters (SPM) mean values were 42.19±1.06 µg/m^3, 40.68±3.02µg/m^3 and 42.93±2.19µg/m^3 at Trans-Amadi, 38.30±3.07µg/m^3, 37.23±1.18µg/m^3 and 38.36±0.84µg/m^3 at Diobu, 33.62±0.12µg/m^3, 30.68±0.25µg/m^3 and 33.64±0.09µg/m^3 at Rukpokwu for the various months. The results showed that the values were below DPR and FMEnv recommended limits of 150-230 µg/m^3 and 250µg/m^3 respectively. These may be due to low dispersion as at the time of sampling. During the morning hours (rush hours) there is less dust storms and high humidity, these could be attributed to the low levels of results obtained in this study. High levels of SPM in inhaled air could cause lung cancer, heart disease and persistent free radicals connected to air borne, fine particles, could cause cardiopulmonary disease (Brohwen 1999; Molles, 2005). The results obtained in this study is similar to those obtained by Akinforaria *et al.,* 2018) and Ana *et al* (2010) in parts of Nigeria. However, higher levels of particulate matter was reported by Chen *et al.*, (2007), in Brisbane.

Gaseous emissions parameters such as SO_2, CO, NO_2, H_2S, VOC, CH_4, O_3 and NH_3were measured in ppm. The mean values of sulfur dioxides(SO_2) obtained from the three locations were 0.35±0.13, 0.32±0.20 and0.33±0.15 ppmat Trans-Amadi, 0.33±0.09, 0.32±0.02 and 0.31±0.02 at Diobu, 0.29±0.04, 0.30±0.02 and 0.25±0.05 at Rukpokwu for the months of September, October and November. The results showed that the values were below DPR and FMEnv recommended limits of 100-150 ppm and 26-260ppm respectively. The low levels of SO_2 obtained in this study could be attributed to the fact that there is no sulphur in petrol obtained in Nigeria. Moreso, there is no coal-burning power plants and industrial boiler close to the study area. However, continuous use of petroleum products in power plant might generate this oxide (SO_2). Sulphr doxide (SO_2) combined with water vapour to form acid rain which damage roof of buildings and sculptures. Inhalation of SO_2 can affect respiratory system and can cause lungs cancer, irritation of eyes, and aggravate asthma and chronic bronchitis (Anderson, 2005).

The mean values of nitrogen dioxides (NO_2) obtained from the three locations were 0.0404±0.0496, 0.1026±0.0515 and 0.1022±0.0718 ppm for Trans-Amadi, 0.0390±0.0171, 0.0374±0.0182 and 0.0387±0.0197 ppm for Diobu (Mile 3), 0.0240±0.0128, 0.0230±0.0079 and 0.0298±0.0085 ppm for Rukpokwu. The results showed that the values were below DPR and FMEnv recommended limits of 0.04-0.06 ppm and 0.29 ppm respectively. Significant levels of NO_2 were reported in this study. This may be attributable to source of NO_2 to the area, some of the major sources of NO_2 to air are burning of fossil fuel, coal oil and motor vehicle exhaust. Trans-Amadi had the highest levels of NO_2 when compared to Diobu (Mile 3) and Rokpukwu. Continuous emission of NO_2 to the atmosphere can lead to the formation of acid rain which can damage roof of buildings, vehicles and pollute the aquatic media. In humans, inhalation of NO_2 can cause bronchitis in asthmatic children (Anderson, 2005).

The mean values of carbon monoxides (CO) obtained from the three locations were 1.38±0.07, 1.41±0.34 and 1.65±0.29 ppm for Trans-Amadi, 1.23±0.12, 1.21±0.51 and 1.24±0.39 ppm for Diobu (Mile 3), 1.19±0.05, 119±0.05 and 1.09±0.03 ppm for Rukpokwu. The results showed that the values were below DPR and FMEnv. recommended limits of 10 ppm and 11-22ppm respectively. Carbon (ii) oxide (CO) and nitrogen (ii) oxide are dangerous to humans. When CO is inhaled by humans, it reduces the amount of oxygen carried by haemoglobin. High concentrations of CO in the body may lead to loss of consciousness or even death. The results revealed that Trans-Amadi area recorded the highest concentrations of CO when compared to Diobu (Mile 3) and Rukpokwu. This may be attributed to the fact the companies in Trans-Amadi use power plant to generate electricity and in the process more CO is emitted into the air. The results obtained in this study agreed with the findings of (Akuro, 2012; Hamabi *et al.,* 2006 and Taware and Abowe, 2012), in Port Harcourt and it environs.

The mean values of hydrogen sulfide (H_2S) obtained from the three locations were 0.05±0.02, 0.05±0.03 and 0.04±0.02 ppm for Trans-Amadi, 0.04±0.03, 0.04±0.02 and 0.06±0.05 ppm for Diobu (Mile 3), 0.01±0.01, 0.02±0.01 and 0.03±0.01 ppm for Rukpokwu. There were no DPR and FMEnv recommended limits indicated for H_2S.Low levels of H_2S obtained in this study is due to fact that the sources of H_2Ssuch as sewage treatment plants, tanneries and natural gas plant are not common in the study area. Hydrogen sulphite (H_2S) is an important gas used in the production of sodium sulfide and sodium hydrosulfide. These chemicals are used in the production of dyes, pesticides and pharmaceuticals. Despite these, H_2S can cause headache, fatigue nausea and irritation of the mucous of the eyes of human.

The mean values of volatile organic compounds (VOCs) obtained from the three locations were 109.30±16.79, 106.91±11.49 and 112.57±12.96 ppm for Trans-Amadi, 88.70±10.06, 84.67±4.32 and 88.19±7.53 ppm for Diobu (Mile 3), 64.34±4.61, 70.64±4.79 and 78.70±6.52 ppm for Rukpokwu. The results showed that the values were below FMEnv recommended limits of 160ppm.The mean values of methane (CH_4) obtained from the three locations were;11.87±1.39, 11.33±5.06 and 11.67±6.45 ppm for Trans-Amadi, 10.22±3.36, 9.94±2.67 and 10.33±2.65 ppm for Diobu (Mile 3), 8.53±0.68, 8.31±2.16 and 8.81±3.09 ppm for Rukpokwu. There were no DPR and FMEnv limits indicated for CH_4.The mean values of ozone (O_3) obtained from the three locations were 0.15±0.06, 0.14±0.08 and 0.16±0.05 ppm for Trans-Amadi; 0.12±0.06, 0.10±0.04 and 0.11±0.01 ppm for Diobu (Mile 3), 0.09±0.04, 0.07±0.02 and 0.07±0.02 ppm for Rukpokwu. There were no DPR and FMEnv limits

indicated for O_3. Ozone is an important gas that shields the earth from the direct ultraviolet rays of the sun. However, low levels of O_3 were reported in this study and could be attributed to the human activities which have depleted the O_3 concentrations. The use of Freon in coolants of car air conditioners, refrigerators, nitrous oxide and pesticide can reduce O_3 in the environment (Franchini and Mannucci, 2007).$NH_3$was not detected in any location of the study area, probably because they were below detection limits of <0.001ppm. The results indicated that there may be no point source of NH_3inthe area, especially in the Trans –Amadi which is an industrial area. The major source of NH_3inanyenvironment is fertilizer and agricultural processes which is far away from the study area. The results obtained for CO, H_2S, NH_3, VOCs, NO_2 agreed with the findings of (Nwaogazie, 2015, Akintolarin *et al.,* 2018), in different parts of Port Harcourt.

Students t-test was used to compare the results in Tables1 to 3 within the locations for each month and the results revealed that for the month of September, at 95% confidence level for Trans-Amadi and Diobu (Mile 3) P(0.941), Trans-Amadi and Rukpokwu P(0.817), Diobu (Mile 3) and RukpokwuP(0.873), for the month of October, Trans-Amadi and Diobu (Mile 3) P(0.941), Trans-Amadi and Rukpokwu was P(0.829), Diobu (Mile 3) and RukpokwuP(0.885), for the month of November, Trans-Amadi and Diobu (Mile 3)P(0.905), Trans-Amadi and Rukpokwu P(0.837), Diobu (Mile 3) and Rukpokwu P(0.928).The results of t-test indicated that all the locations had P>0.05 which indicated that no significant differences between the locations for each month.

Similarly, Analysis of Variance (ANOVA) was used for the three months and revealed that in all the three locations there was not significantly different within the months of the study as all valued were greater than 0.05 (P>0.05).

IV. CONCLUSION

The air quality parameters measured and evaluated for the three months at industrial area - Trans-Amadi, and non-industrial areas, were Diobu (Mile 3) and Rukpokwu showed that the results were within the recommended standard guidelines for Department of Petroleum Resources (DPR) and Federal Ministry of Environment (FMEnv), except noise level which were above the working environment acceptable limits of 75dBA which occurs at Diobu and Rukpokwu. The results of students t-test and Analysis of variance (ANOVA) showed no significant differences within the months as P> 0.05 for all the months. However, high levels of noise were recorded at Diobu (Mile 3) and Rukpokwu because this area is in a busy environment where there are lots of human activities.

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