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Comparative Air Quality Study of Two Commercial Cities in Southern Nigeria.

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Abstract*: High concentration of human population and associated arrays of anthropogenic activities influence air quality conditions of commercial cities. In this study, air quality data (Particulate Matter and Noise Level) as well as meteorological parameters (Relative Humidity and Temperature) of Aba and Port Harcourt environs, with Elele-Alimini community as control, collected during dry and wet seasons, using standard test devices, were evaluated. The results revealed that the city of Aba and Port Harcourt were higher in both Particulate Matter and Noise Level than Elele-Alimini, exceeding both national and international standards. Also, there was significant difference ($p<0.05$) with the values in dry season being significantly higher than those obtained in wet season. Accumulation of particulate matter showed strong correlation with temperature($r = 0.958$) but strong negative correlation with relative humidity ($r = -0.950$), while noise level showed moderate correlation with temperature ($r = 0.641$) but negative with relative humidity ($r = -0.608$). The particulate matter were subjected to air quality index calculation, and it showed higher risk and health implications for residents of Aba and Port Harcourt, with a moderate value in Elele-Alimini (being the control). Aba was observed to be the most polluted in both particulate matter and noise, followed by Port Harcourt and the least was Elele-Alimini.*
Keywords*: Aba, Health Concerns, Noise Level, Particulate Matter, Port Harcourt.*

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I. Introduction

Ambient air, also known as clean or unpolluted air, is a major determinant of environmental stability, sustainably good for human health (WHO, 2016). Greater emphasis has been laid on air quality globally because of its direct impact on manand other environmental components. Air, as we know it, is one of the basic necessities required for human existence (Akinfolarinet al., 2017). Unfortunately, however, this environmental compartment has been severely impaired with inimical substances such as particulate matter (PM), Sulphur oxides, Nitrogen oxides, Carbon (ii) oxide (CO), (Ibeet al, 2017). This interference with the purity of air in its natural state has become a growing environmental issue both in developed and developing nations of the world (Muniret al, 2017). This is occasioned by industrialization and urbanization which has brought about higher concentration of human population in cities with viable economic opportunities such as commercial cities (Koop and Van Leewen, 2017).

Commercial cities are characterized with diverse commercial or business activities that range from small scale industries such as 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 (Ezejioforet al, 2013; Satope and Akanbi, 2014). In Nigeria, commercial cities such as Kano, Zaria, Aba and Port Harcourt serve as backbone of national development (Satope and Akanbi, 2014). Rapid growth in motor vehicles, roasting of animals with tyres and burning of large municipal waste generated in these cities has led to presence of particulate matter in ambient air (Syed, 2007; Njokuet al, 2016; Nwokochaet al, 2015). Few of the cities faced with this problem of impaired air quality challenge in Nigeria, are Port Harcourt in Rivers State and Aba in Abia State (Umunnakwe and Njoku, 2017; Taiwoet al, 2015).

Particulate Matters are complex group of air pollutants that vary in sizes, sources and compositions depending on location and time, and they are made up of sulphates, nitrates, elemental carbon, organic carbon compounds, acidic aerosols, trace metals and materials from the earth crust (Umunnakwe and Njoku, 2017). According to KeXu (2017), Particulate Matter is a mixture of solid particles and liquid droplets found in air and some of these particles such as soot/smoke and dust are large enough to be seen with the naked eyes, while others which are smaller, can only be detected with the aid of electron microscope. The two kinds of Particulate Matter popularly known are $PM_{2.5}$ and PM_{10} (Muniret al, 2017; KeXu, 2017).However, the health implications of Particulate Matter have been reported by different scholars. According to Offoret al (2016), the higher

accumulation of Particulate Matter such as PM_{10} in most Nigerian urban cities could have resulted in significant prevalence of chronic bronchitis, asthma, eye infection, cough and catarrh. Similarly, higher concentration of Particulate Matter in air was reported to have contributed to the increased hospital admission that has led to absence from work and school and other civic functions, as well as increase in the rate of mortality in cities (Hopke, 2009; Weli, 2014). The impact of Particulate Matter is not limited to human health, increased levels of Particulate Matter in air has also been reported tocause deterioration of atmospheric properties, thereby resulting in fog formation and precipitation, alteration of air temperatures and wind distribution, solar radiation reduction which may lead to safety hazard (Weli, 2014; Rosenfeld, 2000).

Apart from the particulate matter, noise is another form of pollution that threatens human well-being by unwanted sounds and it is today more severe than ever because of increasing human population (Goines and Hagler, 2007). Noise remains a nuisance that has impacted negatively on the physical, social and psychological well-being of human (Ibekweet al, 2016).Considering the population of human in the commercial cities of Port Harcourt and Aba in Southern Nigeria, it is important we make concerted efforts to evaluate Particulate Matter and Noise levels in these cities as a way of establishing a baseline information on the impact of commercial activities on Particulate Matter accumulation in air and increase in noise level, since there is paucity of research work in these areas. This will helpthe government and environmental experts in regulating anthropogenic activities with potentials of impairing the air quality, as a way of safeguarding our environment. Therefore the aim of this study is to evaluate particulate matter and noise levels in commercial cities and their health implications.

II. Materials And Methods

Study Area: The study was carried out for the period of six months (3 months wet, August to October and 3 months dry, November to January) in two commercial cities (Aba and Port Harcourt) in Southern Nigeria and a non-commercial area (Elele-Alimini) as control station (see figure 1).

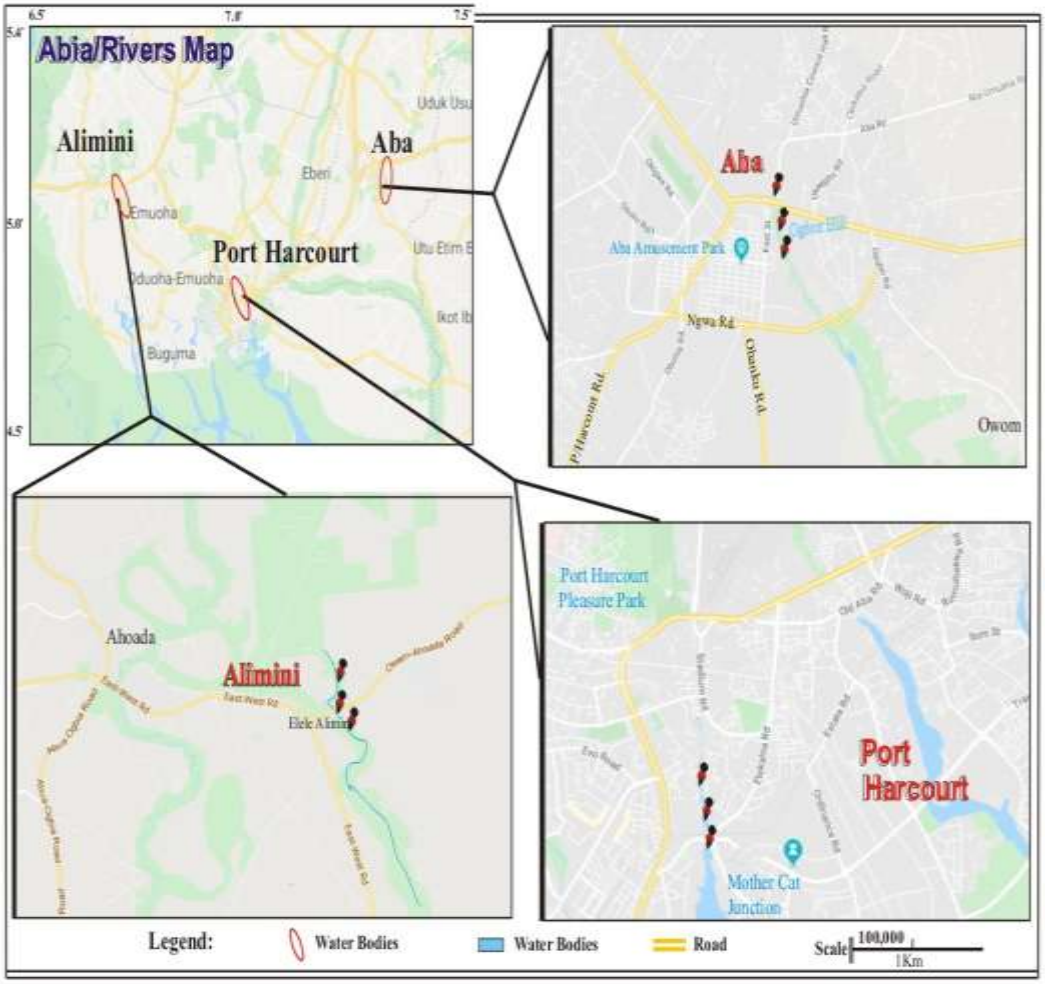

Fig 1: Map of the Study Areas Showing the Sampling Locations.

Site 1 (Aba): The city of Aba is predominantly a commercial hub located in the southern part of Nigeria, lying between Latitude $5^{o}07$N and Longitude $7^{o}22$E with a temperature range of 26.5^{o}C to 33.20^{o}C and relative humidity range of 46.70 to 81.30%. The city is known as one of the busiest commercial city in Nigeria, characterized by a beehive of vehicular and human activities, playing a host to many small and multinational markets like the popular Ariaria market and other marketing activities. Apart from industries and markets, the landscape of the city is dotting with eateries, hotels, Abattoirs, auto repairs, aluminum smelting and other artisanal activities. The chosen sample site in this city was along the Ogbor River area popularly known as waterside,lying between 5.114441N and 7.380805E and this location was selected because of diverse commercial activities and traffic density usually observed due to higher concentration of human population along the axis.

Site 2(Port Harcourt): The city of Port Harcourt is the administrative capital of Rivers State and a hub of commercial and industrial activities in southern Nigeria with prominent oil and gas companies resident in the city. The city of Port Harcourt plays a host to the popular mile 1 and mile 3 markets as well as Ikoku automobile spare parts shopping center. It lies between Latitude $4^{o}45^{1}$N and $4^{o}55^{1}$N and Longitude $6^{o}55^{1}$E and $7^{o}05^{1}$E with a temperature range of 25.80^{o}C to 31.90^{o}C and relative humidity range of 58.70 to 86.70%. The city is bounded in the north by Imo and Abia states, in the east by Akwa-Ibom, in the west by Bayelsa and in the south by the Atlantic Ocean. It is this proximity to the South Atlantic that explains nearness of inlands to the Atlantic which increases annual relative precipitation, thus characteristic heavy and persistent rainfall due to strong south-west wind (Yakubu, 2018). The notable climatic conditions in the city of Port Harcourt are dry season (November to March) and wet season (April to October). The chosen sample site in Port Harcourt was along the Mini-WejaRiver in Trans Amadi area, lying between 4.813793N and 7.015498E and this was because of the concentration of human population in this area, directly engaged in commercial activities and vehicular traffic along the area.

Site3 (Elele-Alimini): This town lies between Latitude $5^{o}45^{1}$N and Longitude $7^{o}60^{1}$E with a temperature range of 24.10 to 29.10^{o}C and relative humidity of 69.70 to 92.60%. Elele-Alimini is a non-commercial community located in Emohua Local Government Area of Rivers State and the people are predominantly agrarian (Farmers). The sampling was done along Mini-Ezi River area with coordinates 5.057881N and 6.737748E inElele-Alimini because of no visible commercial and industrial activities within this area which makes it appropriate to serve as a control station.

Sampling

Nine points were sampled, three points each in the two commercial cities (Aba and Port Harcourt), and three points from the non-commercial city (Elele-Alimini) being the control. Through the use of hand held automated global positioning systems (GPS), the geographical coordinates of the sampling points were obtained. A portable digital handheld air monitor equipment (Kestrel 4200) was used to determine relative humidity and air temperature,Aerocet 531 monitor was used to detect particulate matter ($PM_{2.5}$ and PM_{10}) while digital noise meter was used to monitor noise level. The equipment were pre-calibrated before each usage for the purpose of quality assurance.

Statistical Analysis

All the air parameters were statistically analyzed using Excel Spreadsheet and Statistical Package for Social Sciences (SPSS).

III. Result And Discussion

The results of particulate matter ($PM_{2.5}$ and PM_{10}), Noise level and Meteorological parameters are shown in Table 1.

Table 1: Descriptive Statistics for Particulate Matter, Noise Level and Meteorological Parameters

DRY SEASON												
Parameter (Units)	MEAN	STDEV	MAX	MIN	MEAN	STDEV	MAX	MIN	MEAN	STDEV	MAX	MIN
	ABA				PORTHARCOURT				ELELE-ALIMINI			
PM2.5(µg/m³)	155.13	9.23	165.5	147.8	124.2	12.61	134.9	110.3	85.6	15.02	99.7	69.8
PM 10 (µg/m³)	635.73	12.32	646.7	622.4	555.3	38.96	582.1	510.6	191.93	6.9	198.7	184.9
Temp. (°C)	32.67	0.55	33.2	32.7	31.2	0.87	31.9	30.4	28.63	0.5	29.1	28.1
Rel Hum (%)	49.46	2.7	52.1	49.6	62.9	4.76	68.1	58.7	72.1	2.14	73.8	69.7
Noise Level (dBA)	98.88	0.59	99.3	98.2	80.68	1.32	82.18	79.7	43.6	0.2	43.8	43.4
	WET SEASON											
PM 2.5 (µg/m³)	11.57	2.26	13.7	9.2	11.93	1.17	12.8	10.6	7.88	1.28	8.98	6.47
PM 10 (µg/m³)	55.6	2.98	58.1	52.3	48.57	0.93	49.6	47.8	22.33	5.48	26.7	16.18
Temp. (°C)	26.73	0.21	26.9	26.5	26.47	0.58	26.9	25.8	24.43	0.3	24.7	24.1
Rel. Hum (%)	78.53	2.7	81.3	75.9	84.97	1.55	86.7	83.7	87.96	4.86	92.6	82.9
Noise Level (dBA)	83.96	4.02	87.5	79.6	82.47	4.74	86.1	77.1	38.68	2.21	40.2	36.14

Particulate Matter

The results obtained as shown in Table 1, revealed that the concentration levels of particles <2.5µm in diameter for wet season ranged from 9.2 to 13.7µg/m^3 with a mean value of 11.57±2.26 in Aba, 10.60 to 12.80µg/m^3 with a mean value of 11.93±1.17 in Port Harcourt and 6.47 to 8.98µg/m^3 with a mean value of 7.88±1.28 in Elele-Alimini. The concentration levels of particles <2.5µm for dry season ranged from 147.8 to 165.5µg/m^3 with a mean value of 155.13±9.23 in Aba, 110.3 to 134.9µg/m^3 with a mean value of 124.2±12.61 in Port Harcourt and 69.8 to 99.7µg/m^3 with a mean value of 35.6±15.02 in Elele-Alimini. There was significant difference ($p<0.05$) with dry season recording higher values than the mean values recorded in wet season. This finding is in consonance with the observations of Akinfolarinet al., (2017) in Port Harcourt and KeXu (2017) in China. The low particulate matter ($PM_{2.5}$) recorded in the wet season could be attributed to higher relative humidity values recorded in wet season as shown in Table 1 in this study, since rainfall favors better air quality (Akatobi, 2019), and also lowers air temperature (Gupta et al, 2006). The mean values of $PM_{2.5}$ obtained in this study from the commercial cities (Aba and Port Harcourt) were above 35µg/m^3 reported by Aktheret al., (2019) as USEPA limit for 24hour period. While the mean value obtained in Elele-Alimini was within the standard limit. This higher mean values of $PM_{2.5}$ obtained in Aba and Port Harcourt are similar to the values of $PM_{2.5}$ reported by Nwokochaet al.,(2015) in major commercial areas in Port Harcourt, which was attributed to higher number of power plants generating products, vehicular emissions and burning of woods used in cooking. The mean values of $PM_{2.5}$ obtained in the commercial cities of Aba and Port Harcourt were significantly higher than the values obtained in Elele-Alimini being the control station in both wet and dry seasons.

The results obtained as shown in Table 1, revealed that the concentration levels of particulate matter <10µm in diameter for wet season ranged from 52.30 to 58.60µg/m^3 with a mean value of 55.60±2.98 in Aba, 47.80 to 49.60µg/m^3 with a mean value of 48.57±0.93 in Port Harcourt and 16.18 to 26.70µg/m^3 with a mean value of 22.33±5.48 in Elele-Alimini. The concentration levels of PM_{10} for dry season ranged from 622.40 to 646.70µg/m^3 with a mean value of 635.73±12.32 in Aba, 510.60 to 582.10µg/m^3 with a mean value of 555.30±38.96 in Port Harcourt and 184.90 to 198.70µg/m^3 with a mean value of 191.93±6.90 in Elele-Alimini. The mean showed significant difference ($p<0.05$) with the values obtained in dry season higher than values recorded in wet season across the sample stations. This higher value of PM_{10} in dry season could be attributed to low relative humidity recorded in the study during dry season, as low humidity enhances higher accumulation of particulate matter (Masitahet al., 2007). The concentration levels of PM_{10} obtained in Aba and Port Harcourt were above 150 to 230µg/m^3 standard limit for 24 hour period set by Department of Petroleum Resources (DPR) and United States Environmental Protection Agency (USEPA) but were within the standard in Elele-Alimini. The higher concentration levels of PM_{10} could be attributed to prominent commercial activities that ranged from roasting of animals with tyre in abattoir, aluminum smelting, burning of fossil fuel, burning of refuse generated from differentshoppingcentres (Weli, 2014).

Noise Level

The result in Table 1 revealed that noise level for wet season ranged from 79.6 to 87.5 dBA with a mean value of 83.96±4.12 in Aba, 77.10 to 86.10dBA with a mean value of 82.47±4.74 in Port Harcourt and 36.14 to 40.20 dBA with a mean value of 38.68±2.21 in Elele-Alimini. The noise levels for dry season ranged

from 98.20 to 99.30 dBA with a mean value of 98.88±0.59 in Aba, 79.70 to 82.18dBA with a mean value of 80.68±1.32 in Port Harcourt and 43.40 to 43.80dBA with a mean value of 43.60±0.20 in Elele-Alimini. There was significant difference ($p<0.05$) with the values obtained in dry season higher than the values recorded in wet season. This finding is consistent with the report of Danielet al., (2015), that sound travels faster in dry air than moist air; as a result, higher noise level is obtained in dry season. The noise levels obtained in this study in commercial cities of Aba and Port Harcourt are higher than 75dBAreported by Singh and Dev (2010) as standard limit for day time in industrial and commercial city by central pollution control board. While the mean value obtained in Elele-Alimini being control station fell below the standard. The increased noise level observed in Aba and Port Harcourt in this study can be attributed to higher concentration of human population, vehicular movement, power generator used by business centres (Syed, 2007).

Meteorological Parameters

The results shown in Table 1 revealed that relative humidity in wet season ranged from 75.90 to 81.30% in Aba, 83.70 to 86.70% in Port Harcourt and 82.90 to 92.60% in Elele-Alimini. The values for dry season ranged from 49.10 to52.10% in Aba, 58.70 to 68.10% in Port Harcourt and 69.70 to 92.60% in Elele-Alimini. The values of air temperature for wet season ranged from 26.50 to 26.90^{o}Cin Aba, 25.80 to 26.90^{o}C in Port Harcourt and 24.10 to 24.70^{o}C in Elele-Alimini. The air temperature for dry season ranged from 32.70 to 33.70^{o}C in Aba, 30.40 to 31.90^{o}C in Port Harcourt and 28.10 to 29.10^{o}C in Elele-Alimini. The results of meteorological parameters revealed higher air temperature and lower relative humidity in dry season across the sample stations, and this favours accumulation of particulate matter and higher noise level (Masitah, 2007; Danielet al, 2015; Ibekweet al, 2016; KeXu, 2017).

Statistical Correlation of Particulate Matter, Noise Level and Meteorological Parameters

Pearson's correlation (r) reveals a strong positive correlation between particulate matter and temperature (PM2.5, r = 0.958, PM10, r = 0.965) and a strong negative correlation with relative humidity (PM2.5, r = -0.950, PM10, r = -0.947) while a moderate positive correlation was observed between Noise level and temperature (r = 0.641), and a moderate negative correlation between noise and relative humidity (r = -0.608).See Table 2

Table 2: Pearson Correlation Table of the Different Parameters

PARAMETERS	PM2.5	PM10	TEMP	RELHUM	NOISELEVEL
PM2.5	1				
PM10	0.960	1			
TEMP	0.958	0.965	1		
RELHUM	-0.950	-0.947	-0.972	1	
NOISELEVE	0.412	0.582	0.641	-0.608	1

Risk and Health Implications

The risk and health implications of air quality in this study was calculated using Air Quality Index (AQI) which helps to determine how impaired or clean air in an area is and the associated health implications (EPA,2014). This is shown in Tables 3 and 4.

Table 3: AQI Values, Health Concerns and Colour Codes.

AQI	LEVELS OF HEALTH CONCERN	COLOURS
0-50	GOOD	GREEN
51-100	MODERATE	YELLOW
101-150	UNHEALTHY FOR SENSITIVE GROUPS	ORANGE
151-200	UNHEALTHY	RED
201-300	VERY UNHEALTHY	PURPLE
301-500	HAZARDOUS	MAROON

(source: Akinfolarinet al., 2017)

Table 4: Air Quality Index **(**AQI) for all the Sampling Sites

SITE	MEAN PM 2.5	AQI VALUE	COLOUR CODE	CATEGORY	MEAN PM 10	AQI VALUE	COLOUR CODE	CATEGORY
ABA	83.35	165	RED	UNHEALTHY	345.67	196	RED	UNHEALTHY
PORT HARCOURT	68.07	157	RED	UNHEALTHY	301.93	174	RED	UNHEALTHY
ELELE-ALIMINI	46.74	129	ORANGE	UNHEALTHY FOR SENSITIVE GROUPS	107.13	77	YELLOW	MODERATE

The result of this study revealed a higher accumulation level of particulate matter in Aba and Port Harcourt which is indicative of risk to the residents of these cities. Most death resulting from chronic obstructive pulmonary disease, cardiovascular disease and lung cancer are caused by air pollution due to particulate matter (Yakubu, 2017). Also, higher noise level as obtained in this study in Aba and Port Harcourt can cause aggravated chronic illness like hypertension and other cardiopulmonary diseases (Ibekweet al, 2016). Noise can as well impair on the quality of life resulting in human health ailment such as induced depressive tendencies like fatigue, memory loss, lack of concentration, deafness, rise in blood pressure and digestion problem (Singh and Dev, 2011).

IV. Conclusion

Higher accumulation of particulate matter in air and noise are not issue to be taken for granted as evidences have shownthat high rate of mortality and some life threatening diseases are caused by air pollution and higher noise level in the environment. The results from this research on comparative evaluation of air quality in commercial cities,revealed that the commercial city of Aba is highly polluted with particulate matter and noise level that exceeded both national and international standard, followed by Port Harcourt, while the non-commercial city (Elele-Alimini) being the control station had low particulate matter and noise level that are within the standard. Using air quality index (AQI) to calculate the risk and health implications of the particulate matter, it showed that the residents of Aba and Port Harcourt are exposed to higher health risk caused by higher accumulation of PM in addition to high noise level. Therefore, government and environmental authorities should make concerted efforts to reduce the anthropogenic activities capable of increasing particulate matter accumulation and noise levels in Aba and Port Harcourt as a way of safeguarding human health.

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