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Contribution of Vehicular Emissions to Climate Change in Nigeria: A Closer Look

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ABSTRACT: *Climate change is fast becoming a global challenge, as most countries in the world have continue to increase their industrial capacities, resulting in increase in greenhouse gas emissions in the atmosphere. Also, the increase in human population in Nigeria has caused increase in motor vehicles, thereby resulting to release of more gaseous pollutants to the atmosphere. This study examined contributions of vehicular emissions to climate change in Port Harcourt, Nigeria. The concentration of air particulate matter and pollutants were monitored in three locations (Rumuokoro, Rumuola and Ada George) selected on the basis of traffic density. Air quality was monitored with MX6 Ibrid Multi gas monitors, MET ONE GT 321 for particulate matter, Davis Vantage Vue Weather Station for metrological parameters. Data on meteorological factors such as air temperature, wind speed, relative humidity were collected from the nearest weather station in Port Harcourt. Traffic records were taken at the designated locations using a close circuit television (Plate 5.1) in the morning, afternoon and evening respectively. All the parameters were monitored in each location, five days in a week every month for two years (2016-2017). The result of the analysis revealed that there was an increase in concentration of average air pollutants across the areas monitored between 2016 and 2017. The variation was attributed to increase in vehicular traffic volume and change in climatic conditions. This implies that emission rate from vehicles will continue to increase and contribute significantly to climate change, except measures are put in place to mitigate it.*

KEYWORDS: climate change, concentration level, traffic volume, vehicular emission, air pollutants

INTRODUCTION

There is no doubt that road transportation adds significantly to economic activities of any nation, and happens to be one of the most important indicators of a countries' socioeconomic status. Nevertheless, it exerts numerous negative effects on society: pollution, noise and accidents (Buron, Lopez, Aparicio, Miguel, & Garcia, 2004). It is a very significant source of air pollution in urban areas (Agyemang- Bonsu, Tutu-Benefoh, & Asiamah, 2007). Air pollution results to severe environmental hazards such as acid rain, global warming, depletion of the ozone layer, and are leading causes of climate change. There is a great concern about the climatic problems being faced by the entire world such as; excessive flooding, droughts etc. Nigeria is already a victim of these environmental disasters (Adeyanju & Manohar, 2017).

Soil pollution, which reduces agricultural yield, and water pollution, which kills aquatic life, are two additional threats to the environment. The respiratory system (cough, bronchitis, etc.), kidneys, nervous and immune systems, cardiovascular, reproductive, and developmental systems are all impacted by air pollution, which can result in neurological dysfunction, high blood pressure and heart disease, birth defects, cancer, and even death. Children, the elderly, and people with respiratory infections like asthma are the most vulnerable. According to Adeyanju and Manohar (2017), no nation can live without cars, despite the negative effects they have on public health and the environment. Any nation's socio-economic development relies heavily on automobiles. They move people and goods and services from one location to another in a timely and effective manner. They bring convenience and simplicity to our lives.
Climate change is fast becoming a global challenge, as most countries in the world have continue to increase their industrial capacities, resulting in increase in greenhouse gas emissions in the atmosphere. Australian Academy of Science (2018) defined climate change as the long term change in weather pattern which causes several events such as melting of polar ice, rising sea level, and increasing intensity of natural disaster. Most of the studies have been centered on developed economies, while little attention has been given to developing economies such as Nigeria. Also, contributions of vehicular emissions to climate change have not been seriously looked into, especially in Nigeria context, which is what this study attempts to investigate.

The objectives of the Study include;
1. To determine whether meteorological factors affect pollutant concentration in the selected areas.
2. To ascertain if a relationship exists between the diurnal pattern in vehicular volume and air pollutants concentration in the study area.
3. To compare the air quality of the study area with NESREA standard limit.

The Following Null Hypotheses were tested;
1. Metrological factors do not significantly affect pollutant concentration in the study areas.
2. There is no significant relationship between the diurnal pattern in vehicular volume and air pollutants concentration in the study area.
3. The concentration of air pollutants in the study area does not differ significantly with NESREA standard limit.

REVIEW OF LITERATURE

The impact of climate change in Nigeria affects dry and rainy seasons. This has resulted to unbalanced system such that, too much heat (increase in temperature) can damage crops and vegetation and too much rainfall can produce widespread flooding and forced relocation

(Amanchukwu, 2015). There is evidence of impacts of climate change in Nigeria resulting from (Elisha, 2017; Ebele & Emodi, 2016; Olaniyi, 2013): increases in temperature; variable rainfall (decreasing rainfall amount in the continental interiors, increasing rainfall in the coastal areas); sea level rise, flooding and erosion; drought and increasing desertification; land degradation; extreme weather events (thunderstorms, lightning, landslides, floods, droughts, bush fires); and adverse effect on fresh water resources and loss of biodiversity.

Discoveries have shown that adjustments of weather patterns will keep on significantly affecting human existence and environments (Amanchukwu, 2015). The majority of the country's socioeconomic development, including agriculture, is vulnerable to climate change, which has caused these weather changes. In addition, people have not learned how to prepare for extreme weather, which has made them a yearly occurrence.(Enete, 2014; BNRCC, 2011). Extreme weather has also occurred recently in Nigeria (Akande, 2017; 2015, Amanchukwu).
Floods are the most well-known, repeating fiasco in the country (Federal Government of Nigeria, 2013). Over the past three decades, rainfall duration and intensity have increased, resulting in significant runoffs and flooding in a number of locations (Enete, 2014). According to Ifeanyi-obi and Nnadi (2014), villages in Lagos and some parts of the Niger Delta have been submerged by rising sea levels and ocean surge in Southern Nigeria. Over one million people in Jigawa State were impacted by a flood in 2010 in northern Nigeria (Elisha, 2017). Extreme cross country floods in 2012 brought about exceptional harm and misfortunes to human settlements found downstream (Akande, 2017; Federal Government of Nigeria, 2013).

Several studies have recognized the Niger Delta region as highly vulnerable to impacts from climate change, stemming from sea level rise, increased precipitation, and intensive industrial activities from oil exploration and vehicular emissions (Matemilola, 2019; Ucheje, Ogbuene & Ofoezie, 2021). Coastal erosion and flooding are the most pervasive problems, which have caused the displacement of many settlements in some regions of the Niger Delta (Matemilola, 2019).

Health Implication of Climate Change

In Nigeria, the effects of climate change on human health are significant. Extreme events like heat waves, floods, droughts, windstorms, and wildfires have direct effects on health (BNRCC, 2011). Circuitous impacts of environmental change can rise out of unhealthiness because of food deficiencies; from the spread of diseases that can be spread through food and water; and from more polluted air (Abdulkadir, 2017; BNRCC, 2011). Fresh water supply is affected by rising temperatures, rising sea levels, floods, and shifts in rainfall patterns, all of which can put people at risk for infection and other health issues (Nkechi, 2016).

However, tropical diseases like heat cramps, heat strokes, cerebrospinal meningitis, and malaria can be brought on by high temperatures (Amadi & Udo, 2015; 2014, Osuafor & Nnorom). Drought and high temperatures have reduced the quantity of fresh water in the Sahelian and Savanna regions, which has increased heat stress, compromised hygiene, and raised the risk of diarrhea and other water-borne diseases like cholera, typhoid fever, and river blindness (Nkechi, 2016; BNRCC, 2011). Environmental change can present dangers to the security circumstance in Nigeria through struggle over assets. The increasing scarcity of food and water exacerbates this situation; increasing scarcity of land due to desertification; increasing migration caused by climate change; and an increase in poverty (Madu, 2016; Madu, 2012; BNRCC, 2011).

MATERIALS AND METHODS

Design

Research design constitutes the blueprint for collection, measurement and analysis of data. In this study, experimental research design was employed. In this case, data were gathered for a period of 24 months, which involved the study of air pollutants emissions from vehicles.

Sources of Data

Secondary data was collected from subsidiary sources such as journals and unpublished information held in stock by individual scholars, libraries and government agencies as well as websites and other e-based facilities. Also, the National Environmental Standards and Regulations Enforcement Agency (NESREA) limitation standards for pollutants were obtained. Primary data was obtained from field investigations. Information sourced from field investigation includes: carbon monoxide (CO), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), volatile organic compounds (VOC) and particulate matters ($PM_{2.5}$ PM_{10}). Also, the meteorological parameters; Wind Speed (M/S), Air Temperature (^oC) and Relative Humidity (%), as well as traffic count was collected.

Population of the Study

The population of the study consists of all the high traffic density areas of Port Harcourt, Rivers State.

Sampling Strategy

Sampling stations for the study was identified by a purposive method, based on existing information on traffic density in different parts of Port Harcourt. According to Utang and Peterside (2011) there are ten high traffic density junctions in Port Harcourt, while the remaining is of medium to low density. Three (3) high traffic density locations (Rumuokoro roundabout, Rumuola and Location/Ada George) were selected for the study (Ucheje, Ogbuene & Ofoezie, 2021)

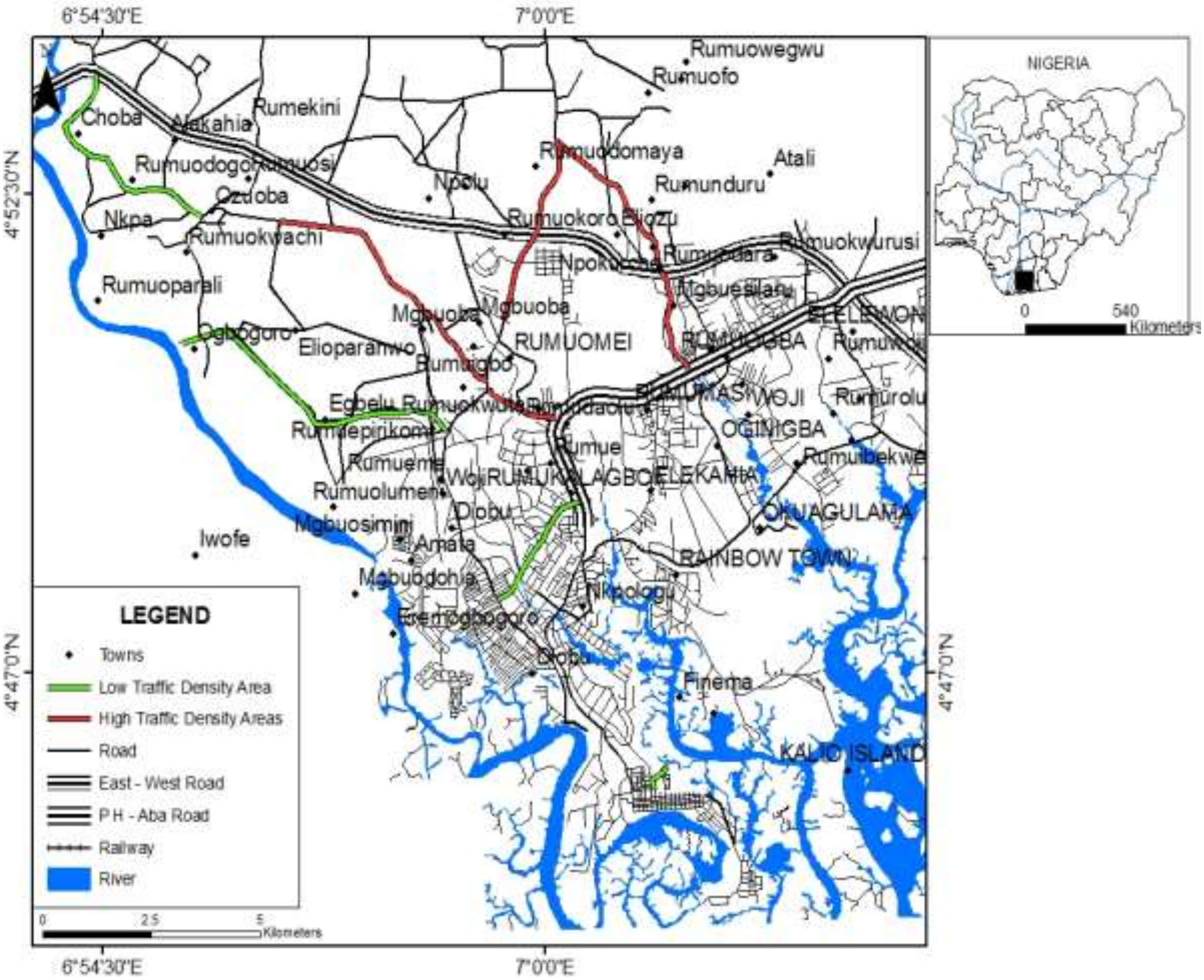

Plate 1: Port Harcourt, Nigeria Showing the Study Area

Collection of Data

Information was collected from each of the selected locations in three sessions, namely morning (7:00am to 10:00am), afternoon (12.00 noon-3.00pm) and evening (5:00pm to 8:00pm) periods. According to Utang and Peterside (2011) the morning and evening are peak periods of traffic density while the afternoon is low density period in Port Harcourt. Each location was monitored from Mondays to Friday every month for twenty-four months (2 years). Information collected during each session of investigation includes:

Traffic Volume Count: The number of vehicles that cross a given point during each sampling session was collected using a close circuit television (Plate 5.1).

By Pollutant Monitoring: The pollutants monitored on each sampling day include; Carbon monoxide (CO), Nitrogen dioxide (NO_2), Sulfur-dioxide (SO_2), volatile organic carbons (VOCs), and Particulate matters ($PM_{2.5}$ & PM_{10}). The concentration of CO, NO_2, SO_2 and VOC

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was determined by using MX6 Ibrid Multigas monitor hand held device and MET ONE GT 321 particulate matter counter for Particular matters ($PM_{2.5}$ & PM_{10}). Also, the meteorological parameters (wind speed, temperature, and humidity) were determined using Davis Vantage Vue Weather Station which was mounted at each of designated locations for the period specified,

Data Handling

The data that was obtained by the investigation was analyzed using appropriate descriptive and inferential statistical methods. Descriptive presentation include summary of data in tables and graphs. Difference of means between explanatory variables was analyzed using Independent t-test, for variables with only two means, one way analysis of variance (one way ANOVA) for more than two means, and Multiple Linear Regression (MLRM) for relationship between variables

DATA ANALYSIS

Seasonal distribution of air pollutants

Figure 1 to 3 shows the concentration of the air pollutants in 2016 and 2017. The overall mean concentration of CO was fairly stable in the two years, increasing only slightly and non-significantly from 16.15±8.21 ppm in 2016 to 16.19±8.03 ppm in 2017. The corresponding values for the other pollutants were NO_2 (0.24±0.32 in 2016 to 0.25±0.33 in 2017); SO_2 (0.18±0.28 in 2016 to 0.19±0.28 in 2017); $PM_{2.5}$ (140.04±91.21 in 2016 to 141.26±93.25 in 2017); PM_{10} (132.06±84.21 in 2016 to 131.32±82.69 in 2017) and VOC (0.22±0.33 in 2016 to 0.27±0.35 in 2017). Therefore, all the pollutants exhibited a similar pattern in their trend of temporal variation, the lower concentration of each except PM_{10} occurring in 2016 while the higher occurred in 2017. Statistical analysis revealed that, the concentration of CO and VOC varied significantly ($p < 0.01$) between 2016 and 2017 while other variables were comparable between the two study years.

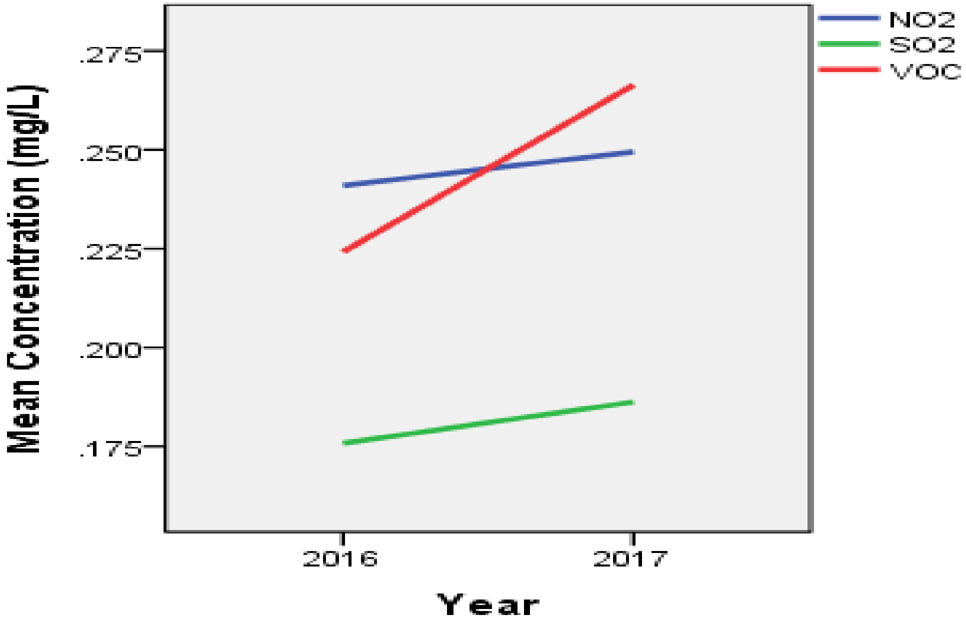

Figure 1: Annual variations in NO_2, SO_2 and VOC concentration between 2016 and 2017 in Port Harcourt (Source, Researchers' Field Work, 2016-2017)

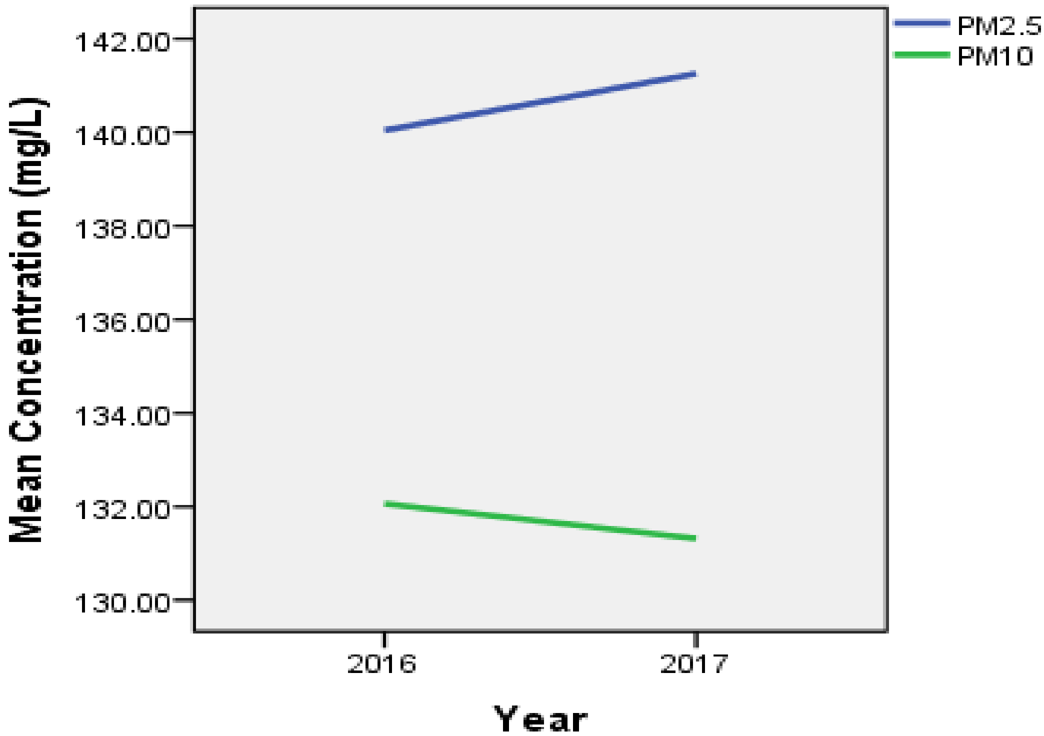

Figure 2: Annual variations in $PM_{2.5}$ and PM_{10} concentration between 2016 and 2017 in Port Harcourt (Source, Researchers' Field Work, 2016 -2017)

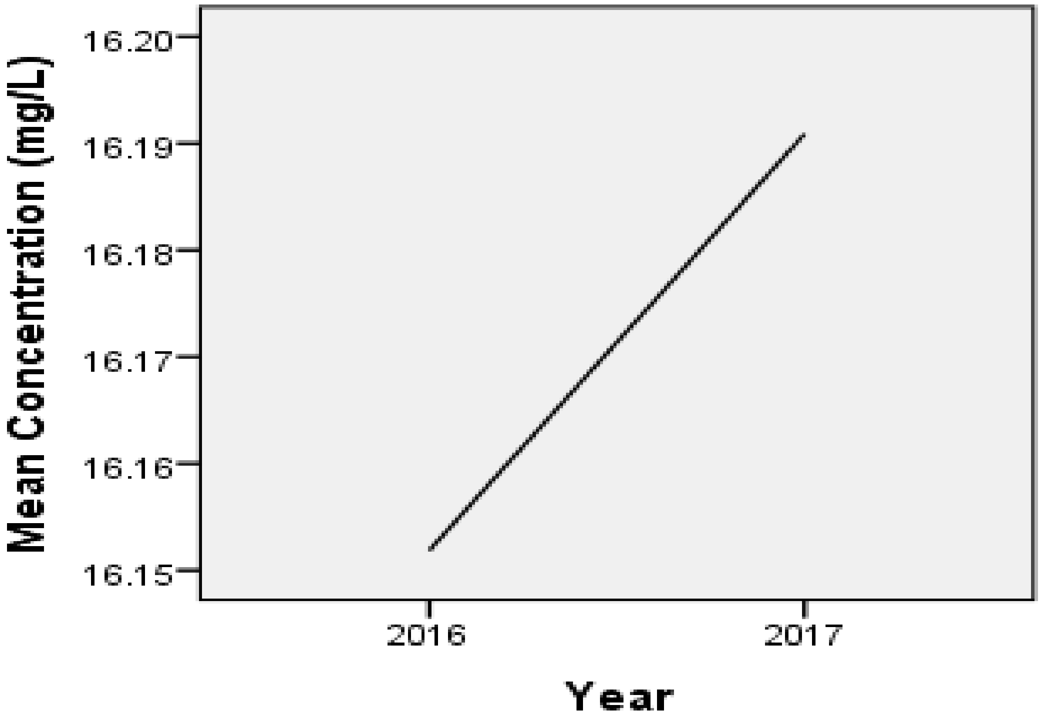

Figure 3: Annual variations in CO concentration between 2016 and 2017 in Port Harcourt (Source, Researchers' Field Work, 2016 -2017)

The pattern of monthly distribution of pollutants is shown in Figures 4 to 6

Figures 4, 5 and 6 revealed the monthly concentration of air pollutants within the study areas in Port Harcourt. The mean concentration of all the pollutants varied slightly between January to December. CO concentration occurred highest (16.91±13.65 ppm) in November and lowest (15.62±13.36 ppm) in the month of April. However, NO_2 recorded the highest concentration (0.27±0.34 ppm) in the month of September and lowest concentration (0.21±0.28 ppm) in October; for SO_2 highest concentration (0.20±0.31 ppm) was in April and lowest (0.16±0.25 ppm) in October. For particulate matters, mean concentration of $PM_{2.5}$ occurred highest (145.27±94.31µg/m^3) and lowest (137.77±93.69 µg/m^3) in the month of December and January respectively; highest (136.08±104.06µg/m^3) and lowest (129.23±82.63 µg/m^3) concentration of PM_{10} was recorded in January and November respectively. Furthermore, the concentration of VOC occurred highest (0.32±0.40ppm) in February and lowest (0.19±0.29ppm) in June. Statistically, only VOC varied significantly ($p<0.05$) between the month of January to December.

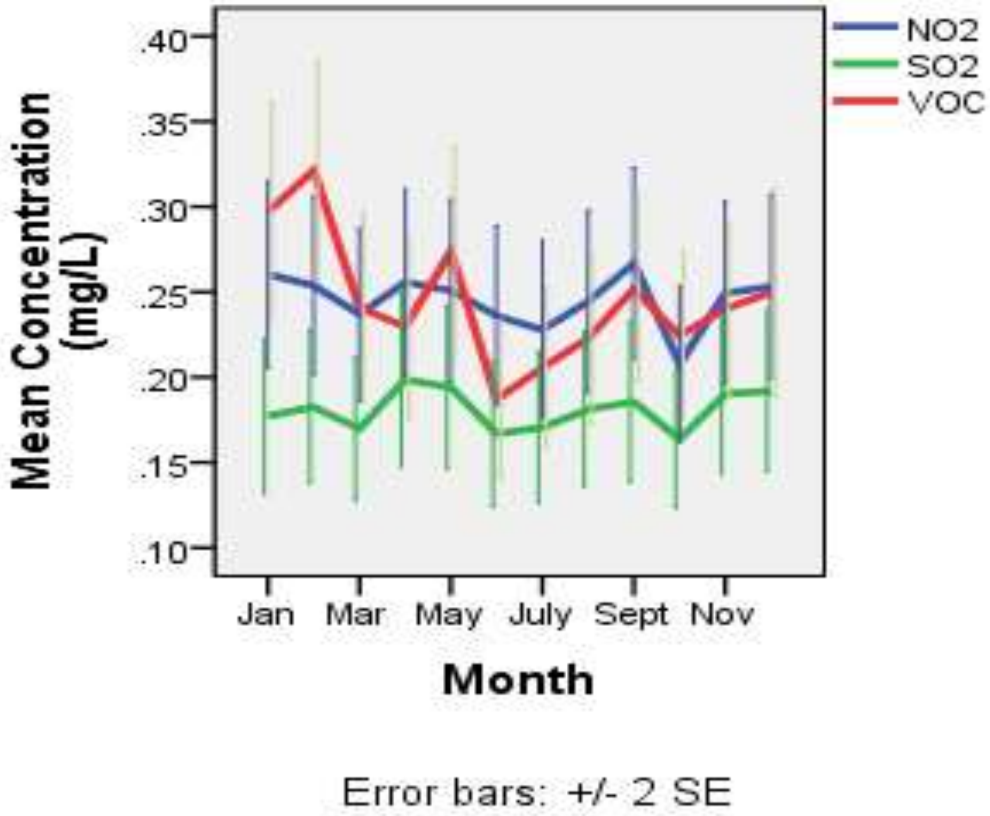

Figure 4: Monthly variations in NO_2, SO_2 and VOC concentration in Port Harcourt (Source, Researchers' Field Work, 2016 -2017)

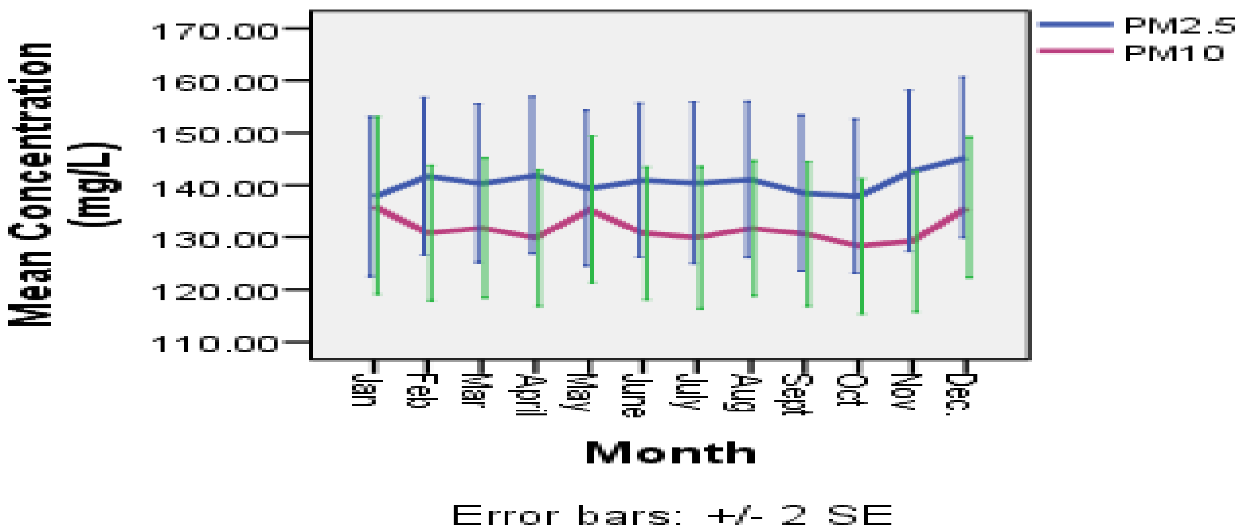

Figure 5: Monthly variations in $PM_{2.5}$ and PM_{10}concentration in Port Harcourt (Source, Researchers' Field Work, 2016 -2017)

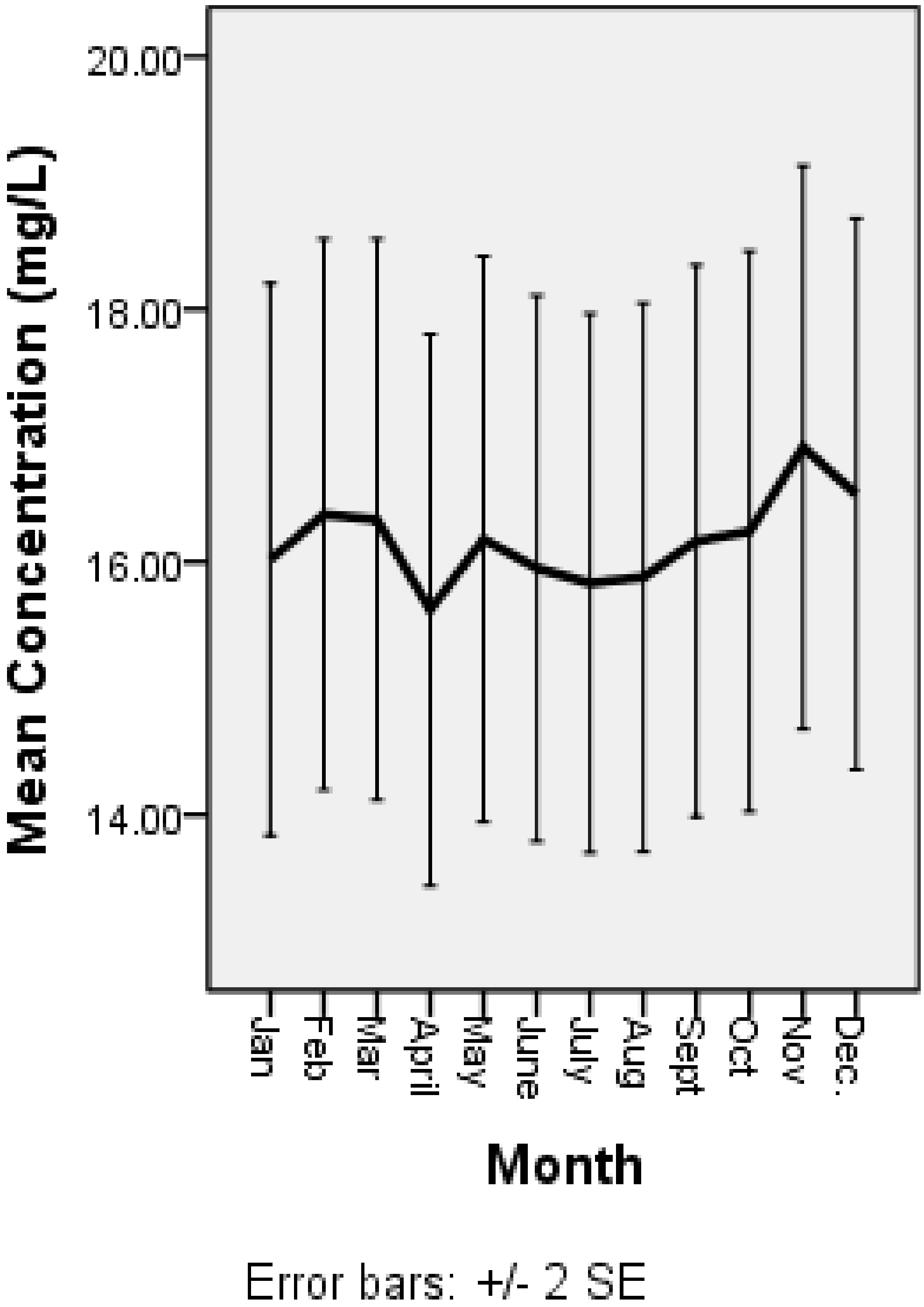

Figure 6: Monthly variations in CO concentration in Port Harcourt (Source, Researchers' Field Work, 2016 -2017)

The pattern of air pollutants distribution at different times and days of the week

Table 1 presents the concentration of air pollutants at different times of the day within the study sites in Port Harcourt. The mean concentration of all the pollutants decreased from their peak values in the morning to their lowest values in the afternoon before rising again to a higher peak in the evening peak. Statistical analysis showed that the variation in pollutants concentration over the period of the day was significantly ($p < 0.001$) different. Table 2 reveals the concentration of air pollutants at different days of the week within the study locations in Port Harcourt. All the air pollutants varied slightly within the days of the week. The mean concentration of CO, $PM_{2.5}$ and PM_{10} occurred highest on Friday at 16.59±13.42 ppm, 146.87±94.00µg/m^3 and 135.67±82.82 µg/m^3 respectively. Variations in concentration of CO, NO_2, SO_2, $PM_{2.5}$ and PM_{10} were not statistically different (P>0.05), while concentration of VOC within the days of the week varied significantly.

Table 1: Mean Concentration of Air Pollutants at different times of the Day in Port Harcourt

Period	N	CO (PPM)	SO_2 (PPM)	NO_2 (PPM)	$PM_{2.5}$ (µg/m^3)	PM_{10} (µg/m^3)	VOC (PPM)
Morning	600	21.00±13.18	0.20±0.29	0.30±0.32	157.79±75.69	150.40±76.27	0.28±0.36
Afternoon	600	7.78±8.08	0.08±0.11	0.08±0.13	79.35±53.68	77.60±50.06	0.15±0.26
Evening	600	19.73±13.85	0.26±0.35	0.36±0.39	184.81±104.48	167.07±89.70	0.31±0.37
F-Value		222.411	75.894	136.097	276.650	248.927	40.609
P-Value		0.000	0.000	0.000	0.000	0.000	0.000

Source: Researchers' SPSS Analysis

Table 2: Mean Concentration of Air Pollutants at different days of the week in Port Harcourt

Days	N	CO(PPM)	NO_2(PPM)	SO_2(PPM)	$PM_{2.5}$(μg/m^3)	PM_{10}(μg/m^3)	VOC(PPM)
Monday	360	15.78±13.71	0.25±0.33	0.18±0.29	138.68±93.53	132.25±90.86	0.25±0.35
Tuesday	360	16.22±13.44	0.26±0.34	0.18±0.28	138.66±92.94	131.12±81.35	0.25±0.36
Wednesday	360	16.28±13.29	0.23±0.31	0.18±0.28	140.00±91.43	129.81±80.50	0.30±0.36
Thursday	360	15.99±13.08	0.23±0.30	0.18±0.27	139.04±89.32	129.59±81.53	0.23±0.33
Friday	360	16.59±13.42	0.25±0.33	0.18±0.27	146.87±94.00	135.67±82.82	0.20±0.29
Total	**1800**	**16.17±13.38**	**0.25±0.32**	**0.18±0.28**	**140.65±92.21**	**139.69±83.43**	**0.25±0.34**
F-value		0.189	0.531	0.022	0.525	0.315	4.393
P-value		0.944	0.713	0.999	0.718	0.868	0.000

Source: Researchers' SPSS Analysis

Effects of traffic volume on the mean concentration of air pollutants in different parts of Port Harcourt

Table 3 presents the result of regression analysis of traffic volume with concentration of air pollutants within the study sites of Port Harcourt. The concentration of CO, SO_2NO_2, VOC, $PM_{2.5}$ and PM_{10} increased with increasing traffic volume. However, traffic volume was significantly predictive of CO, SO_2, NO_2, VOC, $PM_{2.5}$ and PM_{10}.

Table 3: Effects of Traffic Volume on the Mean Concentration of Air Pollutants in different Parts of Port Harcourt

Independent Variable (X)	Dependent Variables (Y)	N	Mean ± SD	T-value	B	SE of B	P-value
	CO	1800	16.17±13.38	15.37	0.01	0.00	< 0.001
	NO_2	1800	0.25±0.32	14.21	0.00	0.00	< 0.001
Traffic Volume	SO_2	1800	0.18±0.28	13.94	0.00	0.00	< 0.001
	$PM_{2.5}$	1800	140.65±92.21	15.87	0.04	0.00	< 0.001
	PM_{10}	1800	131.69±83.43	15.10	0.04	0.00	< 0.001
	VOC	1800	0.25±0.34	14.93	0.00	0.00	< 0.001

Source: Researchers' SPSS Analysis

Test of Hypotheses

The hypotheses guiding this research work were tested using the result of each parameter. The level of significance was tested at 95% confidence ($P < 0.05$). The general decision rule for each of the hypotheses is that where the null hypothesis is rejected the alternate hypothesis is accepted and vice versa. Decision on whether to accept or reject any hypothesis is based on the significant level $P < 0.05$ or less.

H_{O1}: Metrological factors does not significantly affect pollutant concentration in the study areas.

Table 4: Result of Statistical Analysis on metrological factors affecting pollutant concentration in the study areas

Parameter	Air Temp				Humidity				Wind Speed			
	B	R^2	SE of B	P-value	B	R^2	SE of B	P-value	B	R^2	SE of B	P-value
CO	-1.65	0.24	0.07	0.000	-0.37	0.24	0.07	0.000	-11.92	0.24	5.11	0.020
NO_2	-0.03	0.15	0.00	0.000	-0.00	0.15	0.00	0.025	-0.50	0.15	0.13	0.000
SO_2	-0.02	0.07	0.00	0.000	-0.01	0.07	0.00	0.000	-0.160.07		0.12	0.172
$PM_{2.5}$	-12.08	0.28	0.48	0.000	-1.47	0.28	0.50	0.003	-182.32	0.28	34.31	0.000
PM_{10}	-10.74	0.27	0.43	0.000	-1.36	0.27	0.45	0.003	-211.11	0.27	31.26	0.000
VOC	-0.010.06		0.00	0.000	0.01	0.04	0.06	0.000	-0.16	0.06	0.15	0.28

Source: Researchers' SPSS, Analysis

The results of regression analysis carried out on factors affecting pollutant concentration in the study areas are presented in Table 4. All the three (air temperature, humidity and wind speed) meteorological parameters assessed significantly ($p< 0.05$) affect concentration of CO, NO_2, $PM_{2.5}$ and PM_{10}. On the other hand, two of (air temperature and humidity) the factors significantly ($P<0.001$) aids the concentration of SO_2 and VOC, in the study areas of Port Harcourt.

Decision

The null hypothesis was rejected for all the parameters investigated, while the alternative hypothesis was accepted. Therefore, metrological factors significantly affect pollutant concentration in the study areas.

H_{O2}: There is no significant relationship between the diurnal pattern in vehicular volume and air pollutants concentration in the study area.

Table 5: Result of Statistical Analysis on relationship between the diurnal pattern in vehicular volume and air pollutants concentration in the study areas

Parameter	**Traffic Volume**			
	B	R^2	SE of B	P-value
CO	0.01	0.49	0.00	0.000
NO_2	0.00	0.44	0.00	0.000
SO_2	0.00	0.46	0.00	0.000
$PM_{2.5}$	0.04	0.45	0.00	0.000
PM_{10}	0.04	0.46	0.00	0.000
VOC	0.00	0.45	0.00	0.000

Source: Researchers' SPSS Analysis

The results of regression analysis carried out on relationship between the diurnal pattern in vehicular volume and air pollutants concentration in the study area are presented in table 5. The vehicular volume is significantly ($p< 0.001$) related to all the air pollutants investigated in the study site. Also, at least 44% of each pollutant concentration can be explained by vehicular volume. This reveals a daytime pattern in vehicular volume and air pollutants.

Decision

The null hypothesis was rejected for all the parameters investigated while the alternative hypothesis was accepted. Therefore, there is a significant relationship between the diurnal pattern in vehicular volume and air pollutants concentration in the study area.

H_{O3}: The concentration of air pollutants in the study area does not differ significantly with NESREA standard limit.

Table 6: Result of Statistical Analysis on the difference in the concentration of air pollutants and NESREA limitation standards in Port Harcourt

Parameter	Mean	Standard deviation	NESREA Standard	Mean Difference	T-Value	Df	P-value
CO	16.17	13.38	10	6.17	19.58	1799	0.000
NO_2	0.25	0.32	0.06	0.19	24.28	1799	0.000
SO_2	0.18	0.29	0.01	0.17	26.03	1799	0.000
$PM_{2.5}$	140.25	92.21	250	-109.35	-50.31	1799	0.000
PM_{10}	131.69	83.43	250	-118.31	-60.16	1799	0.000
VOC	0.25	0.34	0.06	0.19	23.02	1799	0.000

Source: Researchers' SPSS Analysis

This hypothesis was tested using the One Sample t-test to compare sample means obtained for this study and the NESREA standards for each investigated parameter. The result is presented in Table 6. All the parameters compared with the NESREA standards differed significantly ($p< 0.001$) with the NESREA standard. Of all the parameters that showed significant difference, $PM_{2.5}$ and PM_{10} were significantly lower than NESREA standards.

Decision

The null hypothesis is rejected and the alternate hypothesis accepted. Therefore, the concentration of air pollutants in the study area differs significantly with NESREA standard limit.

DISCUSSION OF FINDINGS

Diurnal pattern in vehicular volume and air pollutants Concentration

This study also revealed a significant relationship between daytime pattern in vehicular volume and air pollutants concentration. The concentration of all the pollutants correlated positively and significantly with density of traffic vehicles. The findings in this study agreed with those of Prince and Essiet (2014), which investigated pollution from automobiles during traffic peak periods at intersections on some selected roads in Uyo, Nigeria. Their outcomes revealed that concentration of CO was higher during the peak periods of traffic congestion. They attributed the high pollutant loading at these periods not only to traffic density but also to the long waiting time that result in the discharge of products of incomplete combustion by the carburetors of vehicles.

Factors affecting pollutant concentration

The analysis of meteorological parameters revealed that temperature, relative humidity and wind speed significantly correlated with the concentration of air pollutants.The variation in the metrological parameters explained the dispersion rate experienced by CO, NO_2, SO_2, $PM_{2.5}$, PM_{10} and VOC at difference peak periods. The slight variation in average temperature, humidity and wind speed between 2016 and 2017, revealed a pattern in concentration of the air pollutants investigated.

Conversely, Doreena, Mohd, Hafizan, Ahmad, and Sharifuddin (2012) assessed the influence of meteorological factors on PM_{10} and NO_2 at selected stations in Malaysia. This study was aimed at determining the influence of meteorological parameters (ambient temperature, relative humidity and wind speed) based on a daily average computation of air pollutants PM_{10} and NO_2 at three selected stations in Malaysia, namely Shah Alam and Johor Bahru on the Peninsular Malaysia and Kuching on the island of Borneo. A three-year (2007-2009) database was statistically analyzed using the Pearson Correlation and Multiple Linear Regression methods. The results obtained through these analyses showed that at all the three stations, NO_2 has a reverse relationship with wind speed, while PM_{10} has a negative relationship with relative humidity and wind speed, but a positive relationship with ambient temperature. This finding was contrary to the deduction made in Port Harcourt, and disagrees with present study. The difference between the two studies may be attributed to regional variations in meteorological parameters.

Yong and Wulin (2017) examined pollution characteristics and influencing factors of atmospheric particulate matter ($PM_{2.5}$) in Chang-Zhu-Tan area of China. The monitoring of $PM_{2.5}$ was carried out between 1st of May to 31st of May 2013. Their findings revealed that temperature and wind speed had a negative correlation with the pollutants, except relative humidity, which was positively correlated with the pollutants. Even though only one pollutant was considered, it contradicted the findings of the present study. Also, Ucheje (2014) investigated the influence of meteorological factors on vehicular emissions during wet season in south-south Nigeria and, his findings revealed that variation in pollutants concentration can be explained by the meteorological conditions such as wind speed, temperature, and relative humidity. This investigation agrees with the present study. The direct effect of metrological factors on pollutant concentration can be attributed to change in climatic conditions.

Air quality of the study area based on NESREA limitation standards

The study revealed that at $P<0.05$, the concentration of air pollutants in the study sites differed significantly with NESREA limitation standards. The concentration of air pollutants investigated was higher than the accepted standards, except for $PM_{2.5}$ and PM_{10}. The difference in concentration was highest for CO, at both morning and evening peak periods. This finding suggests a growing threat of air pollution across the city of Port Harcourt and Nigeria, which of course contributes to climate change. Although this study did not determine the proportion of this threat attributable to vehicular emission, the finding of this study that pollutant loading is correlated with vehicular volume points to the latter as a major contributory factor to air pollution in the study area.

In related investigations, Abam and Unachukwu (2009) assessed vehicular emissions in selected areas of Calabar, while Oke and Ukpebor (2013) assessed the spatial and temporal variation in total suspended particulate (TSP) matter in Isoko land. Their findings revealed the total suspended particulates were also higher in the investigated cities when compared with

W.H.O standard. Also, some of the locations that were above limits were clearly violated, which suggested of health and environmental concerns respectively. Their findings agree with the present study.

Jerome (2000) did a comparative study of emission in Lagos and Niger Delta, with emphasis on Port Harcourt and Warri. The result obtained, showed that concentration of total suspended particulates, NO_x, SO_2 and CO_2 in Lagos and the Niger Delta were above FEPA recommended limit. The total suspended particulates were also higher in the study cities when compared with W.H.O standard. The study showed an increasing trend in those cities, and thus possesses a potential hazard to the population. His finding validates the present study and shows a high degree of similarity because of the cities investigated.

Okelola and Appolonia (2013) conducted a study on vehicular carbon emission concentration in Minna, Nigeria. Their findings revealed that emissions' level of carbon monoxide from vehicular emissions in particular exceeded internationally accepted safe limits of 350 parts per million in the atmosphere. This also agrees with the findings of the present study.

CONCLUSION

There was a slight increase in concentration of average air pollutants across the areas monitored between 2016 and 2017. The variation was attributed to increase in vehicular traffic volume. Concentration of CO was relatively high across the high density areas (Rumuokoro roundabout, Rumuola road and Location/Adageorge road), this is because there was high traffic volume in these areas. With respect to hydrocarbons and carbon monoxide, the spark-ignited emissions are significantly higher, in some cases by an order of magnitude, than diesels, due to the excess air and compression conditions for diesels.

Most cars/buses run on petrol, which results into emission of CO as a result of incomplete-combustion during traffic. This implies that emission rate from vehicles will continue to increase and contribute significantly to climate change, except measures are put in place to mitigate it. Some of these measures could come as; constructing more link roads/ alternate routes along the high traffic density areas, in order to decongest traffic and reduce waiting time of vehicles; reduction in importation of fairly used vehicles for over 10 years; planting of trees along the major roads especially, the high traffic density areas should be encouraged, in order to serve as carbon sinks.

REFERENCES

Abam, F.I., & Unachukwu, G.O. (2009).Vehicular Emission and air quality standards in Nigeria. *European Journal of Scientific Research. 34*(4), 550-560

Abdulkadir, A. (2017). Climate change and its implications on human existence in Nigeria: a review. *Bayero Journal of Pure and Applied Sciences, 10*(2), 152-158.

Adeyanju, A. A., & Manohar, K. (2017). Effects of Vehicular Emission on Environmental Pollution in Lagos. *Sci-Africa Journal of Scientific Issues, Research and Essays, 5*(4), 034-051

Agyemang-Bonsu, W.K., Tutu-Benefoh, D., & Asiamah, H., (2007). *Ghana Vehicular Emission Report, Accra, Ghana*. Environmental Protection Agency, Accra

Akande, A. (2017). Geospatial Analysis of Extreme Weather Events in Nigeria (1985–2015) Using Self-Organizing Maps. *Advances in Meteorology, 6*(5), 234-256

Amadi, S.O., & Udo, S.O. (2015). Climate change in contemporary Nigeria: An empirical analysis of trends, impacts, challenges and coping strategies. *IOSR Journal of Applied Physics, 7*(2), 1-9

Amanchukwu, R. N. (2015). Climate change education in Nigeria: The role of curriculum review. *Education, 5*(3), 71-79.

BNRCC (Building Nigeria's Response to Climate Change). (2011). *National adaptation strategy and plan of action on climate change for Nigeria* (NASPA-CCN). Prepared for the Federal Ministry of Environment Special Climate Change Unit

Buron, J. M., Lopez, J.M., Aparicio, F., Miguel, A.M., & Garcia, A. (2004). Estimation of road transportation emissions in Spain from 1988 to 1999 using COPERT III program. *Atmospheric Environment 38* 715–724.

Doreena, D., Mohd, T.L., Hafizan, J., Ahmad, Z.A., & Sharifuddin, M, Z. (2012). An assessment of influence of meteorological factors on PM_{10} and NO_2 at selected stations in Malaysia. *Sustain. Environ. Res., 22*(5), 305-315

Ebele, N. E., & Emodi, N. V. (2016). Climate change and its impact in Nigerian economy. *Journal of Scientific Research & Reports, 10*(6), 1-13.

Elisha, I. (2017). Evidence of climate change and adaptation strategies among grain farmers in Sokoto State, Nigeria. *IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT), 11*(3), 1-7.

Enete, I.C. (2014). Impacts of climate change on agricultural production in Enugu State, Nigeria. *Journal of Earth Science & Climatic Change, 5*(9), 234

Federal Government of Nigeria. (2013). *Nigeria Post-Disaster Needs Assessment – 2012 Floods*

Ifeanyi-obi, C.C., & Nnadi, F.N. (2014). Climate change adaptation measures used by farmers in South-south Nigeria. *Journal of Environmental Science, Toxicology and Food Technology, 8*(4), 1-13

Jerome, A. (2000): "*Use of, Economic Instruments for Environmental Management in Nigeria*". A paper presented at workshop on Environmental Management in Nigeria and Administration (NCEMA), Nigeria.

Madu, I. A. (2012). *Spatial vulnerability of rural households to climate change in Nigeria: Implications for internal security*. Robert S. Strauss Center for International Security and Law at the University of Texas at Austin

Madu, I. A. (2016). *Rurality and climate change vulnerability in Nigeria: Assessment towards evidence based even rural development policy*. Paper presented at the 2016 Berlin Conference on Global Environmental Change, 23-24 May 2016 at Freie Universität Berlin.

Matemilola, S. (2019). Mainstreaming climate change into the EIA process in Nigeria: Perspectives from projects in the Niger Delta Region. *Climate, 7*(2), 29

Nkechi, O. (2016). Mitigating climate change in Nigeria: African traditional religious values in focus. *Mediterranean Journal of Social Sciences, 7*(6), 299-308.

Oke, M.A. & Ukpebor, E. E. (2013). Baseline, spatial and temporal variation of total suspended particulate (TSP) matter in Isoko land. *Journal of Environmental Chemistry and Ecotoxicology, 5*(5), 129-135.

Okelola, O.F., & Appollonia O., (2013). Vehicular Carbon Emissions Concentration level in Minna, Nigeria: The Environmental Cum Climate Implication: *African Technology policy Studies Network.* Working Paper Series No. 71

Olaniyi, O. A. (2013). Review of climate change and its effect on Nigeria ecosystem. *International Journal of African and Asian Studies, 1*, 57

Osuafor, A. M., & Nnorom, N.R. (2014). Impact of Climate Change on Food Security in Nigeria. *AFRREV STECH, 3*(1), 112

Prince, C.M., & Essiet, U. (2014).Spatio-Temporal Variations in Urban Vehicular Emissions in Uyo City, Akwa Ibom State, Nigeria. *Journal of Sustainable Development.7*(4), 272-281.

Ucheje, O. (2014). Influence of meteorological factors on vehicular emissions during wet season in South-South Nigeria. *Archives of Applied Science Research*, *6*(4), 162-164

Ucheje, O., Ogbuene, E.B., Ofoezie, I.E. (2021) Modeling of CO and PM2.5 Concentration Level in High Traffic Density Areas, using Regression Model. *International Journal of Environment and Pollution Research, 9*(3), 33-50

Utang P. B., & Peterside, K.S (2011): Spatio-tempora variations in urban Vehicular emission in Port Harcourt city, Nigeria. *Ethiopia Journal of Environmental Studies and Management.4* (2), 10-15

Yong, Z., & Wulin, J. (2017) Pollution characteristics and influencing factors of atmospheric particulate matter ($PM_{2.5}$) in Chang-Zhu-Tan area. *Earth Environ. Sci.108,* 1-6