Trend Analysis of Vehicular Traffic Contribution to Air Pollution in Urban Cities: A Case Study of Port Harcourt, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Original Research Article

ABSTRACT

The study investigated contributions of vehicular emissions to air pollution in Port Harcourt City, Nigeria for two years (24months), 2017-2018. The daytime pattern, monthly pattern, major traffic congested areas and factors that aid dispersion of air pollutants were considered. Using a closed-circuit television, traffic records were obtained at the chosen places by counting the number of vehicles passing at a spot for two hours in the morning, afternoon, and evening (Plate 5.1). For two years, all parameters were monitored once a month (Monday to Friday) in each location (2017-2018). Where appropriate, descriptive analysis, ANOVA, and multiple linear regressions were used to assess the data. The findings demonstrated that the mean concentrations of all pollutants followed a similar pattern in terms of temporal variation and were significantly ($P < 0.05$) different during the day. Similarly, within the daytime, the mean traffic volume fluctuated greatly and considerably ($P < 0.05$) between the two research years. Furthermore, all of the pollutants showed a similar pattern in terms of temporal change, with the lowest concentrations in 2017 and the highest in 2018. Statistical analysis revealed that, the concentration of all the air pollutants and traffic volume varied significantly ($p < 0.05$) between 2017 and 2018.

Keywords: Trend; concentration level; traffic volume; vehicular emission; air pollutants.

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1. INTRODUCTION

Air is a universal gas, composed of nitrogen (78%) and oxygen (21%), leaving about 1% for all other components. It is regarded as the most important natural life support system probably due to the oxygen component. All living organisms require oxygen to breath and no organism can survive more than five minutes of hypoxia. Air therefore makes human existence and other forms of life possible. The ability of air to effectively support life, however, depends on its quality. Quality air is generally regarded as that which is in the right natural proportion. Deviation to this makes the air polluted. The degree of pollution depends on what additional constituents or pollutants it contains. There are many types of pollutants classified on the bases of their sources, type and toxicity. Thus, while good quality is very essential in sustaining life, polluted air is detrimental to it. There are several sources of air pollution but it is generally believed that the most important sources are those related to human activity.

According to FEPA, [1] air pollution is defined as any substance in air which could, if in high enough concentration could harm man, animals, vegetation, or artificial composition of matter capable of being airborne. There are some many other definitions that agree with above. But, it is important to understand that air pollution occurs mostly as a result of human activity which is a problem to the environment. The pollutants that result to disequilibrium of air in the atmosphere are either primary source; which are substances directly emitted from a process, or secondary; which are produced by reactions between primary pollutants. These sources include industrial, transportation among others. Among these sources, transportation accounts for greater percentage of toxic pollutants emitted [2]. Carbon monoxide has 77% and Oxides of Increased automotive emissions result in a rise of 80-90 percent nitrogen, volatile organic compounds amount to 36 percent with particulate matter making up 22 percent [3]. Land transportation sources of air pollutant have contributed more to air pollution than other sources, especially in developing countries like Nigeria. Vehicular traffic has constituted increased air pollutants in the atmosphere, which is becoming threat to urban cities. Because of incomplete combustion in stationary automobiles, traffic congestion contributes substantially to air pollution [4]. For instance, it has been shown that roughly 50-80% of CO and NO_2 concentration in emerging nations is attributable to traffic congestions. Therefore, taking inventory of air pollutants from vehicular emission from a long period of time has become necessary.

1.1 Contributions of Vehicular Traffic to Air Pollution

This section discusses different studies that focused on how vehicular emissions contribute to air pollution in most Nigerian cities;

A study carried out by Jimo and Ndoke, [5] in congested areas of Minna, Niger State reported a concentration of 5,000ppm for CO_2. This is however less when compared to the stipulated maximum value set by WHO which is 20,000ppm. CO emission value recorded was 15ppm, which is below the WHO baseline of 18ppm, and FEPA standard of 20ppm. The low emission concentration in Minna was attributed to the city's low traffic and industrial activities, according to the researchers.

Koku and Osuntagun [6] investigated the impact of urban road transportation on ambient air quality in three cities: Lagos, Ibadan, and Ado-Ekiti. Air quality indicators that were monitored were NO_2, SO_2, CO and total suspended particulates (TSP). Their findings reported concentrations of SO_2-2.9ppm at Idumota, CO-23.3ppm, at idumota, NO_2-1.5ppm at Iyana-ipaja and total particulates 852ppm at Oshodi bus stop. For CO and SO_2 concentration of 27.1ppm and 0.44ppm respectively were measured at Mokola round about, while 10ppm of NO_2 was obtained at Bere roundabout. In Ado-Ekiti the highest concentration recorded were at old Garage junction with SO_2 levels at 0.8ppm, Ijibo junction with NO_2 levels at 0.6ppm and Oke Isha with CO levels at 31.7ppm. The concentrations gotten for SO_2, CO, NO_2, and particulate counts per minute all exceeded the FEPA limits (SO_2-0.0lppm, CO-10ppm, NO_2-0.04 to 0.06ppm). The study concluded that there is an increasing risk of traffic-related air pollution in Nigeria cities. The author covered some major cities in Nigeria which is a merit on the study. Notwithstanding, the duration of the study is not known. Also, factors that affect dispersion rate were not considered.

Jerome [7] compared emissions in Lagos with the Niger Delta, focusing on the cities of Port Harcourt and Warri. The findings revealed that total suspended particulates, oxides of nitrogen (NOx), SO_2, and CO_2 concentrations in both

localities, all exceeded the FEPA recommended limit. For Lagos, the concentration of CO emissions was quite high, ranging between 10-250ppm, as compared with 5.0-61.0ppm recorded for oil communities in the Niger Delta. The total suspended particulates were also higher in the study areas when compared with W.H.O threshold. The study showed an increasing trend in those cities, and thus possesses a potential hazard to the population. In the above study, the researcher should have analyzed the data statistically, as well as formulating hypotheses which would have given more relevance to the work.

Abam and Unachukwu [8] investigated vehicular emissions in selected areas of Calabar, Nigeria and reported the respective concentration of SO_2, NO_2, CO, PM_{10} and likewise the noise level to be in the range of 0.04-0.5ppm, 0.02-0.09ppm, 3.3-8.7ppm and 72.4db. When comparing air quality index (AQI) as against the pollutants, the following results were obtained: NO_2- very poor to poor; CO-poor to moderate, and moderate to poor in different locations; SO_2 very poor to poor. Also, PM_{10} and noise level were all poor in all locations. As per the findings, transportation-related pollution in Calabar was found to be significant, with potentially serious health repercussions.

Utang and Peterside [9] took a gander on automobile emissions in sections of Port Harcourt, Nigeria, during peak traffic periods. The degree of fluctuation in emission concentrations between peak and off-peak traffic periods, as well as between locations, was determined. At all times and locations, only traces of SOx (Sulphur Oxides) were discovered, whereas CO concentrations were higher than the federal environmental protection agency limit and recommended municipal (local) norm. During peak traffic periods, NOx (nitrogen oxides) levels were generally higher than local and international norms in all sites. They concluded that the city was under threat of traffic related pollution which was intensified by increasing population influx and heavy vehicular traffic.

The findings of an investigation into air pollution from autos at intersections on several selected major highways in Ogbomosho, South Western Nigeria, were published by Ojo and Awokola [10]. Four routes were sampled for this investigation, with ten sampling locations (SP1- SP10) situated 2.0m from the road's edge. Priority parameters: SO_2, NO_x, CO were monitored. The results of SO_2, NO_x CO were in the range of 0.02-0.09ppm,

0.009-0.039ppm, and 1.79-51.38ppm respectively with peaks at traffic congestions and intersection points. Compared with standard; AQI (Air quality index) SO_2- rated very poor to good, NO_x – ratings were good to very good while CO-ratings were very good to moderate with some locations being moderate to poor. The research concluded that understanding the effects of mobile source emissions on air quality via well-designed studies has become more important, and that this data can give valuable input for the construction of successful air quality control plans.

A study was conducted by Okelola and Appolonia [11] on vehicular carbon emission concentration in Minna, Nigeria. They looked at the trend of automobile carbon footprint emissions in Minna, Niger State, Nigeria, in their research. Emission levels in selected flashpoints within the study location were revealed. These flashpoints can be seen scattered around the road networks in Minna. The measurements were achieved using gasman meters for each type of gas investigated in this study namely: nitrogen dioxide (NO_2), carbon dioxide (CO_2), sulphur dioxide (SO_2), ammonia (NH_3), chlorine (Cl_2), carbon monoxide (CO), and hydrogen suiphide (H_2S). The tests were conducted during peak and off-peak traffic periods. By utilizing the Arc-GIS software, the average emission levels during peak and off-peak traffic periods were ascertained and shown. The entire dataset was also generated and evaluated using statistical methods. The findings revealed that carbon dioxide emissions, particularly from vehicles, exceeded globally agreed safe limits of 350 parts per million in the atmosphere.

Prince and Essiet [12] investigated pollution from automobiles during traffic peak periods at intersections on some selected roads in Uyo, Nigeria. They investigated selected air pollutants namely H_2S, NO_2, CO and SO_2 in six sampling locations during peak traffic hours (morning and evening) and off-peak hours (afternoon). CO levels were found to be greater during peak periods of traffic congestion and intersections, when there was a considerable wait for vehicles. Emission levels at these periods, surpassed the Federal Ministry of the Environment's limits/standards. In addition, the level of SO2 was frighteningly high, particularly in location C. In all six locations, levels of nitrogen oxides (NO_2) and hydrogen sulphide (H_2S) changed in time and space during peak traffic periods, and were also above specified municipal and international thresholds.

Ucheje and Ikebude [13] published a study comparing automobile emissions in urban and rural settings. Nitrogen dioxide, Sulphur dioxide and likewise Carbon monoxide concentrations were measured in Port Harcourt (urban milieu) and Etche (rural milieu) (Rural Milieu,). The cities for the sample sites were chosen using a basic random sampling technique. Carbon monoxide had the highest content in both milieus during the two peak periods (morning and evening), according to the data; sulphur dioxide in both Port Harcourt and Etche were found to have the lowest concentration. The investigation revealed that the urban environment is more polluted than the rural environment, owing to traffic congestion in Port Harcourt.

The above studies by different scholars emphasized how vehicular traffic emissions have contributed immensely to urban air pollution. Similarly, there seems to be a serious threat of increased air pollutants concentration in urban cities. Conversely, these studies in Nigeria failed to properly establish a trend of air pollution contributed by vehicular emissions in urban milieus, for more than two seasons. Though, much studies involving longer period of monitoring have been investigated in other developed countries, but not really in Nigeria. This study therefore, bridged the gap, by investigating the contributions of vehicular emissions to air pollution for two years (24months), 2017-2018. The daytime pattern, monthly pattern, major traffic congested areas and factors that aid dispersion of air pollutants were considered.

2. MATERIALS AND METHODS

2.1 Sampling Technique

Purposive sampling technique was used to choose sampling stations for the study, which was determined from existing data on traffic density in various regions of Port Harcourt, Rivers State, Nigeria. In keeping with Utang and Peterside [9], Port Harcourt has ten high traffic density junctions and the rest are medium to low density. Through stratified random sampling, three (3) high traffic density routes (Rumuola, Rumuokoro roundabout and Location/Ada-George) were chosen for the study.

2.2 Method of Data Collection

For each of the identified locations, data collection was done at various sessions during the day with the morning session being between 7:00am to 9:00am, the afternoon session was between 12:00 noon to 2:00pm and the evening session fell between 5:00pm to 8:00pm. As per Utang and Peterside [9], traffic density is at its peak in the morning and evening, and lowest in the afternoon in Port Harcourt. Each month for twenty-four months (2 years), each spot was watched from Monday to Friday. Data gathered throughout each investigation session comprises:

Traffic Volume Count: During each sample session, a close circuit television camera was used to count the number of vehicles that passed at a certain place (Plate 5.1).

By Pollutant Monitoring: Sulphur dioxide (SO_2), Carbon monoxide (CO) and particulate matter (PM2.5 & PM10) are among the contaminants measured on each sample day. CO and SO_2 concentrations were measured using a hand-held MX6 Ibrid Multigas Monitor and for particular matter ($PM_{2.5}$ & PM_{10}), a MET ONE GT 321 particulate matter counter was utilized. A Davis Vantage Vue Weather Station was erected at every designated location for throughout the course of the study to determine the meteorological parameters (wind speed, temperature, and humidity).

2.3 Statistical Analysis

The information gathered throughout the research was examined with descriptive and inferential statistical methods. Descriptive presentation includes 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.

2.4 Study Area

The study was conducted in Port Harcourt city South-south Nigeria. Port Harcourt city is a metropolitan and capital city of Rivers State, Nigeria. It is located within latitude 6' 54°N and longitude 4°E. It falls nearly within the low land swamp forest ecological zone and is flanked in the east, west and southern limits by the mangrove swamp forest [14]. It is characterized by residential, commercial, transportation, and institutional and industrial zones. Port Harcourt's geography is flat, and its drainage system is insufficient. Its elevation ranges from 3 metres to over 15 metres above sea level. Because the area's low relief slopes gradually towards the

sea, discharges are channelled into the Bonny River, the area's primary natural drainage system. Port Harcourt has two major seasons: dry and wet; yet, the environment maintains an acceptable level of moisture throughout the year. The average maximum and minimum temperatures are 34°C and 21°C, respectively, with the months of April to October having the highest temperatures [15].

3. RESULT AND DISCUSSION

Table 1 revealed the conc. of air pollutants, meteorological variables and traffic volume within the study sites in Port Harcourt, Nigeria. The mean conc. for tested pollutant were all low, likewise the volume of traffic. They were all below the maximum limits. This indicates the significant differences in pollution levels and traffic volume between the two research years.

3.1 Daytime Distribution of Air Pollutants and Traffic Volume

Figs 1, 2, 3, 4, and 5 depicted air pollution concentrations and traffic volume during the day in 2017 and 2018. Throughout the two study years, the mean traffic volume was highest in the evening (956±109 vehicles/hr) and lowest in the afternoon peak (133±67 vehicles/hr). The total mean concentration of CO in morning peak was at its highest (21.00±13.18ppm) and lowest in the afternoon peak (7.78±8.08ppm). Similarly, mean concentration of SO_2 occurred highest in the evening peak (0.26±0.35ppm) and lowest in the afternoon peak (0.08±0.11ppm). Further, the overall mean conc. of $PM_{2.5}$ and PM_{10} were found to be at their highest during evening peak (184.81±104.48 µg/m^3) and (167.00±89.70 µg/m^3) respectively and lowest in the afternoon peak (79.35±53.68 µg/m^3) and (77.60±50.06 µg/m^3) respectively. Statistically, all pollutants' mean concentrations throughout the day followed a similar pattern in terms of temporal variation and were significantly (P<0.05) different. Equally, within the daytime, the mean traffic volume fluctuated greatly and considerably (P<0.05) between the two research years. The increased traffic volume witnessed in Port Harcourt, Nigeria, throughout the morning and evening hours can be attributed to this.

3.1.1 The pattern of air pollutants and traffic volume distribution at different days of the week

Fig.s 6, 7, 8, 9 and 10, show the conc. of air pollutants and traffic volume at different days of

the week in 2017 and 2018. 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±82.82µg/m^3 respectively. Conversely, the mean concentration of SO_2 occurred highest on Wednesday at 0.184±0.28 ppm. Traffic volume distribution was highest on Friday at 895±148 vehicles/hr. According to statistical analysis, the variation in pollutants concentration over the different days of the week was not significantly (p > 0.05) different, but the average traffic volume was significantly (p < 0.05) different within the days of the week. The implication is that the more increase in concentration of pollutants apart from SO_2 experienced on Fridays, is most likely to be attributed to high traffic volume.

3.1.2 The pattern of monthly distribution of pollutants and traffic volume is shown in Figs. 11 to 15

The monthly concentrations of air pollutants and traffic volume within the research areas in Port Harcourt, Nigeria are shown in Figures 11, 12, 13, 14, and 15. Between January and December, the mean concentrations of all contaminants fluctuated somewhat. The greatest CO concentration (16.91±13.65 ppm) was in November, while the lowest (15.62±13.36 ppm) was in April. Still, SO_2 recorded the highest concentration (0.20±0.31 ppm) in the month of April and lowest concentration (0.16±0.25ppm) in October. The highest (145.27±94.31µg/m3) and lowest (137.77±93.69g/m3) mean $PM_{2.5}$ concentrations were reported in December and January, respectively; the highest (136.08±104.06m/L) and lowest (129.23±82.63 g/m3) mean PM_{10} concentrations were recorded in January and November, respectively. In addition, the average traffic volume was highest (617±796 vehicles per hour) in March, July, and August, and lowest (538±726 vehicles per hour) in January, May, and September. Between January and December, there was no statistically significant difference in air pollutants or traffic volume (p>0.05).

3.1.3 Seasonal distribution of air pollutants and traffic volume

The concentrations of air pollutants and traffic volume in 2017 and 2018 were shown in Figures 16 to 20. In the two years, the total mean CO concentration increased dramatically, from 16.47±13.34 ppm in 2017 to 20.25±14.62 ppm in 2018. The corresponding values for the other

pollutants were SO_2 (0.18±0.28 ppm in 2017 to 0.35±0.33 ppm in 2018); $PM_{2.5}$ (140.04±91.21 µg/m^3 in 2017 to 157.16±75.82 µg/m^3 in 2018) and PM_{10} (132.06±84.21µg/m^3 in 2017 to 193.32±90.67µg/m^3 in 2017). Furthermore, average traffic volume is (522±726 vehicles/hr in 2017 to 839±423 vehicles/hr in 2018). As a result, all of the pollutants showed a comparable pattern in their temporal variation, with the lowest concentrations occurring in 2017 and the highest in 2018. Statistical analysis found that between 2017 and 2018, the concentrations of all air contaminants and traffic volume differed considerably ($p < 0.05$).

Table 1. Statistics of pollutants, meteorological variables and traffic variables in the analysis

Variables	N	Minimum	Maximum	Mean	Std. Deviation
CO (ppm)	1800	0.02	48.00	16.92	12.86
$PM_{2.5}$ (µg/m^3)	1800	6.00	336.00	140.65	92.21
PM_{10} (µg/m^3)	1800	13.00	327.00	142.50	91.07
SO_2 (ppm)	1800	0.00	1.66	0.18	0.28
Air temp (^{o}C)	1800	16.00	34.00	25.12	3.99
Wind speed (ms^{-1})	1800	1.28	2.39	1.39	0.13
Rel. Humidity (%)	1800	30.00	52.00	42.40	4.62
Traffic Volume (Vehicles/hr)	1800	11.00	1200.00	592	473

Fig. 1. Daytime variations of CO concentration between 2017 and 2018 in Port Harcourt, Nigeria

Fig. 2. Daytime variations of SO$_2$ concentration between 2017 and 2018 in Port Harcourt, Nigeria

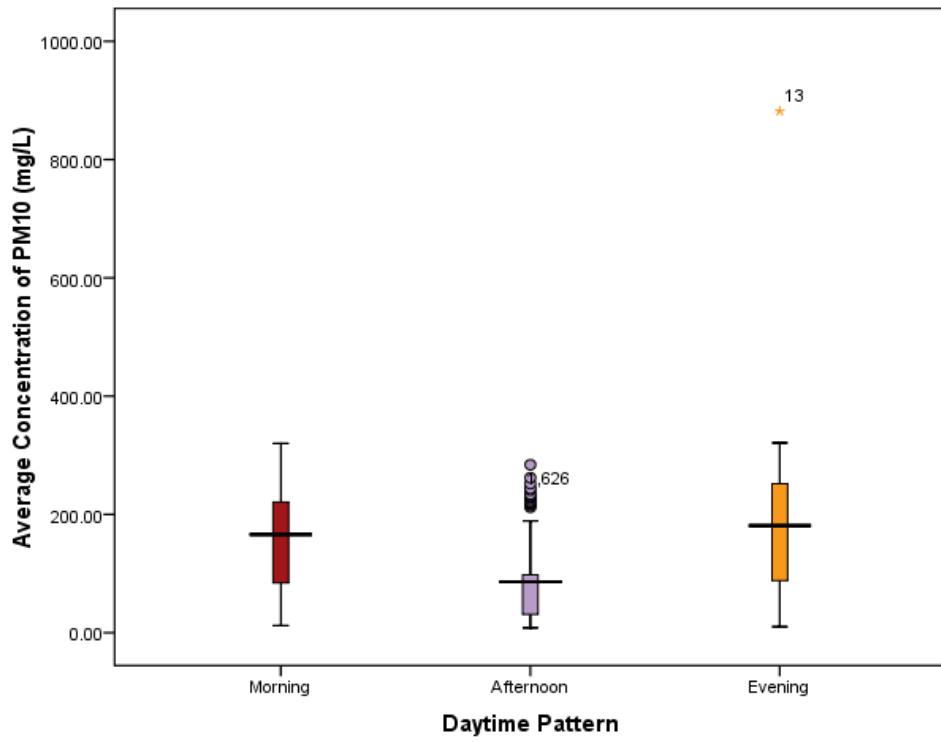**Fig. 3. Daytime variations of PM$_{2.5}$ concentration between 2017 and 2018 in Port Harcourt, Nigeria**

Fig. 4. Daytime variations of PM$_{10}$ concentration between 2017 and 2018 in Port Harcourt, Nigeria
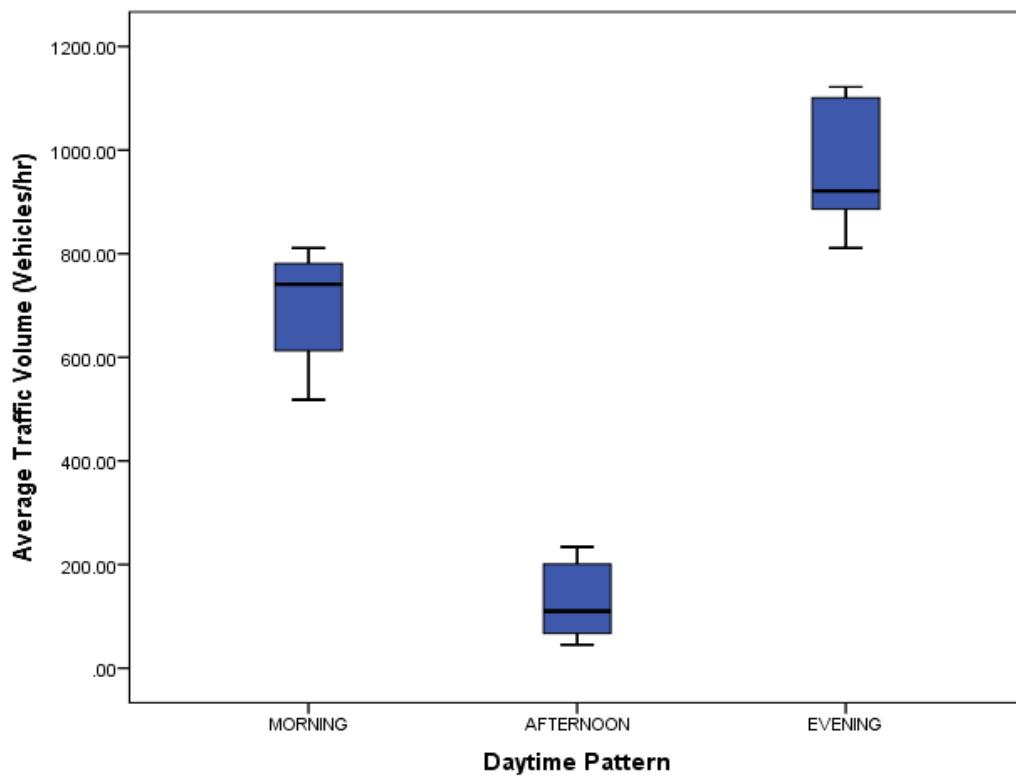

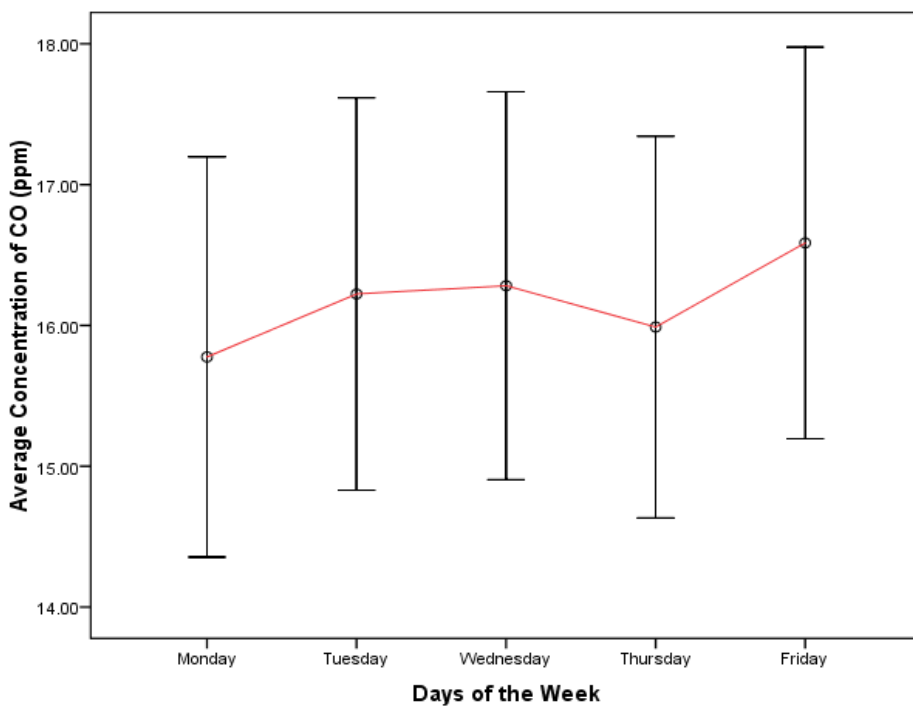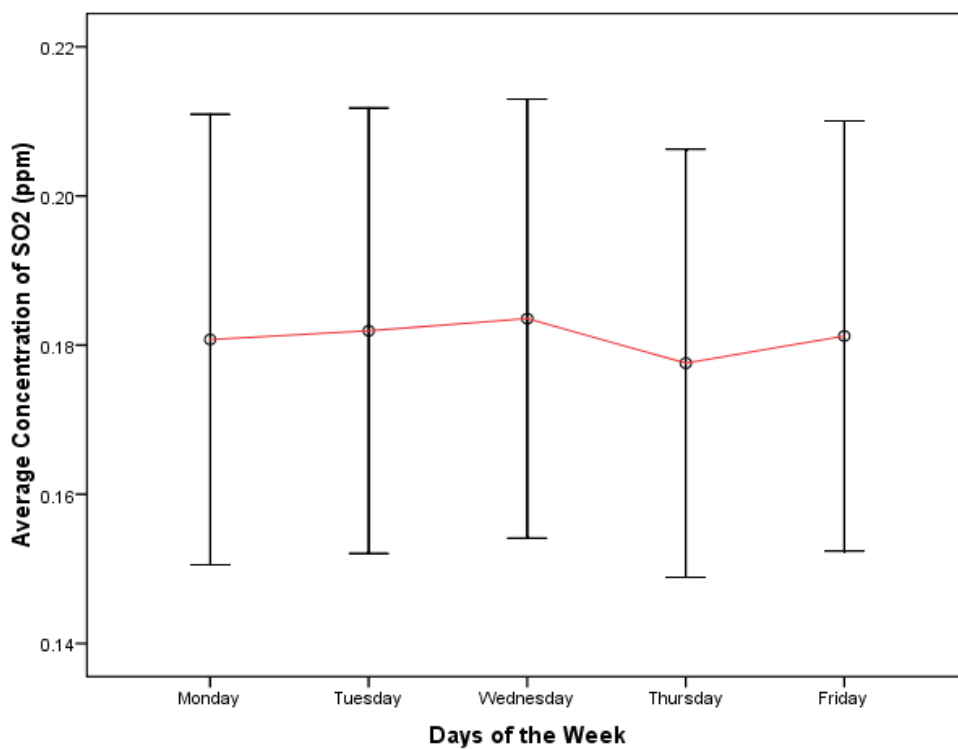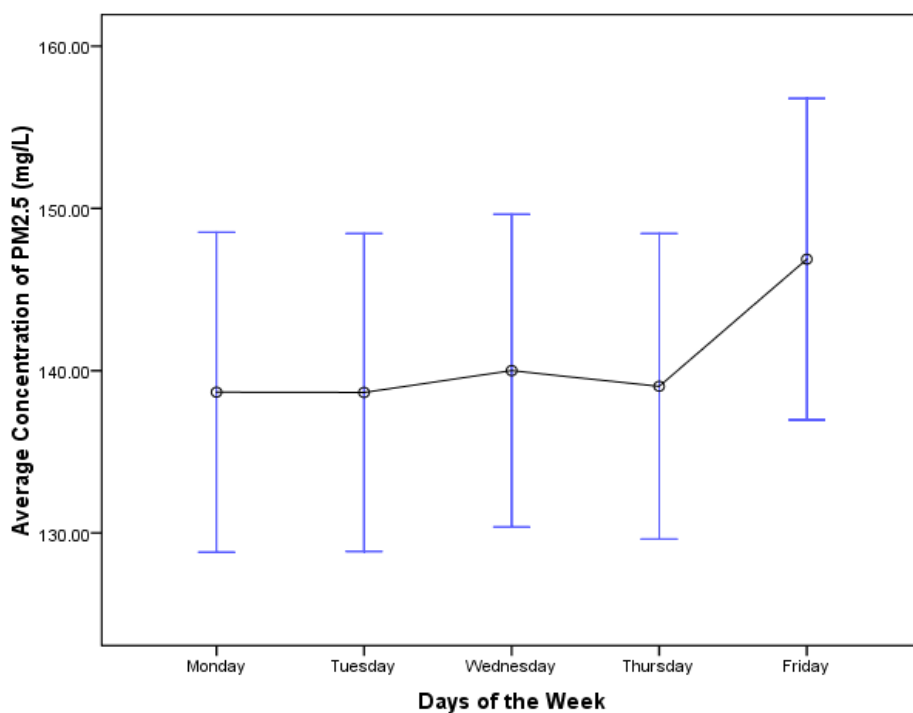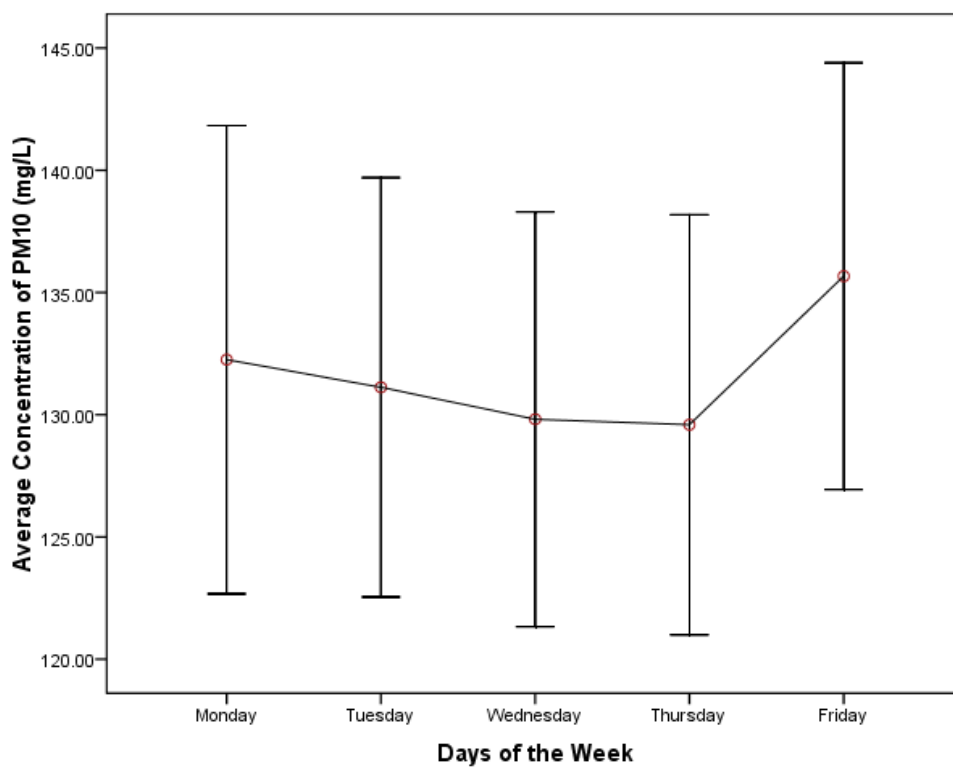**Fig. 5. Daytime variations of traffic volume between 2017 and 2018 in Port Harcourt, Nigeria**

Fig. 6. Days of the week variations of CO concentration between 2017 and 2018 in Port Harcourt, Nigeria
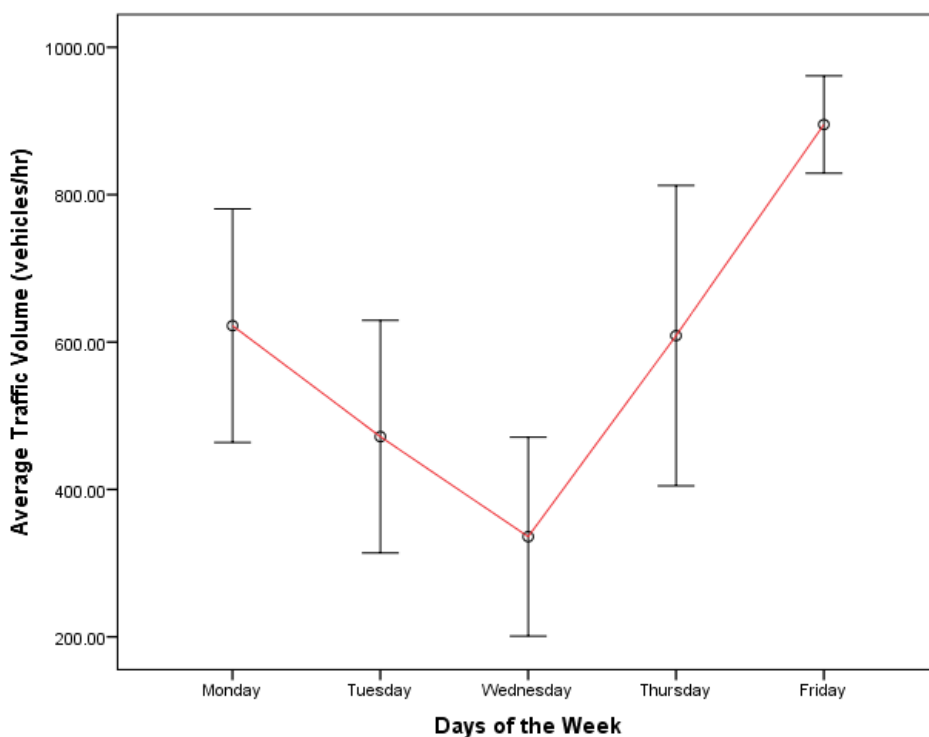

Fig. 7. Days of the week variations of SO$_2$ concentration between 2017 and 2018 in Port Harcourt, Nigeria

Fig. 8. Days of the week variations of PM$_{2.5}$ concentration between 2017 and 2018 in Port Harcourt, Nigeria

Fig. 9. Days of the week variations of PM$_{10}$ concentration between 2017 and 2018 in Port Harcourt, Nigeria

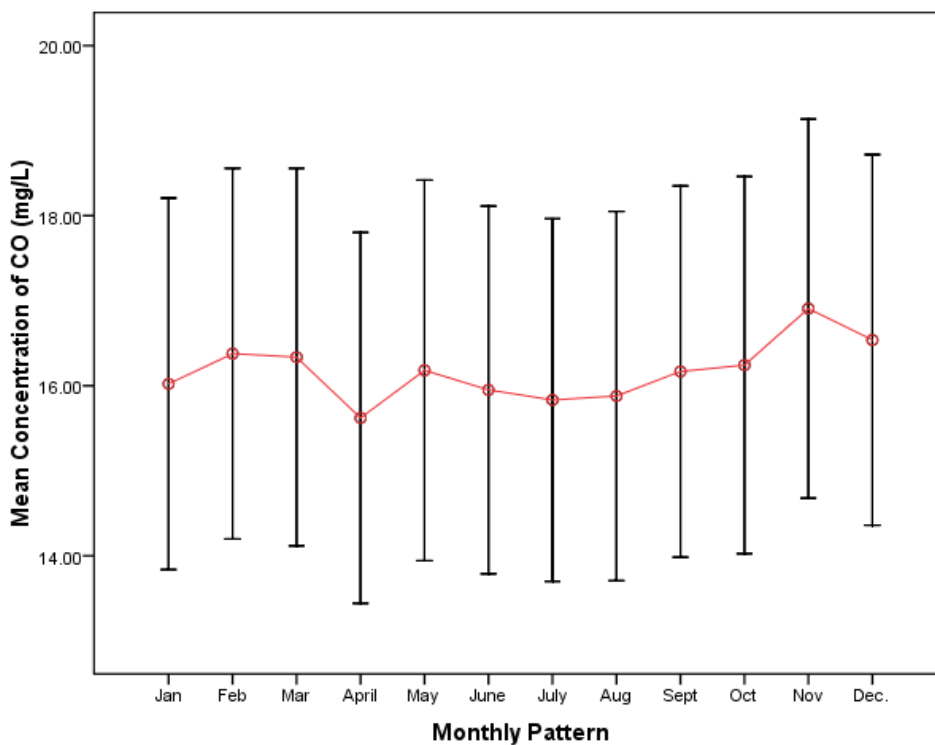**Fig. 10. Days of the week variations of traffic volume between 2017 and 2018 in Port Harcourt, Nigeria**

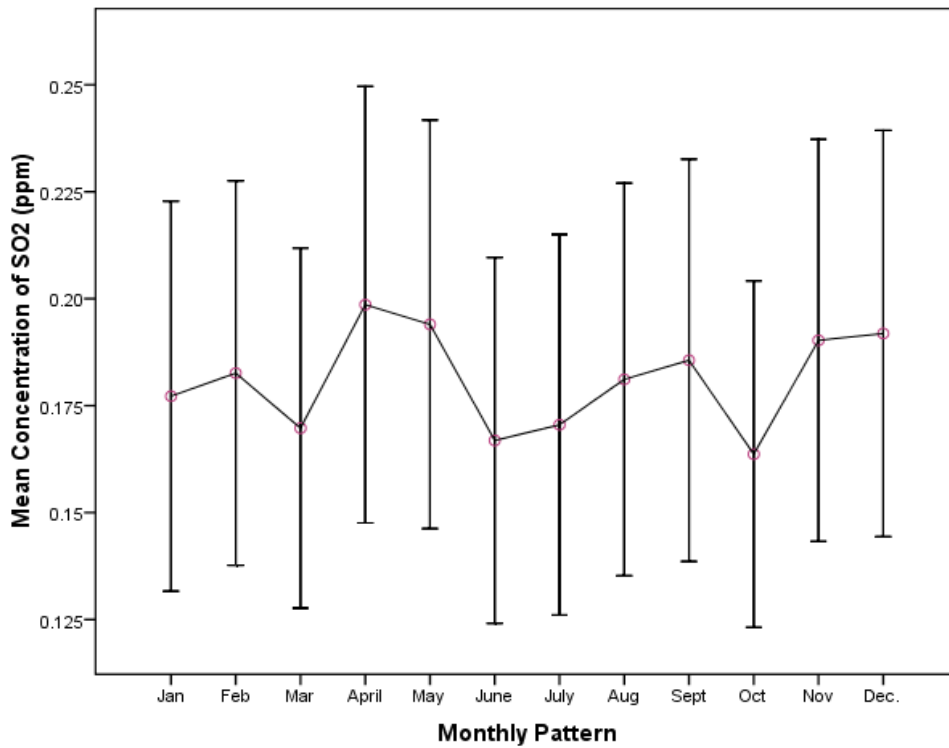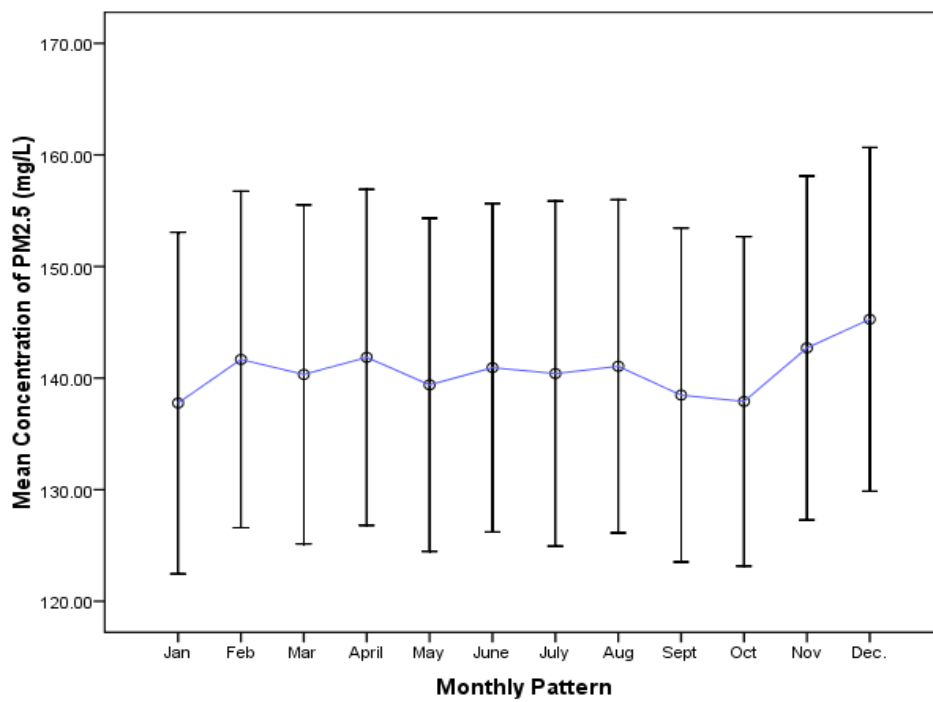**Fig. 11. Monthly variations in CO concentration between 2017 and 2018 in Port Harcourt, Nigeria**

Fig. 12. Monthly variations in SO$_2$ concentration between 2017 and 2018 in Port Harcourt, Nigeria

Fig. 13. Monthly variations in PM$_{2.5}$ concentration between 2017 and 2018 in Port Harcourt, Nigeria
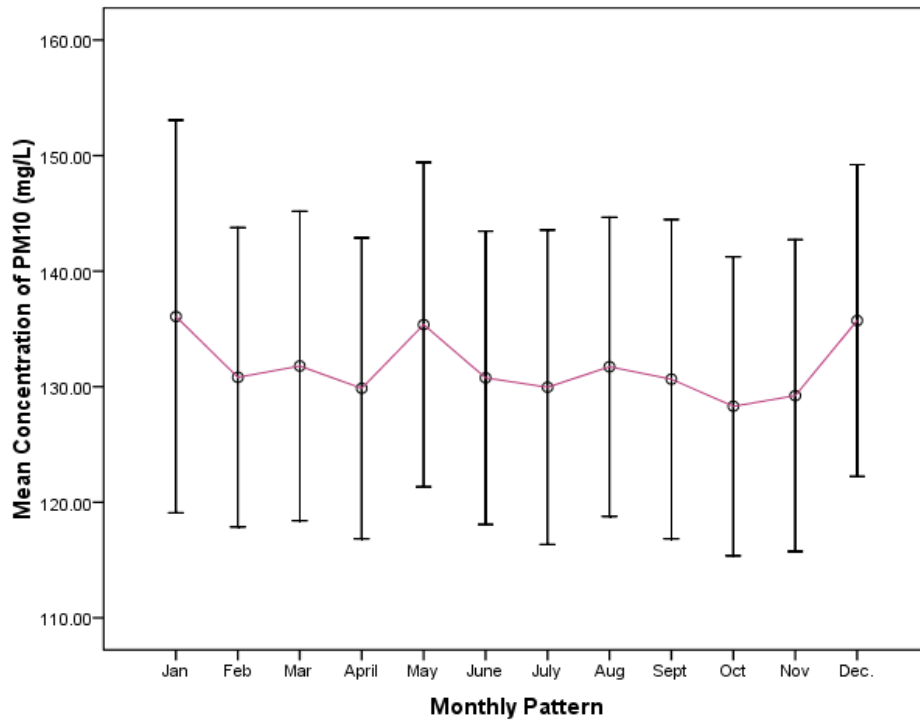
Fig. 14. Monthly variations in PM$_{10}$ concentration between 2017 and 2018 in Port Harcourt, Nigeria
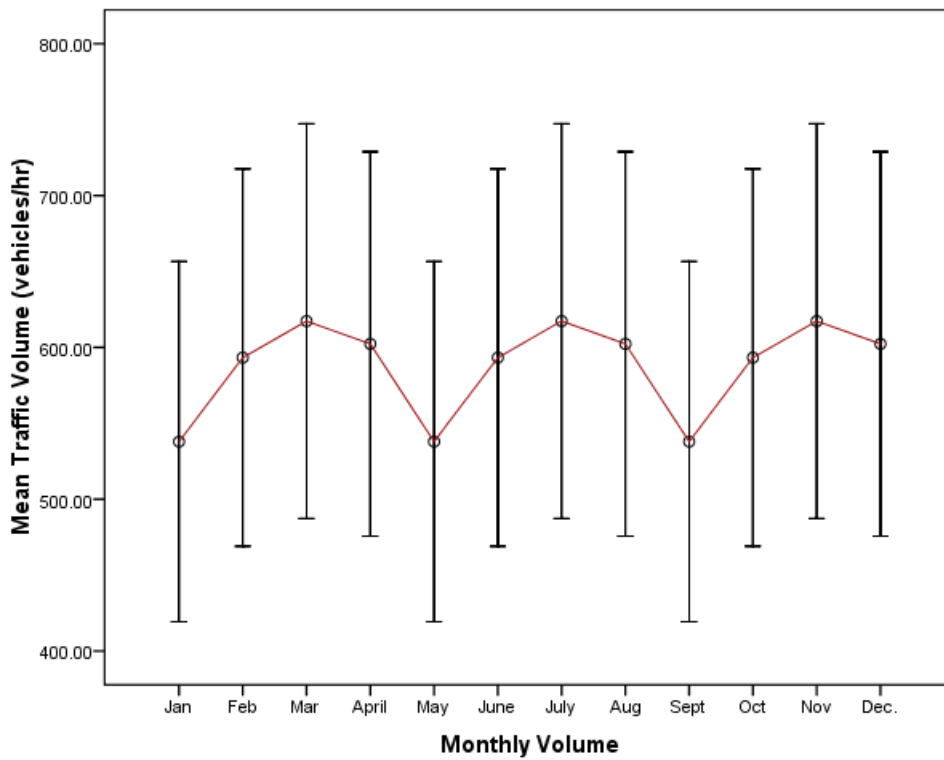

Fig. 15. Monthly traffic volume between 2017 and 2018 in Port Harcourt, Nigeria
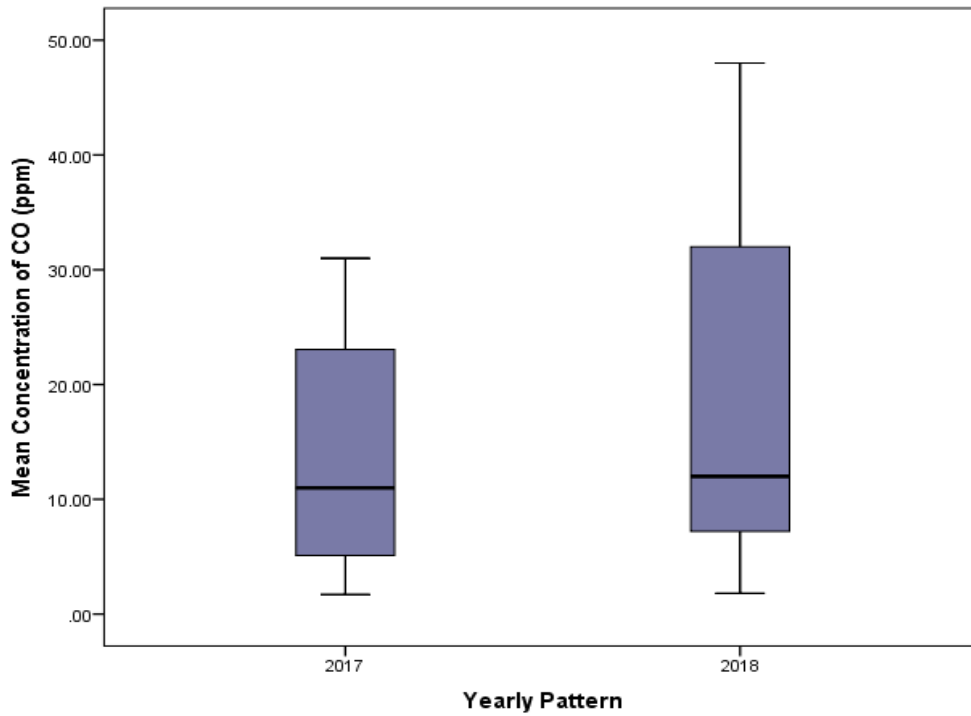
Fig. 16. Annual variations in CO concentration between 2017 and 2018 in Port Harcourt, Nigeria
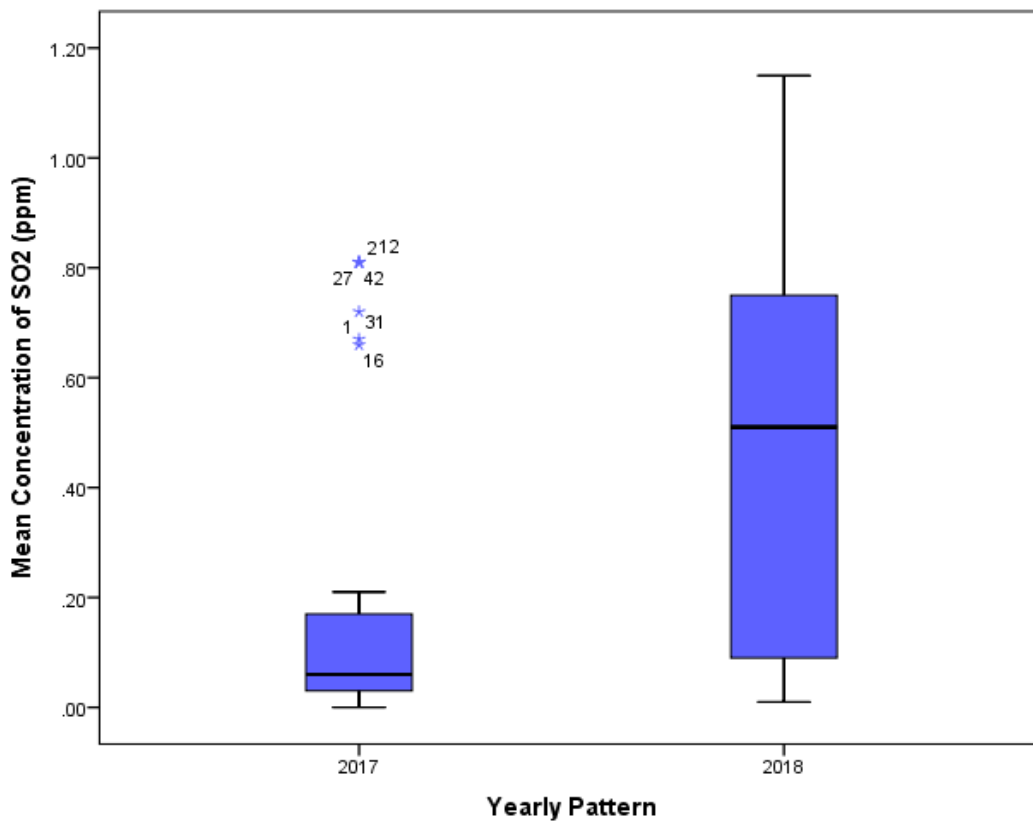

Fig. 17. Annual variations in SO$_2$ concentration between 2017 and 2018 in Port Harcourt, Nigeria
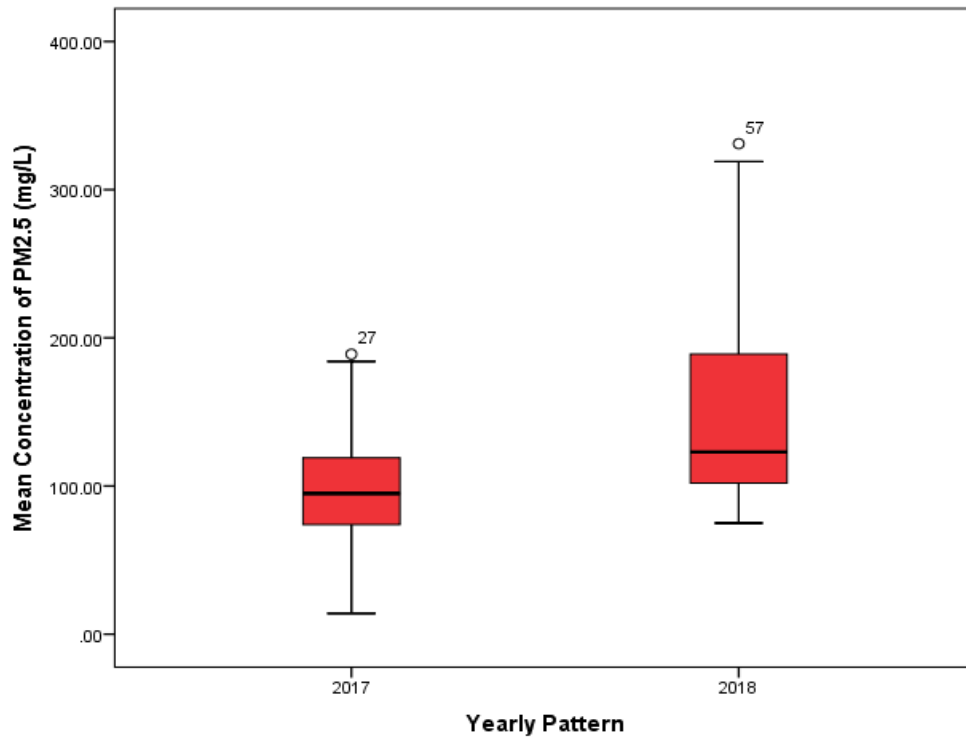
Fig. 18. Annual variations in PM$_{2.5}$ concentration between 2017 and 2018 in Port Harcourt, Nigeria
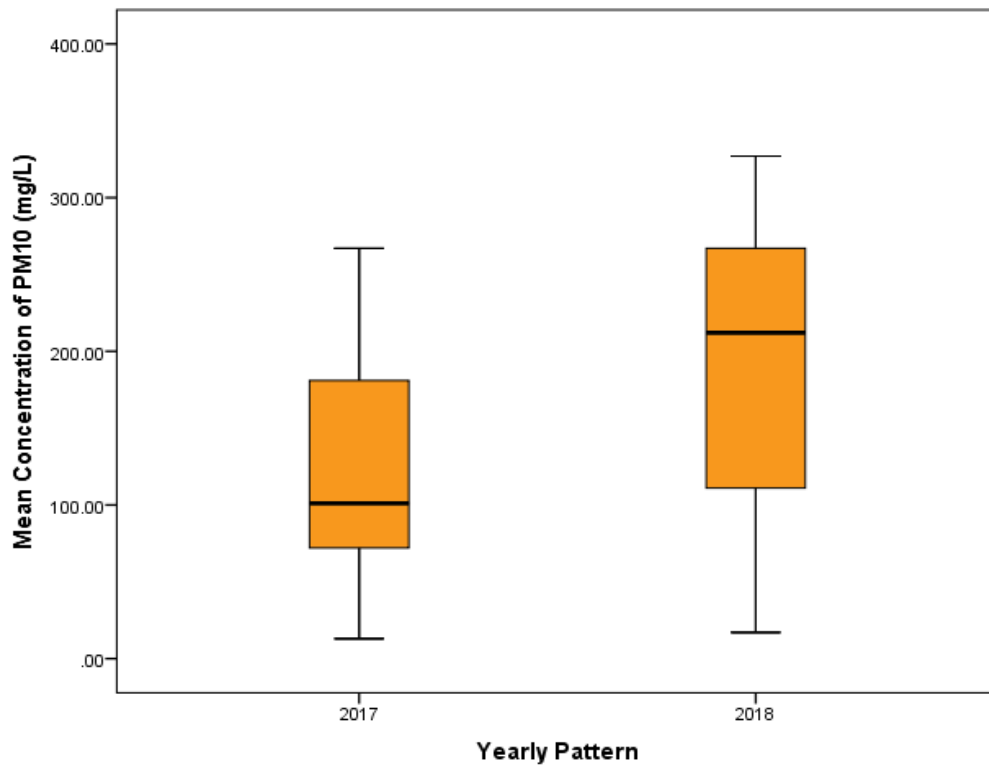

Fig. 19. Annual variations in PM$_{10}$ concentration between 2017 and 2018 in Port Harcourt, Nigeria
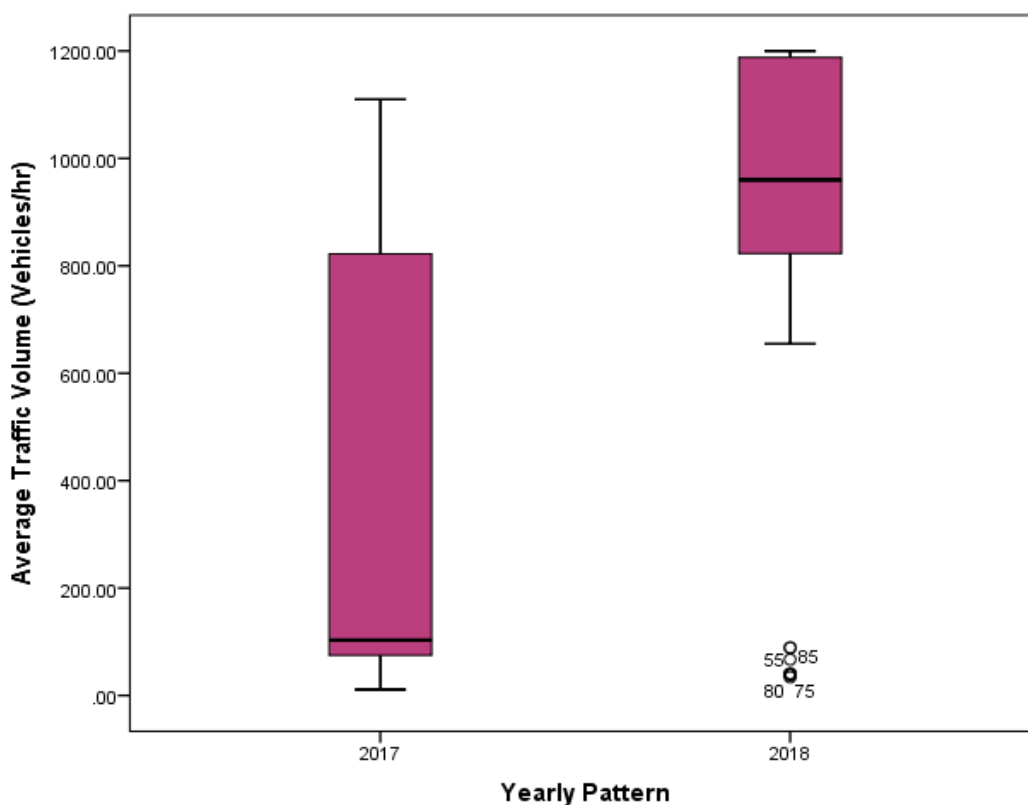
Fig. 20. Annual variations in traffic volume between 2017 and 2018 in Port Harcourt, Nigeria

Table 2 shows the impact of wind speed (WS), air temperature (AT), relative humidity (RH) and traffic volume (TV) on CO concentration in Port Harcourt, Nigeria. CO concentrations increased as air temperature, relative humidity, and traffic volume increased. However, CO was significantly ($P < 0.05$) predicted by relative humidity, air temperature and traffic volume. The coefficient of determination ($R^2 = 0.637$) demonstrated that air temperature, relative humidity, wind speed and traffic volume account for 63.7 percent of the variation in CO concentration.

Table 3 shows the impact of wind speed (WS), air temperature (AT), relative humidity (RH), and traffic volume (TV) on SO2 concentration in Port Harcourt, Nigeria. SO_2 concentrations increased as air temperature, relative humidity, and traffic volume increased. Relative humidity, Air temperature and traffic volume, on the other hand, were all significantly ($P < 0.05$) associated with SO_2. The coefficient of determination (R2 = 0.742) demonstrated that relative humidity, wind speed, air temperature and traffic volume account for 74.2 percent of the fluctuation in SO_2 concentration.

Table 4 shows the impact of relative humidity (RH), wind speed (WS), air temperature (AT) and traffic volume (TV) on $PM_{2.5}$ concentrations in Port Harcourt, Nigeria. $PM_{2.5}$ concentrations increased as wind speed, air temperature and traffic volume increased. Traffic volume, air temperature and wind speed on the other hand, were all found to be significantly ($P < 0.05$) predictive of $PM_{2.5}$. The coefficient of determination ($R^2 = 0.881$) demonstrated that relative humidity, wind speed, air temperature and traffic volume account for 88.1 percent of the variation in $PM_{2.5}$ concentration.

Table 5 shows the impact of wind speed (WS), air temperature (AT), relative humidity (RH), and traffic volume (TV) on PM_{10} concentrations in Port Harcourt, Nigeria. PM_{10} concentrations increased as wind speed, air temperature and traffic volume increased. Traffic volume, air temperature and wind speed, on the other hand, were all found to be significantly ($P < 0.05$) predictive of PM_{10}. The coefficient of determination ($R^2 = 0.798$) demonstrated that relative humidity, wind speed, air temperature and traffic volume account for 79.8% of the variation in PM_{10} concentration.

Table 2. Relationship between AT, WS, RH and TV on Mean Concentration of CO in the Study Areas (2017-2018)

Dependent Variables (Y)	Independents Variables(X)	N	Mean ± SD	T-value	B	P-value	R^2
	Air Temp	1800	25.12±3.99	25.123	2.972	0.004	
CO	Wind Speed	1800	1.39±0.13	-1.836	-0.157	0.874	0.637
	Rel. Humidity	1800	42.40±4.62	-2.455	-0.123	0.024	
	Traffic Volume	1800	592.00±473.00	4.773	0.012	0.000	
Constant				1.331	34.093	0.187	

Table 3. Relationship between AT, WS, RH and TV on Mean Concentration of SO_2 in the Study Areas (2017-2018)

Dependent Variables (Y)	Independents Variables(X)	N	Mean ± SD	T-value	B	P-value	R^2
	Air Temp	1800	25.12±3.99	12.204	0.019	0.000	
SO_2	Wind Speed	1800	1.39±0.13	-0.657	-0.073	0.511	0.742
	Rel. Humidity	1800	42.40±4.62	-2.619	-0.004	0.009	
	Traffic Volume	1800	592.00±473.00	14.540	0.001	0.000	
Constant				4.830	0.852	0.004	

Table 4. Relationship between AT, WS, RH and TV on Mean Concentration of $PM_{2.5}$ in the Study Areas (2017-2018)

Dependent Variables (Y)	Independents Variables(X)	N	Mean ± SD	T-value	B	P-value	R^2
	Air Temp	1800	25.12±3.99	-41.611	-18.802	0.000	
$PM_{2.5}$	Wind Speed	1800	1.37±0.06	3.546	156.115	0.020	0.881
	Rel. Humidity	1800	39.20±4.10	0.752	0.484	0.604	
	Traffic Volume	1800	588.00±763.00	8.712	10.201	0.001	
Constant				2.999	335.222	0.003	

Table 5. Relationship between AT, WS, RH and TV on Mean Concentration of PM_{10} in the Study Areas (2017-2018)

Dependent Variables (Y)	Independents Variables(X)	N	Mean ± SD	T-value	B	P-value	R^2
	Air Temp	1800	25.12±3.99	-22.301	-24.611	0.000	
PM_{10}	Wind Speed	1800	1.37±0.06	5.421	88.002	0.010	0.798
	Rel. Humidity	1800	39.20±4.10	0.752	0.484	0.411	
	Traffic Volume	1800	588.00±763.00	11.306	10.201	0.006	
Constant				5.122	117.112	0.008	

4. CONCLUSION

The investigation found that during the day, the mean concentrations of all pollutants followed a similar pattern in terms of temporal variation and were significantly (P < 0.05) different. Likewise, within the daytime, the mean traffic volume fluctuated greatly and considerably (P < 0.05) between the two research years. The high traffic volume witnessed in Port Harcourt, Nigeria, throughout the morning and evening hours can be attributed to this. It was shown that average traffic volume differed considerably (p < 0.05) between days of the week, implying that the higher increase in pollutant concentrations on Fridays, aside from SO_2, is most likely due to increased traffic volume. Furthermore, in terms of temporal change, all of the pollutants followed a similar pattern, with the lowest concentrations in 2017 and the greatest in 2018. Statistical analysis found that between 2017 and 2018, the concentrations of all air contaminants and traffic volume differed considerably (p < 0.05).

These findings agreed with those of Ojo and Awokola [10] which investigated the effects of traffic volume on air pollution along four major roads in Ogbomosho, South Western Nigeria.

Their findings revealed that the concentration of SO_2, NO_x, CO in all sample locations were higher than regulation standards. They concluded that their study area was highly polluted and attributed this to heavy traffic congestion in the areas. Similar studies in Lagos, Ibadan and Ado - Ekiti in South-west Nigeria also corroborated the findings of this investigation [6]. The study revealed that in each of the cities, the highest concentration of pollutants (CO, NO_2, and SO_2) was recorded in areas where the highest volume of traffic was also recoded. The finding of these studies thus, unequivocally confirmed the positive relationship between pollutants pollution of air and traffic density. Further, the SO_2 observed during the monitoring of vehicular emissions in this study, can be attributed to low quality of fuel and modular oil refineries within the study areas.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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