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IMPACT OF VEHICULAR TRAFFIC ON AMBIENT AIR QUALITY IN SELECTED JUNCTIONS IN PORT HARCOURT, NIGERIA

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ABSTRACT

The increase in the vehicle population in Port Harcourt associated with increase in economic activities has left a scar in ambient air quality. This study investigated the impact of vehicular traffic in selected junction of Port Harcourt city. Air quality survey was conducted using standard analytical protocols Anemometer, and multi-purpose air quality analyzers. The generated results showed that $PM_{2.5}$ and PM_{10} at Garrison, Isaac Boro park, Lagos Bus stop and control were above NAAQS limit of 35.0µg/m^3 and 150.0µg/m^3 respectively. Total suspended particulate matter (TSPM) in Garrison, and Lagos Bus stop were 208.0µg/m^3, and 398.53µg/m^{3}which were above NAAQS limit of 200.0µg/m^3. The other measured parameter including hydrocarbons, CO, N_2O, S_2O were above NAAQS and FMEnv signifying that the ambient air around study areas were polluted. Results of a 2-way analysis of variance (ANOVA) indicated that there was no significant difference at respective sampling locations; but for individual pollutant characteristics there were significant differences at $p<0.05$. Cumulative effects under prolong exposure may result in various chronic health challenges. The study recommended that government should establish vehicular integrity and emission testing centers in Port Harcourt City to reduce air pollution.

Keywords: Ambient, Air Quality, Emission, Chronic, Vehicular, Pollution

INTRODUCTION

The poor traffic flow and congestions are major problems sighted in many cities due to obstructions and increase vehicular population. A study by Kayode (2015), stated that the causes of congestion on road are frequent break-down of vehicle, road traffic crashes, low road network capacity, road condition, narrow lane, and violation of traffic rules.

Most vehicles in Nigeria are driven by fossil fuel which seriously caused ambient air quality degradation, environmental impact and public health problems. The increase in vehicles population in the Port Harcourt city was associated with increase in business and economic activities.

Some researchers have predicted that air pollution in some cities in Nigeria would be nine times worse in 2020. The prediction was based on projected rapid growth in population and the number of vehicles many cities in Nigeria inclusive of Lagos, Kano and Port Harcourt) have witness very recently. The implication of this prediction is that there will more emissions and pollutants in the atmosphere if not controlled (Karlsson, 2004)

Studies have shown that the effect of polluted air from exhaust emissions from increased vehicles, poor integrity automobiles and congestion culminates to public health and climate change (Ojolo, 2007 and Johnson & Hyelda, 2013).Most vehicles today use internal combustion engines which burn gasoline or other fossil fuels during the process of combustion, and subsequently generate a number of gaseous materials and impurities. These combustion by-products (such as un-burnt petrol, carbon monoxide, and hydrocarbon, oxides of nitrogen, lead compounds and smoke) are emitted into the environment as exhaust gases. Previous studies have linked traffic-related air pollution to asthma exacerbation, reduced lung function, respiratory complications and public health (Barber, 1992; Prather, 1995; Gordian, 2006 & Janel, 2013).

Experience also had shown that, some of the problems witness in Port Harcourt could have been better avoided improve road and cities design. The government should have encourage the spread and development of mini cities around the metropolitan city of Port This will help decongest the city and create road facility that eliminate traffic problems. (Disbro & Frame, 1989).

Traffic problem in Port Harcourt could be solved by adopting Samson, (2011) and Inemesit, (2015) methods including better roads network, proper traffic management, public education; and enforcement of traffic laws. Abam & Unachukwu, (2009) and Anukam (2015) collaborated these facts.

Lawrence (2015) stated that the methods to quantify and solve health effects associated with air pollution are available today. Okere *et al* (2003) suggested emission testing all vehicles at the point of renewal and ban on carbureted automobiles as one of the ways of reduction emissions caused by automobiles.

RESEARCH METHODOLOGY

The Study Area

The study areas include Garrison, Isaac Boro Park junction, Lagos Bus stop, and Ibadan street junctions. These areas were selected because they experience daily high traffic density. The location of study area is within N4^{0}48'23.520 and E7^{0}00'41.976". The distances from Garrison to Isaac Boro Park, Lagos Bus stop and Ibadan Street were 4.9km, 11.6Km, and 12.5Km respectively. Map of study area is shown in Figure 1.

Field monitoring were carried between 9.0am to 5.0pm at these different sampling locations in different days. Results of the monitoring were presented in Figure 2 to 4

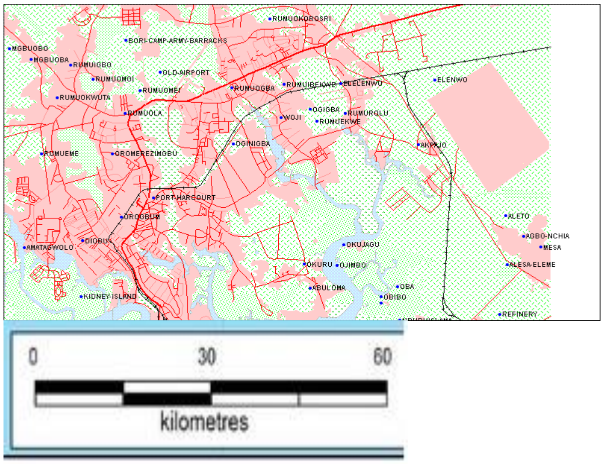

Figure 1: Comprehensive Map of Port Harcourt city, showing major junctions.
(Source: Nairaland, 2017)

Study Instruments

Field instruments used to carry out the air quality measurements were Madur GA-21Plus/Flue gas analyzer (serial no GA-21Plus 21752013; kestrel Anemometer (serial no-Kestred-4500); New Smy Z600, GPS (Wind direction) serial no 21600); HAT $PM_{2.5}$/PM_{10}/TSP meter (serial no cul-HAT 200) and the Aerotrak handheld particle counter 9303. The other instruments mobilized for the measurements include High-volume sampler, Gas chromatography in combination with flame ionization, Gravimetric, Colorimetric, Ultraviolet, spectrophotometer, hydrogen sulfide sensor or H2S sensor, GPA Methods Standard 2285.

The observed field measurements were used evaluate the level of pollution of air by vehicular emission within study location and compare with National Ambient Air Quality Standards (NAAQS) and Federal Ministry of Environment (FMEnv.).

Since the study was to gather basic environmental and public health consequence of criteria pollutants, the study was delimited by time. Therefore, eight (8) hourly bases was spent for field measurement at each selected station for effective cost control and the study satisfied the scope and objectives of study considering traffic variation and effect with time.

The air quality instrument known as Aerotrak handheld particle counter 9303 was used in sample location to analyze air quality. The read off results were recorded as shown in Table1-4.

Two way ANOVA was used as a statistical tool to compare significant of result at $p<0.05$ level of confidence

RESULTS AND DISCUSSION

Results

The results of field monitoring in study areas were presented in Tables 1to 4. Variations with time of parameters including SO_2, NO_2, CO, H_2S, Hydrocarbon; and TSPM, PM_{10} and$PM_{2.5}$ at selected Junctions for study were shown in Figure 2 to 12. The mean values of temperature, wind speed and relative humidity were measured during field measurement and shown in Figures 13; while meteorological wind rose of the area was shown in Figure 14.

Table 1: Average ambient air quality parameters at Garrison Junction

N4⁰48'23.520" E7⁰00'41.976"														
Time (hr)	SO_2 (ppm)	NO_2 (ppm)	CO (ppm)	H_2S (ppm)	C_xH_y(ppm)	NH_3 (ppm)	TSPM (µg/m³)	PM10 (µg/m³)	PM 2.5 (µg/m³)	Noise dB (A)	Wdspd (m/s)	Temp (⁰C)	Rel. Hum (%)	Wind dirct
10:00	1.20	0.05	0.00	1.02	304.01	0.20	192.32	248.01	112.02	78.73	1.04	29.52	89.05	NE
11:00	1.03	0.01	3.10	0.00	202.40	0.11	605.25	521.03	260.04	85.71	1.31	30.71	81.52	NE
12:00	1.15	0.03	4.07	0.03	406.80	0.06	418.46	459.08	225.07	92.03	2.38	31.82	78.72	SE
13:00	0.53	0.06	7.02	0.06	601.20	0.08	98.15	83.09	39.04	87.45	3.25	34.06	69.63	NE
14:00	0.35	0.08	1.04	0.08	404.50	0.31	87.05	78.67	48.05	71.31	1.82	32.21	71.91	SE
15:00	0.61	1.12	4.06	0.01	203.10	0.15	108.20	97.07	57.08	86.29	1.43	33.58	68.33	SW
16:00	1.31	0.05	2.08	0.04	401.50	0.30	69.19	98.08	37.02	75.57	2.57	33.22	65.66	NE
17:00	0.08	0.09	5.01	0.09	609.05	0.21	97.04	79.09	32.05	87.62	1.88	31.05	67.08	NE
Range	1.31-0.08	1.12-0.01	7.02-0.00	1.02-0.00	202.0-608.0	0.31-0.06	605.25-69.19	521.03-78.67	260.04-32.05	92.03-71.31	3.25-1.04	34.06-30.71	89.05-65.66	
Mean	**0.78±** 0.45	0.19±0.38	**3.30± 2.25**	**0.17± 0.35**	**391.57 ± 156.17**	**0.18± 0.09**	**209.46 ± 196.60**	**208.02± 183.60**	**101.30 ±91.20**	**83.09± 7.08**	**1.96±0.74**	**32.02 ±1.56**	**73.99±8.27**	
FMEnv	0.01	0.06	10	NA	NA	NA	250	NA	NA					
NAAQS	0.14	0.1	9	NA	NA	NA	200	150	35					

Note: NA = Not Available

Table 2: Average ambient air quality parameters at Boro Park Junction

N4⁰47'15.240" E7⁰00'09.366"														
Time	SO_2 (ppm)	NO_2 (ppm)	CO (ppm)	H_2S (ppm)	C_xH_y(ppm)	NH_3 (ppm)	TSPM (µg/m³)	PM10 (µg/m³)	PM 2.5 (µg/m³)	Noise dB (A)	Wdspd (m/s)	Temp (⁰C)	Rel. Hum. (%)	Wind dirct
9:15	1.02	0.03	0.04	2.00	401.31	0.02	368.05	356.12	172.11	80.40	0.82	34.56	72.28	NW
10:15	1.03	1.06	4.06	1.00	201.32	0.04	183.08	114.41	55.03	77.80	1.45	33.62	74.47	NW
11:15	1.05	1.01	1.07	0.00	302.40	0.08	48.05	37.56	19.02	78.60	1.87	35.28	68.88	NW
12:15	0.05	0.02	5.01	0.00	603.06	0.03	114.09	100.23	50.19	75.50	1.56	38.98	64.83	NE
13:15	1.04	1.08	5.03	1.00	403.30	0.04	119.14	113.15	56.89	70.50	1.19	37.97	56.29	NW
14:15	0.06	1.09	2.07	0.00	202.05	0.06	124.23	115.03	59.03	73.40	1.82	39.52	57.56	SE
15:15	1.06	0.21	4.31	0.00	405.08	0.05	98.02	84.45	35.82	81.20	2.45	37.56	58.99	NE
16:15	0.08	0.05	2.09	0.00	103.14	0.03	119.31	102.12	66.08	72.00	1.25	34.15	71.45	SW
Range	1.05-0.05	1.09-0.02	5.03-0.04	0.0-2.0	603.60-103.14	0.08-0.02	368.05-48.05	356.12-37.56	172.11-35.82	70.5-80.4	2.45-0.82	39.52-33.62	74.47 - 56.29	
Mean	**0.67± 0.51**	**0.57± 0.53**	**2.96± 1.90**	**0.50± 0.76**	**327.71± 158.46**	**0.04± 0.02**	**146.75±96.73**	**127.88 ± 95.71**	**64.27± 46.07**	**76.18 ±3.95**	**1.55± 0.50**	**36.46± 2.32**	**65.59 ±7.21**	
FMEnv	0.01	0.06	10	NA	NA	NA	250	NA	NA					
NAAQS	0.14	0.1	9	NA	NA	NA	200	150	35					

Note: NA = Not Available

Table 3: Average ambient air quality parameters at Lagos Bus stop Junction

N4⁰45'46.60" E7⁰01'07.919"														
Time	SO_2 (ppm)	NO_2 (ppm)	CO (ppm)	H_2S (ppm)	C_xH_y (ppm)	NH_3 (ppm)	TSPM (µg/m³)	PM_{10} (µg/m³)	$PM_{2.5}$ (µg/m³)	Noise dB (A)	Wdspd (m/s)	Temp (⁰C)	Rel. Hum. (%)	Wind dirct
9:00	1.31	0.09	4.07	0.03	601.23	0.01	413.02	287.04	131.02	75.02	1.21	31.63	78.32	SW
10:00	0.02	0.05	25.08	0.05	802.87	0.02	488.04	346.03	157.04	77.51	1.44	32.22	69.52	NE
11:00	0.23	1.06	32.09	0.07	603.08	0.01	241.05	178.05	86.02	83.56	1.12	34.81	61.23	NE
12:00	0.32	0.07	20.05	0.08	400.97	0.03	116.12	99.03	49.21	78.81	2.02	35.92	58.65	NE
13:00	1.33	0.08	7.09	0.10	306.45	0.04	1069.03	108.21	541.12	75.83	2.23	36.54	57.83	NE
14:00	0.05	1.09	12.08	0.12	523.07	0.01	385.02	371.05	161.13	79.14	1.25	37.91	56.26	SW
15:00	2.06	0.04	3.08	1.01	243.06	0.05	287.05	212.08	112.08	89.12	1.19	33.13	60.54	SE
16:00	0.04	0.08	14.02	0.02	406.56	0.01	213.05	167.12	79.02	79.23	3.01	33.85	66.09	NW
Range	2.06-0.02	1.09-0.05	32.09-3.08	0.12-0.02	802.87-243.06	0.05-0.01	1069.03-116.12	371.05-212.08	541.12-49.21	89.12-75.02	3.01-1.12	37.91-31.63	78.32-56.26	0
Mean	**0.67± 0.51**	**0.32± 0.47**	**14.70± 10.70**	**0.19± 0.34**	**485.91± 182.66**	**0.02± 0.02**	**401.55± 292.03**	**221.08± 103.46**	**164.58± 157.00**	**79.78 ± 4.58**	**1.68± 0.68**	**34.50 ± 2.19**	**63.56 ± 7.41**	Not determined
FMEnv	0.01	0.06	10	NA	NA	NA	250	NA	NA	90	0	25	Nil	Nil
NAAQ	0.14	0.1	9	NA	NA	NA	200	150	35	85	**0**	25	Nil	Nil

Table 4: Average ambient air quality parameters at (Ibadan Street) Control Junction

N4⁰45'25.481" E7⁰02'02.004"														
Time	SO_2 (ppm)	NO_2 (ppm)	CO (ppm)	H_2S (ppm)	C_xH_y (ppm)	NH_3 (ppm)	TSPM (µg/m³)	PM_{10} (µg/m³)	$PM_{2.5}$ (µg/m³)	Noise dB (A)	Wdspd (m/s)	Temp (⁰C)	Rel. Hud. (%)	Wind dirct
9:30	0.00	0.01	0.00	0.00	201.02	0.00	483.09	324.09	146.10	55.85	0.81	28.33	84.62	SW
10:30	0.01	0.03	0.00	0.01	0.02	0.01	368.13	227.08	115.02	53.71	1.02	28.72	83.04	SW
11:30	1.04	0.07	1.00	0.01	101.07	0.02	466.98	319.08	213.09	60.13	0.81	28.62	80.11	SE
12:30	0.02	1.08	0.05	0.02	0.08	0.07	357.40	265.06	119.21	57.64	1.43	29.68	75.77	SE
13:30	0.04	0.05	2.06	0.03	402.40	0.10	289.10	215.20	110.04	62.09	2.06	31.34	68.08	NE
14:30	0.03	0.80	0.20	0.02	0.06	0.04	120.60	111.60	97.41	48.02	1.77	33.56	64.25	SW
15:30	1.01	0.04	0.06	1.02	0.09	0.12	131.09	171.23	85.21	53.61	0.92	34.69	56.79	SW
16:30	0.10	0.01	0.08	0.01	0.18	0.01	221.13	151.40	76.01	60.89	1.49	33.58	57.36	NW
Range	0.0-1.0	0.0-1.0	2.06-0.05	1.02-0.00	402.40-0.20	0.12-0.00	466.98-120.60	319.08-111.60	213.09-76.01	62.89-48.02	2.06-0.81	34.69-28.62	84.62-56.79	NW
Mean	**0.28± 0.46**	**0.26± 0.43**	**0.43± 0.74**	**0.14± 0.36**	**88.12± 146.00**	**0.05± 0.05**	**304.69± 139.50**	**223.09± 77.01**	**120.26± 43.30**	**56.49 ± 4.68**	**1.29± 0.47**	**31.07 ±2.58**	**71.25± 11.20**	NW
FMEnv	0.01	0.06	10	NA	NA	NA	250	NA	NA	0	25	Nil	Nil	Nil
NAAQS	0.14	0.1	9	NA	NA	NA	200	150	35	**0**	25	Nil	Nil	Nil

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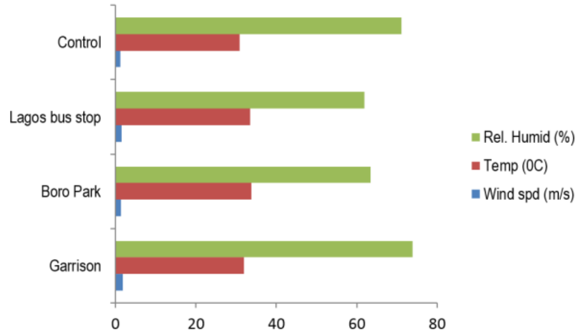

Figure 2: Mean values of temperature, Wind Speed and Relative Humidity at monitored Junctions

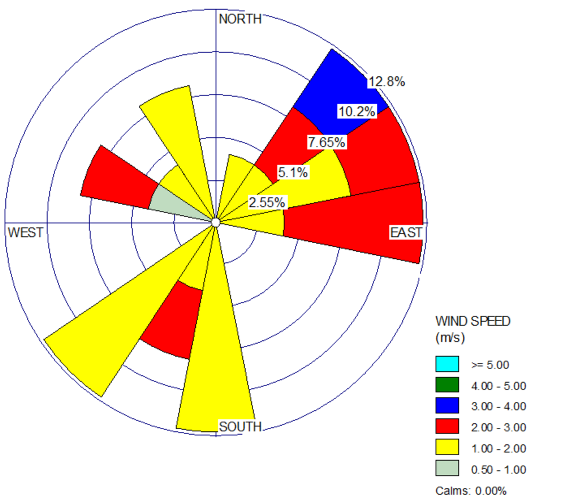

Figure 3: Wind Rose showing Wind Directions monitored at the Junctions

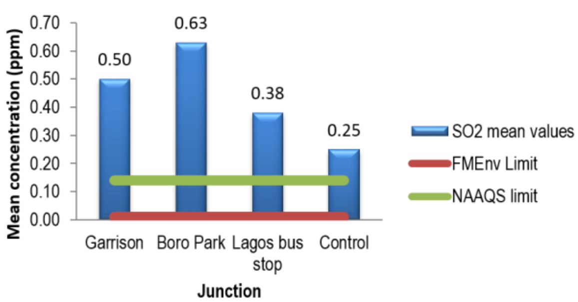

Figure 4: Mean concentrations of SO_2 at sample stations

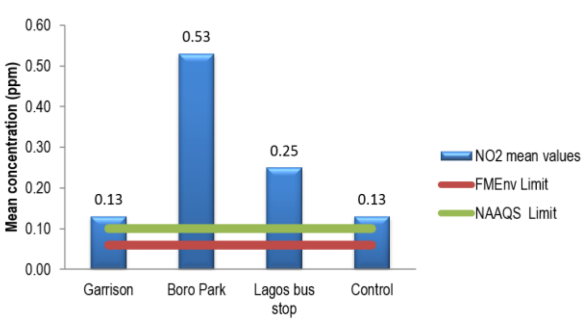

Figure 5: Mean concentration of NO_2 at sample stations

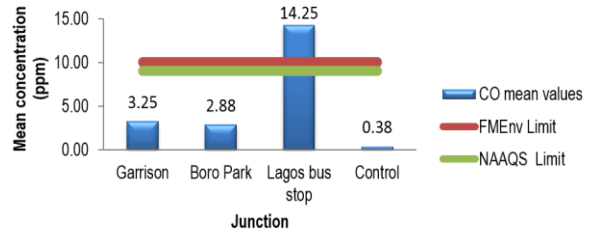

Figure 6: Mean Concentration of CO at sample stations

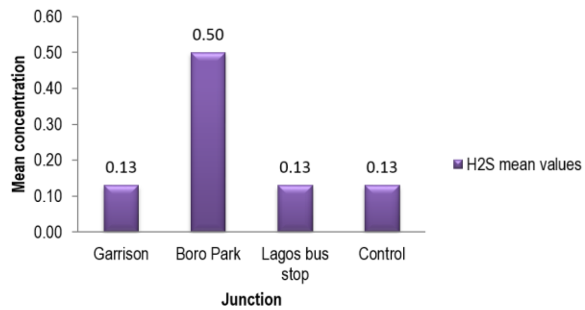

Figure 7: Mean concentration of H_2S at sample stations

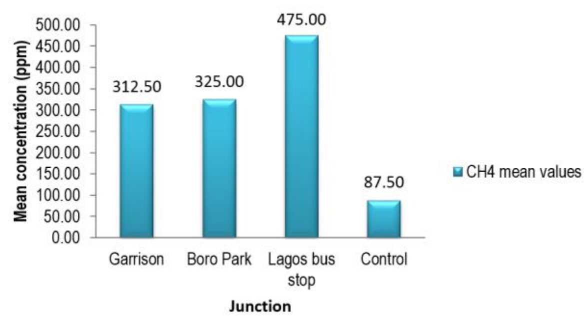

Figure 8: Mean concentrations of Hydrocarbon at sample stations

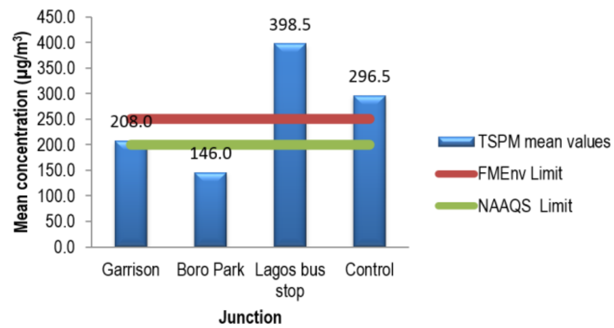

Figure 9: Mean concentration of TSPM at Sample Stations

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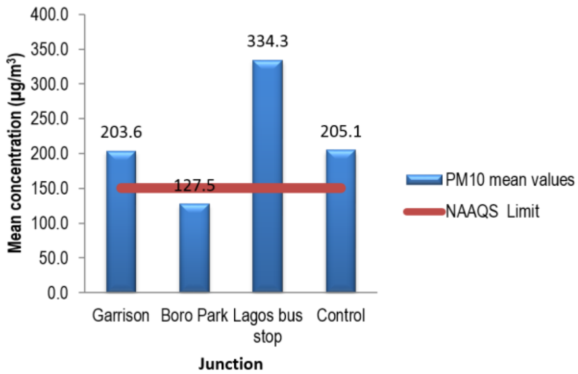

Figure 10: Mean concentration of PM_{10} at Sample Station

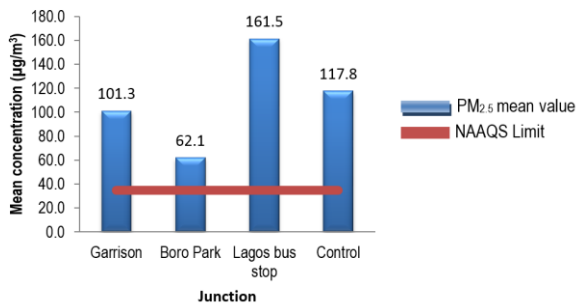

Figure 11: Mean Concentration of $PM_{2.5}$ at sample stations

Table 5: A 2-way ANOVA without replication for Garrison pollutants Concentration

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	135043.2	7	19291.89	1.799179	0.10552989	2.1781556
Columns	1261821	8	157727.7	14.70983	2.5321E-11	2.1086885
Error	600465.9	56	10722.61			
Total	1997331	71				

ANOVA= Analysis of Variance; SS= Sum of Squares; df= degree of freedom; MS= Mean Squares

Table 6: A 2-way ANOVA without replication for Boro Park pollutants Concentration

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	180108.7	7	25729.81	1.581681	0.159906	2.178156
Columns	2311299	8	288912.4	17.76022	7.5E-13	2.108688
Error	910973.6	56	16267.38			
Total	3402381	71				

ANOVA= Analysis of Variance; SS= Sum of Squares; df= degree of freedom; MS= Mean Squares

Table 7: A 2-way ANOVA without replication for Lagos Bus Stop pollutants Concentration

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	180108.7	7	25729.81	1.581681	0.159906	2.178156
Columns	2311299	8	288912.4	17.76022	7.5E-13	2.108688
Error	910973.6	56	16267.38			
Total	3402381	71				

ANOVA= Analysis of Variance; SS= Sum of Squares; df= degree of freedom; MS= Mean Squares

Table 8: A 2-way ANOVA without replication for Ibadan Street pollutants Concentration

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	84048.09	7	12006.87	2.613691	0.020826	2.178156
Columns	835434.5	8	104429.3	22.73249	5.36E-15	2.108688
Error	257254.8	56	4593.836			
Total	1176737	71				

ANOVA= Analysis of Variance; SS= Sum of Squares; df= degree of freedom; MS= Mean Squares

Discussion

The study investigated the impacts of vehicular traffic on public health at selected junctions in Port Harcourt city, Rivers State.

Figure 4 showed that SO_2 at Garrison, Isaac Boro Park, Lagos Bus stop and Ibadan Street junction (control) were 0.50ppm, 0.63ppm, 0.38ppm and 0.50ppm as against NAAQS limit of 0.10 and FMEnv limit of 0.20 respectively.

Figure 5 showed that N_2O at Garrison, Isaac Boro Park, Lagos Bus stop and control were 0.13ppm, 0.53ppm, 0.25ppm and 0.13ppm respectively as against NAAQS limit of 0.10ppm and FMEnv limit of 0.10.

Figure 6 indicated that CO at Garrison, Isaac Boro Park, Lagos Bus stop and control were 3.25ppm, 2.88ppm, 14.25ppm and 0.38ppm respectively as against NAAQS limit of 4.00ppm and FMEnv limit of 6.00ppm.

Figure 7 showed that H_2S, at Garrison, Isaac Boro Park, Lagos Bus stop and control were 0.13ppm, 0.50ppm, 0.13ppm and 0.13ppm.

Figure 8 indicated that Hydrocarbon at Garrison, Isaac Boro Park, Lagos Bus stop and control were 312.5ppm, 325ppm, 475ppm and 87.5ppm.

Figure 9 showed that Total Suspended Particulate Matter (TSPM) at Garrison, Isaac Boro Park, Lagos Bus stop and control were 208.0µg/m3, 146.03µg/m^3, 398.53µg/m^3 and control 296.5ug/m3 respectively as against NAAQS limit of 200.0µg/m3.

Figure 10 showed that the mean concentration of PM_{10} at Garrison, Boro Park, Lagos Bus stop and control were 203.6µg/m3, 127.5µg/m3, 343.3µg/m3 and 205.1µg/m3 respectively, as against NAAQS permissible limit of 150µg/m3.Boro Park was the only station below the prescribed limit indicating that other sample stations were contaminated above NAAQS limit.

Figure 11 showed that $PM_{2.5}$ at Garrison, Boro Park, Lagos Bus Stop and sample control station were 101.3µg/m3, 62.1µg/m3, 161.5µg/m3 and 117.8µg/m3 respectively.

This indicated that the measured parameters at these stations were all above NAAQS permissible limit of 40.0µg/m3. Table 5-8 showed the statistical analyzes of a 2-way at Garrison junction, Boro Park, Lagos Bus stop and Ibadan. ANOVA determined that there was no significant difference at the respective sampling points at Garrison junction but for individual pollutant characteristics, there was a significant difference using the 0.05 probability level. These statistical analyses indicated that differences among the pollutant characteristics are statistically significant. There was also no significant difference at the respective points at Boro Park junction, while individual pollutant characteristics recorded significant difference ($P<0.05$). At Lagos Bus Stop, there was no significant difference at the various sampling points. But same significant difference was evaluated for individual characteristics. The control was not influenced significantly at the sampling points, while the individual pollutant characteristics were influenced and statistically significant.

Extreme concentration thresholds of air pollutants have been elevated to have broad harmful consequences on human health (Ambient air quality standards for criteria pollutant established by USEPA, 1991; Leton, 2007; Allen *et al*., 2009; Enotoriuwa *et al*., 2016). From the results of field survey and data analysis, the study concluded that congestion and vehicular traffic observed at Garrison, Isaac Boro Park and Lagos Bus stop junctions were the major cause of air pollutants in the area. Also, the average concentration of Sulphur dioxide (SO_2), Nitrogen dioxide (NO_2), Carbon monoxide (CO), Hydrocarbon, and Particulate Matters (such as TSPM, PM_{10} and $PM_{2.5}$) were relatively high due to partially burnt emission from exhaust smoke which may constitute a health risk (see Table 1- 4).

Overall results of ambient air quality parameters in the study area were above Federal Ministry of Environment (FMEnv) and National Ambient Air Quality Standard (NAAQS) indicating that the public in the study areas were exposed to high concentrations of air pollutants

Recommendations

The study recommends that government should enact stringent laws against indiscriminate parking of vehicles along major roads; establishment of emergence road task force, motor vehicle integrity check, the production and use of cleaner fuel with low sulphur. The study also, advises further research to evaluate the degree of public health impacts by vehicular traffic and emissions at selected busy road junctions in Port Harcourt city.

REFERENCES

Abam, F. I. and Unachukwu G. O(.2009).Vehicular Emissions and Air Quality Standards in Nigeria. *European Journal of Scientific Research*, 34(4):550-560

Allen, R. W., Criqui, M. H., Diez-Roux, A. V., Allison, M., Shea, S. (2009). Fine particulate air pollution, proximity to traffic, and aortic atherosclerosis: the multiethnic study of Atherosclerosis. *Epidemiology*, 20(2): 254-264.

Anukam.L. (2015). Air Quality Monitoring and Management Challenges. DG/CEO NESREA Stakeholders' Workshop on Air Quality and Transportation Challenges in Nigeria. Agenda for Clean Air Action Plan,3rd November.

Barber, A. (1992). *Handbook of noise and vibration control*.6th edition, Elsevier Advanced technology, Oxford, UK.

Disbro, J. E and Frame, M. (1989).Traffic flow theory and chaotic behavior.*Transportation research record*, 1225; 109-115.

Enotoriuwa, R. U., Nwachukwu, E. O., Ugbebor, J. N. (2016). Approaches to Air Quality Assessment: A Tool for Advancement of Air Quality Policy. *International Journal of Research in Engineering and Science*, 4(6): 37-42.

Inemesit, U. (2015) 4 things need to control in Nigeria.Published 31.08.2015.Available in http://www.pulse.ng. Retrieved 11/13/18.

Gordian M.E, Haneuse S, Wakefield J. (2006).An investigation of the association between traffic exposure and the diagnosis of asthma in children. *Journal of Expo Science Environment Epidemiology*, 16:49–55.

Johnson A. and Hyelda A (2013).Assessment of Vehicular Emission and Health Impacts in Jos Plateau State.Journal of Research in EnvtalSciand Toxicology.pp80- 86.

Janel, H (2013).Potential health effects of noise exposure. Public health Madison and Dane county. Retrieved on 11/13/2013 from:
https://www.publichealthmdc.com/documents/NoiseHealthEffectsReport.pdf

Karlsson, L (2004). Ammonia, Nitrous oxide and hydrogen cyanide Emissions from five passenger vehicles.*Science of the total environment*.334 / 335.125-132.

Kayode, O. (2015). Evaluative Traffic Congestion in developing Countries. A case study of Nigeria. Paper presented at *the 2015 Chartered Institute of Logistics and Transport (CILT) Africa Forum Held at Mount Meru Hotel, Arusha, Tanzania 2015: 1-28.*

Lawrence, C. (2015). Air quality monitoring and management challenges. Stakeholders' workshop on Air quality and transportation challenges in Nigeria. Agenda for clean Air action plan.

Leton, T.G. (2007) *Pollution control engineering (selected topics),* pearl publishers Port Harcourt, Nigeria.Pp 101, 138-140

Ojolo, S (2007). A survey on the effects of vehicle emissions on human health in Nigeria. Department of Mechanical Engineering, University of Lagos, Nigeria.

Okere G. Nwachukwu. K,.Ezebuiro,V.(2003).Alternative Automobile Pollution Control Policies: Perspective of Motorists in Owerri Municipal of Imo State, Nigeria. *Journal of Educational and Social Research*, Vol.3 No. 4:1-12.

Prather, M. J. (1995). Time scales in atmospheric chemistry: Theory, GWP's for CH and CO, and runaway growth.*Geophysical Research Letters*, 23 (19): 2597-2600

Samson, T. A. (2011). Traffic Jams in Port Harcourt city. The tide, May, 8, 2011

Ugbebor J. N., Raphael, Yorkor B., (2015). Measurement and Evaluation of Road Traffic Noise in Three Selected Junctions in Port Harcourt Metropolitan, Nigeria *Journal of Environmental Science, Computer Science and Engineering & Technology*, Vol.4. No.2: 1-10.

U.S.EPA (1991) National air quality and emissions trends report, 1990. U.S. Environmental protection agency, office of air quality planning and standards research triangle park NC 27711, EPA-450/4-91-023.