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Full Length Research

Health and Environmental Effects of Vehicular Traffic Emission in Yenagoa City Bayelsa State, Nigeria

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The study was conducted in Yenagoa city to examine the health and environmental effects of vehicular traffic emission in the city. The study adopted experimental and survey research method. Measurements were done for air quality parameters of interest which are PM_1,$PM_{2.5}$,PM_7, PM_{10}, TSP, NO_2, SO_2 and CO. Hospital records from 2015-2018 of ailments associated with air pollution were used to identify the impact of air pollution on the health of inhabitants. Anova was used to test the hypothesis of the study. The findings of the study showed that CO was the most prevalent pollutant in the study area, and that pollutant concentration varies with time and location. It was also found that traffic volume has a correlation with pollutant concentration, CO as a pollutant amongst others had high significant relationship with traffic count in Yenagoa City. Study revealed that vehicular traffic pollution has effects on the health of the people, having a high amount of persons who have suffered from different air pollutant based ailments in the area, with URTI as the ailment with the highest respondents all through the four year. Study recommends regular vehicular checks on emission limits to be enforced and subsequent withdrawal of such high emission vehicles off the road to stem the pollution of the environment. The implementation of such traffic rule will greatly rid of the environment of noxious pollutants from automobiles and engender a pollution free environment.

Key words: Health, Environmental, Effects, Vehicular, Emissions, Yenagoa.

INTRODUCTION

Vehicles are indispensable part of modern mode of transportation especially in the city centers. There is an increasing concern about its environmental impact, particularly the negative effects of pollutants from vehicular emissions into the atmosphere (Rowland, 2011). Human exposure to air pollution especially in the major cities are of different scale and have varying health effects, ranging from lungs, heart and kidney diseases etc, (Brunekreef and Holgate, 2015). According to (WHO, 2010) report on the health related air pollution cases, it revealed that most death cases in Switzerland, Austria and France were attributed to lungs, heart and kidney diseases which were traced to air pollution. In the United State and Europe, statistics has shown that motor vehicles are the main contributors to air pollution problems (NAS, 2002). In some developed and developing countries with high population densities and high vehicular traffic activities such as Bangkok, Mexico, Lagos, Abuja, Port Harcourt and Bayelsa States in Nigeria, air pollution has been implicated for the recent soot and smog observed in the environment and all arising from vehicular emissions and other anthropogenic sources (Achalu, 2017). In Nigeria, the government policy on air pollution has targeted the control and management of traffic congestion, with little concern on vehicular emission evaluation. The dearth of information on the effects of vehicular emissions in Yenagoa Bayelsa State is the focus of this study (Ndoke and Jimoh, 2005). Yenagoa city is the capital of Bayelsa State in Nigeria. The city being the only developing city has experienced increase in population as well as in vehicular traffic and emissions. The situation has resulted in the presence in the atmosphere air pollutants in the city and its environs. The study will examine the effects of vehicular traffic emission in Yenagoa city, to evaluate the health related impact on the inhabitants and the environment.

Aim and Objectives of the Study

The aim of this study was to examine the health and environmental impact of vehicular emissions in Yenagoa city, Bayelsa State.

The specific objectives are to:

1. Determine the composition and concentration of vehicular pollutants in the major traffic junctions in Yenagoa.
2. Evaluate the spatial variation in pollutant concentration in the different sample location.
3. Establish the effect of air pollution and vehicular traffic congestion/emission in Yenagoa city on inhabitants.
4. Determine the health effect of vehicular emission on residents in the study area.

Hypotheses Statement

1 There is no statistically significant variation in pollutants concentration in the different sample locations.

2 There is no statistically significant relationship between traffic volume and vehicular emission concentration in the study area.

Method of Study

The study adopted the experimental as well as survey research methods. The secondary data includes hospital records of ailments within the study area arising from air pollutants along traffic corridors and also to determine the effect of vehicular emission on health of residents using secondary data from selected hospitals within the study area. The purposive sampling technique was adopted to select six high traffic intersections (junctions) zones in Yenagoa City. The six (6) nodes selected were Tombia/Imiringi roundabout, Opolo/Elebele Junction, Otiotio junction, INEC junction, Old Azikoro junction, and Azikoro junction Table 1 below and Figure 1 below.

Data collection and Results

The pollutants measured were Nitrogen dioxide (NO_2), Sulphur dioxide (SO_2), Carbon monoxide (CO), and Particulate matter (PM). The samples were collected to cover a period of five days of the week (Monday-Friday). The data on health related ailment from the hospital covered a period of three years Table 2 below.

The Table 3 below shows vehicular emission concentration at morning peak period at six locations in the study area. The result shows that PM1 has the lowest concentration amongst all the sampled pollutants for the sample point A area which was the Tombia/Imiringi Road by Melford Okilo road, it also showed that CO has the highest concentration of pollutants in the area. Furthermore, the table also reveals the vehicular emission concentration for sample point B in the morning peak, the result also shows that amongst other pollutants that were analyzed for the study, PM_1 had the lowest concentration of vehicular emission with a value of 0.001mg/m^3 while CO was more concentrated in the area amongst others with a value of 14.701 mg/m^3. These are graphically represented below in Figures 2 and 3. At Otiotio road by Melford Okilo Road which was designated as sample point C in the morning peak, the result shows that PM_1 has the lowest concentration amongst all the sampled pollutants in the area, it also showed that CO has the highest concentration of pollutants in the area.

At INEC road by Melford Okilo road, sample point D in the morning peak, the vehicular emission

Table 1. Sample Points and GPS Position.

S/N	Sampling Routes (junction)	Sampling Points	GPS location	
			x	Y
1	Tombia/Imiringi Road by Melford Okilo road	A	4.954	6.358
2	Opolo by Elebele Road	B	4.949	6.336
3	Otiotio Rd by Melford Okilo rd	C	4.940	6.316
4	INEC Road by Melford Okilo road	D	4.935	6.310
5	Old Azikoro Road by Melford Okilo Road	E	4.929	6.303
6	Azikoro Rd by Melford Okilo road	F	4.929	6.294

Table 2. Vehicular Traffic flow and Coordinate Points along Sample Streets in Yenagoa City. (Volume/Time).

S/N	Sample Location	Coordinates		Morning peak (7:30am– 9:30 am)	Evening peak (4:00pm- 6:00 pm)	Off peak (1:00pm- 3:00pm)
		X	Y	No of Vehicles		
Sp1	Tombia/Imiringi Road by Melford Okilo road	4.954	6.358	3,634	3218	2,286
Sp2	Opolo/Elebele Road by Melford Okilo road	4.949	6.336	3,329	2,634	1,891
Sp3	Otiotio Road by Melford Okilo Road	4.940	6.316	2,142	2053	1,235
Sp4	INEC Road by Melford Okilo Rd.	4.935	6.310	3,156	2,246	1,224
Sp5	Old Azikoro Road by Melford Okilo Road	4.929	6.303	2,138	2,515	1,341
Sp6	Azikoro road by Melford Okilo Road	4.929	6.294	2,011	2,318	1,014

concentration result shows that amongst other pollutants that were analyzed for the study, PM_1 had the lowest concentration of vehicular emission with a value of 0.003mg/m^3 while CO was more concentrated in the area amongst others with a value of 15.244 mg/m^3. These are also graphically represented in Figures 4 and 5. More so, At Old Azikoro road by Melford Okilo Road, sample point E in the morning peak, the vehicular emission concentration result shows that amongst other pollutants that were analyzed for the study, PM_1 had the lowest concentration of vehicular emission with a value of 0.002mg/m^3 while CO was more concentrated in the area amongst others with a value of 6.798mg/m^3, while at Azikoro road by Melford Okilo road, sample point F in the morning peak, the vehicular emission concentration result shows that amongst other pollutants that were analyzed for the study, PM_1 had the lowest concentration of vehicular emission with a value of 0.001mg/m^3 while CO was more concentrated in the area amongst others with a value of 4.942 mg/m^3. These are also graphically represented in Figures 6 and 7 respectively.

Table 4 below shows vehicular emission concentration levels of the different pollutants at evening peak in the six sample points in the study area. From the table, a careful observation reveals that amongst all the pollutants examined in the study, PM_1 has a low concentration in the six sample points having a mean value of 0.001mg/m^3 and CO has the highest concentration level in the six sampling points, with a mean value of 7.970 mg/m^3. This is graphically represented Figure 8.

Table 3. Vehicular emission concentration at morning peak in the six sampled locations in the study area.

Sample points	AIR QUALITY PARAMETERS							
	MORNING PEAK							
	PM_1 (mg/m^3)	$PM_{2.5}$ (mg/m^3)	PM_7 (mg/m^3)	PM_{10} (mg/m^3)	TSP (mg/m^3)	NO_2 (mg/m^3)	SO_2 (mg/m^3)	CO (mg/m^3)
A	0.001	0.009	0.0492	0.062	0.082	0.144	0.132	11.878
B	0.001	0.112	0.0478	0.060	0.074	0.17	0.144	14.172
C	0.002	0.01	0.0276	0.035	0.046	0.178	0.014	3.822
D	0.003	0.014	0.0354	0.047	0.053	0.189	0.204	15.244
E	0.002	0.010	0.0292	0.033	0.038	0.169	0.132	6.798
F	0.001	0.006	0.0258	0.033	0.037	0.156	0.152	4.942
Mean	0.002	0.010	0.035	0.045	0.055	0.168	0.129	11.055

The Table 5 below shows vehicular emission concentration levels of the different pollutants at off peak hours in the six sample points in the study area. A glance at the table reveals that amongst all the pollutants examined, PM_1 has a low concentration in the six sample points with a mean value of 0.007mg/m^3 and CO has the highest concentration level in the six sampling points, with a mean value of 6.16 mg/m^3. This also is graphically represented Figure 9 below.

Spatial -Temporal variations in concentration of vehicular emissions

This section discusses the spatial-temporal variation of air pollutants in the different sample locations in the study area.

Figure 10 below shows concentration of PM_1 at different peak periods at sample locations in the study area. The figure also shows that PM_1 varies from one sample location to the other and from one period to another. From the figure, there was a higher concentration of PM_1 at sample location A during the evening peak, and for the morning peak period the concentration of $PM_1$was more at sample location D, while during the off peak period, its concentration was more at same location E.

The Figure 11 below shows the concentration of $PM_{2.5}$ at different peak periods and sample locations. The figure also shows that $PM_{2.5}$ varies from one sample location to the other and from one period to another. In Figure 11, $PM_{2.5}$ was high at sample location B during the morning peak. Also the same level of concentration was experienced during morning peak period and off peak period at all the locations in the study area.

The Figure 12 below shows the concentration and distribution of PM_7 at different peak period and sample locations in the study area. The figure shows that PM_7 varies from one sample location to the other and from one period to another. Also, there is a higher concentration of PM_7 at sample location A during the evening peak, the same at the evening peak and off peak period at the same location, the same situation occurred at location D for all the period.

The Figure 13 below shows the concentration and distribution of PM_{10} at different peak periods and sample locations in the study area. The figure also shows that PM_{10} varies from one sample location to the other and from one period to another. From the figure, there is a higher concentration of PM_{10} at sample location A during the morning peak, the same at the evening peak and off peak period at the same location.

The Figure 14 below shows the concentration of Total Suspended Particles at different peak periods and sample locations in the study area. The figure also shows that TSP varies with time and location. Also from the figure, there was a higher concentration of TSP at sample location A during the morning peak, the same at the evening peak and off peak period at the same location, with a slight increase in concentration of TSP at sample location F.

The Figure 15 below shows the concentration of NO_2 at different peak periods and sample locations in the study area. The figure also shows that NO_2

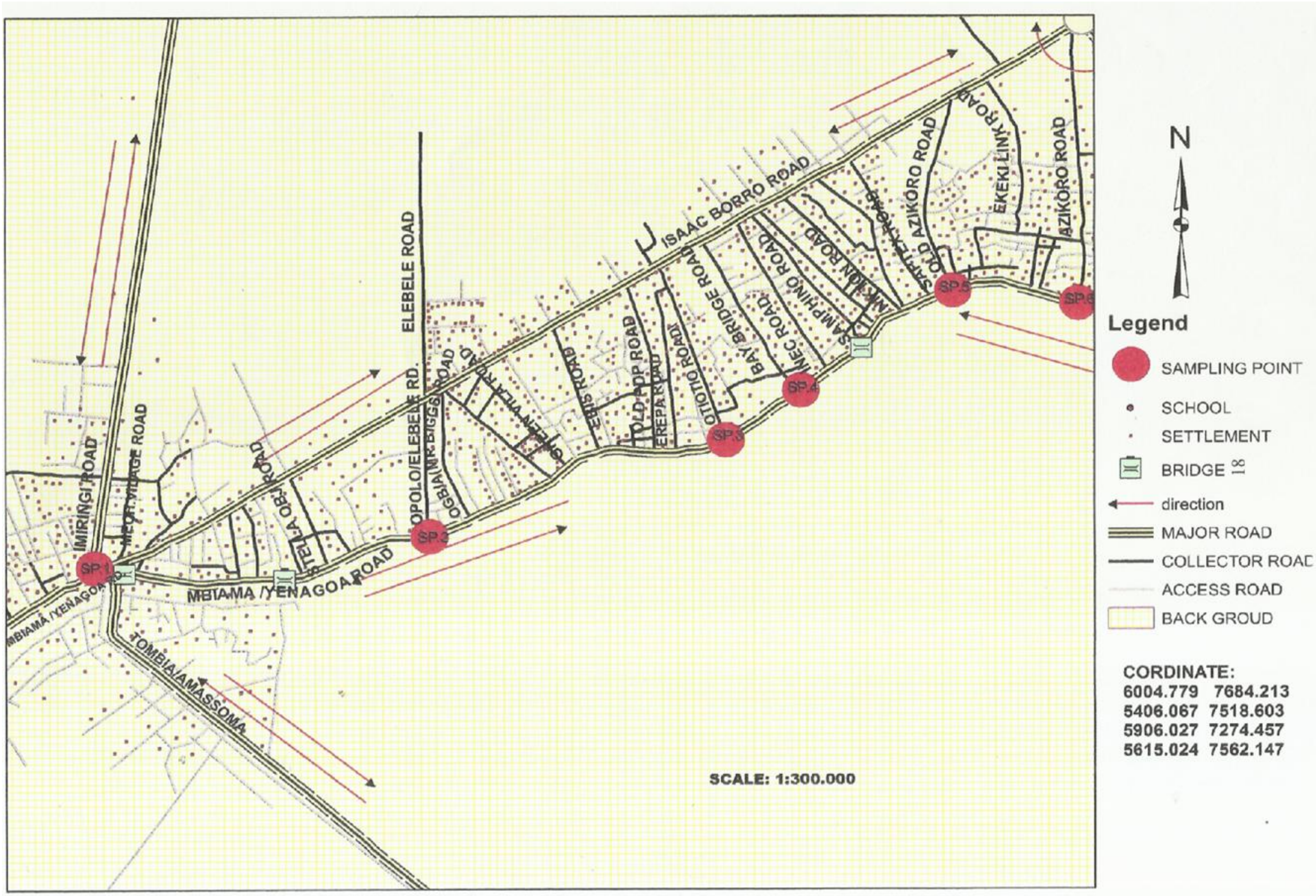

Figure 1. Showing sampling point along Melford Okilo road Yenagoa.

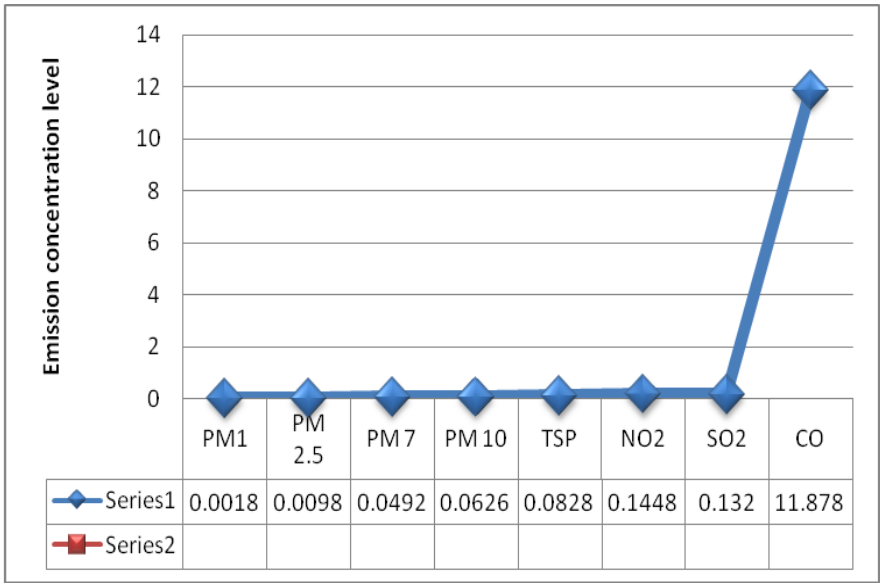

Figure 2. Graphical representation of vehicular emission concentration at morning peak in sample point A.

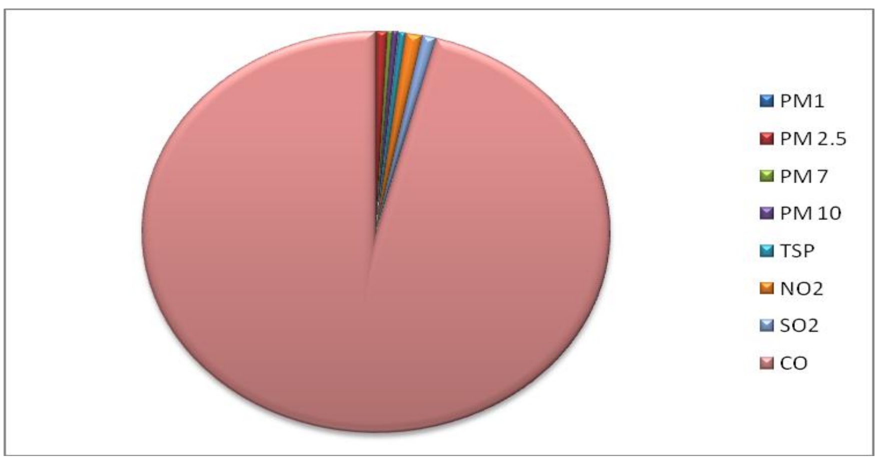

Figure 3. Graphical representation of vehicular emission concentration at morning peak in sample point B.

varies with time and location. From the figure, there is a higher concentration of NO_2 at sample location C during the evening peak, at location D during the morning peak, at off peak period there was a higher concentration of NO_2 at sample location B.

The Figure 16 below shows the concentration of SO_2 at different peak periods and sample locations in the study area. The figure also shows that SO_2 varies with time and location. From the figure, there was a higher concentration of SO_2 at sample location D during the morning and evening peak, and at location A during the off peak period.

The Figure 17 below shows the concentration of CO at different peak periods and sample locations in the study area. The figure also shows that CO varies with time and location. From the figure, there is a higher concentration of CO at sample location D during the morning and in the evening peak there

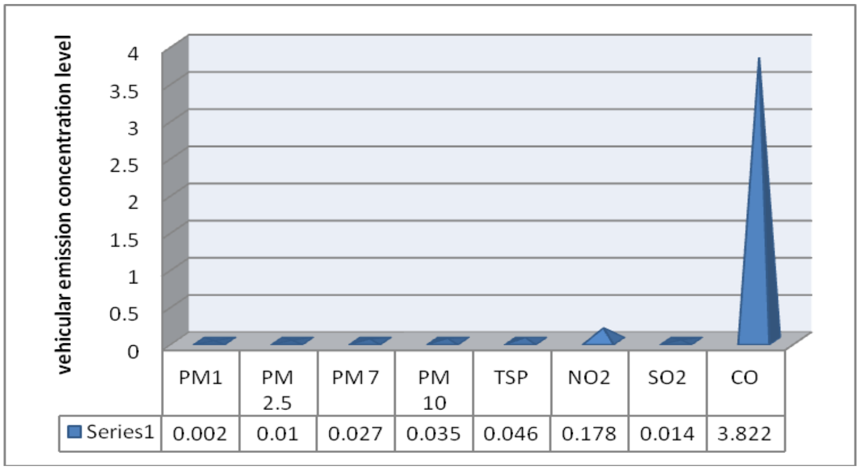

Figure 4. Graphical representation of vehicular emission concentration at morning peak in sample point C.

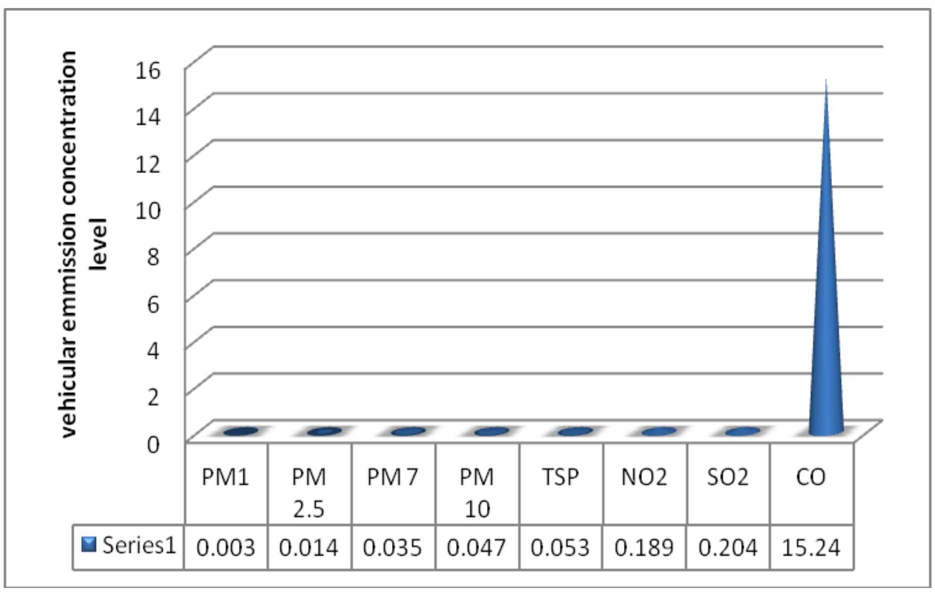

Figure 5. Graphical representation of vehicular emission concentration at morning peak in sample point D.

was a higher concentration of CO at sample point A, and at location B a higher concentration at off peak period was also identified.

Traffic count at peak and off peak periods in the sampled locations

Table 6 below shows traffic count result in relation to the sampled location and peak periods in Yenagoa. The result shows that the morning peak which was within 7:30am - 9:30 am at sampled location A had the highest amount of traffic with about 3,634 vehicles. Followed by sample location B with a total of 3,329 vehicles and sampled location D which had a total of 3,156 vehicles within the morning period. Amongst all the sampled location, location F had the least traffic, 2011 vehicles within the morning peak. At the evening peak 4:00 pm-6:00 pm result showed location A had the highest amount of traffic with a total of 3218 vehicles, followed by sample location B which had 2,318 vehicles.

Amongst all the sampled locations, sample

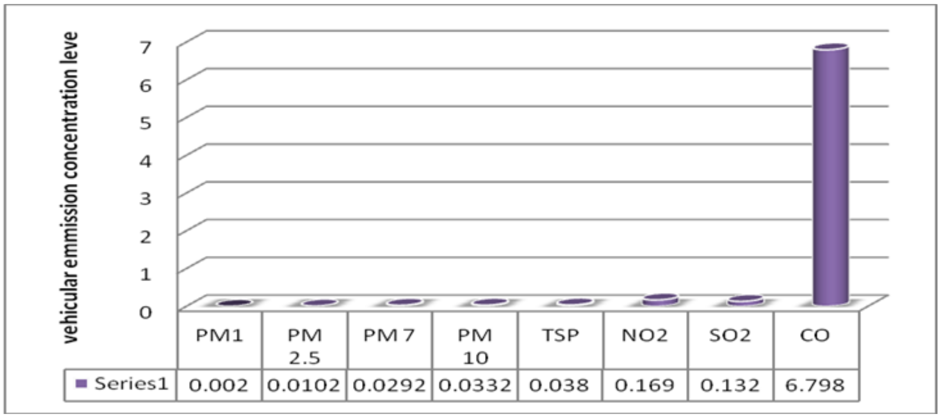

Figure 6. Graphical representation of vehicular emission concentration at morning peak in sample point E.

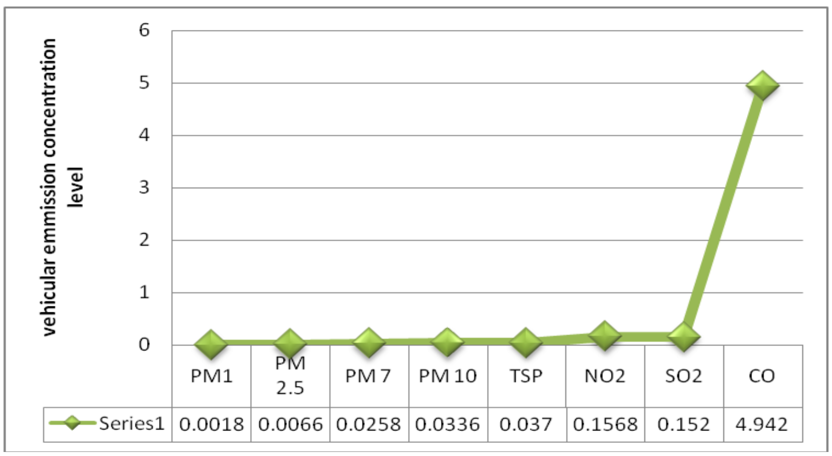

Figure 7. Graphical representation of vehicular emission concentration at morning peak in sample point F.

location C had the least traffic, about 2053 vehicles. The off peak period count, showed sample location A had the highest about 2,286 vehicles, followed by sample location B with 1891 vehicles. The least traffic count location in the off peak period was location F, about 1014 vehicles. The Table 6 was shown graphically in Figure 18 below.

The Table 7 below shows that CO was a predictor of traffic count in the multiple regression analysis. It should also be noted that CO, TSP, PM1, PM7 and PM10, PM2.5, NO2, and SO2 are indirect predictors of traffic count; this was because they correlate positively with traffic count , but there was a more positive correlation with CO which was the direct predictor as revealed in this study.

Table 8 below shows the health records obtained from the Ministry of Health Yenagoa for four years on the different ailments associated with CO inhalation caused by vehicular traffic in the City.

Hypothesis: Hypothesis one states that there is no statistically significant variation in pollutants concentration in the different sample locations in the study area.

Table 9 shows Anova results that calculated F value for the analysis was 1.037189, while the critical value was 1.709271. Also, the calculated F value of 1.037189 was less than the critical value of 1.709271at F^{7}_{143} degree of freedom. The implication was that the null hypothesis H_0 was accepted while the alternate $H_1$was rejected.

The Table 10 below shows the correlation matrix

Table 4. Vehicular Emission concentration at evening peak in the six sampled locations in the study area.

Sample points	Air Quality Parameters							
	Evening Peak							
	PM_1 (mg/m^3)	$PM_{2.5}$ (mg/m^3)	PM_7 (mg/m^3)	PM_{10} (mg/m^3)	TSP (mg/m^3)	NO_2 (mg/m^3)	SO_2 (mg/m^3)	CO (mg/m^3)
A	0.002	0.013	0.040	0.045	0.062	0.169	0.064	14.701
B	0.001	0.012	0.030	0.030	0.051	0.175	0.012	6.612
C	0.001	0.009	0.029	0.037	0.045	0.218	0.048	6.612
D	0.002	0.014	0.035	0.044	0.049	0.206	0.194	7.536
E	0.002	0.009	0.025	0.037	0.041	0.166	0.126	5.28
F	0.001	0.012	0.027	0.032	0.040	0.140	0.152	7.478
Mean	0.001	0.012	0.031	0.038	0.048	0.179	0.099	7.970

Table 5. Vehicular emission concentration during off peak period in the six sampled locations in the study area.

Sample points	Air Quality Parameters							
	off Peak							
	PM_1 (mg/m^3)	$PM_{2.5}$ (mg/m^3)	PM_7 (mg/m^3)	PM_{10} (mg/m^3)	TSP (mg/m^3)	NO_2 (mg/m^3)	SO_2 (mg/m^3)	CO (mg/m^3)
A	0.001	0.009	0.041	0.044	0.057	0.153	0.15	7.57
B	0.001	0.009	0.03	0.044	0.055	0.179	0.019	9.488
C	0.002	0.007	0.023	0.035	0.043	0.118	0.026	4.514
D	0.001	0.011	0.030	0.040	0.043	0.126	0.102	6.484
E	0.002	0.009	0.026	0.034	0.038	0.147	0.112	5.386
F	0.001	0.013	0.033	0.037	0.047	0.154	0.062	3.518
Mean	0.007	0.0103	0.030	0.039	0.047	0.145	0.078	6.16

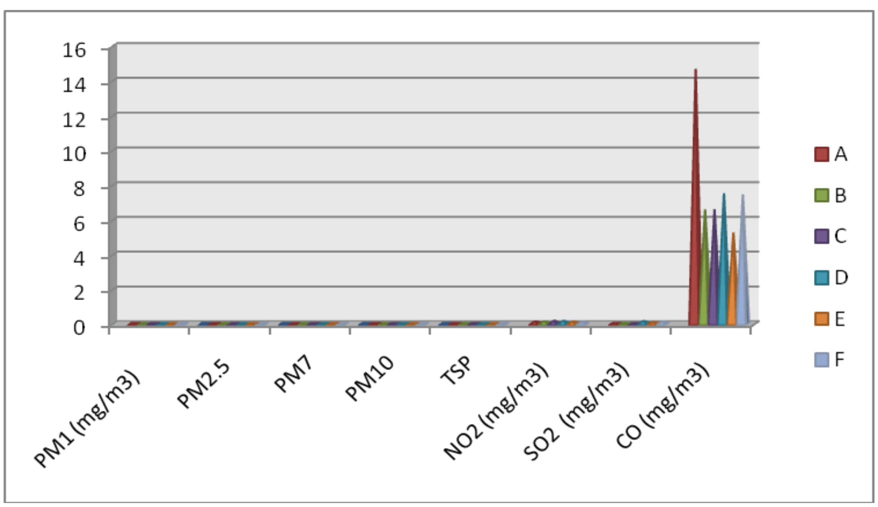

Figure 8. Graphical representation of vehicular emission concentration at evening peak in the study area.

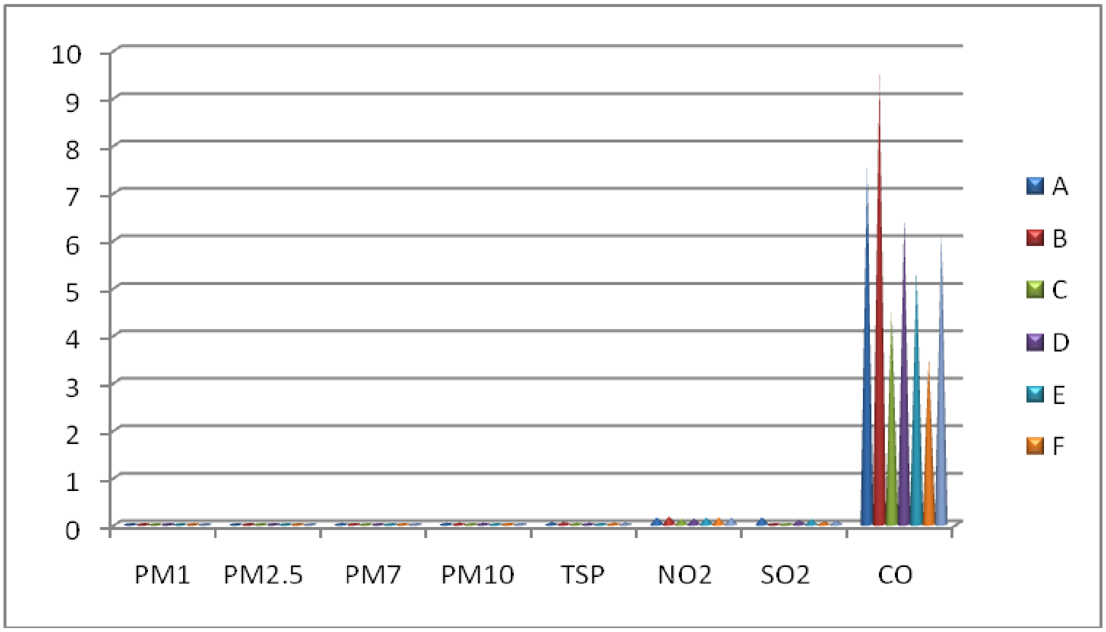

Figure 9. Graphical representation of vehicular emission concentration at evening peak in the study area.

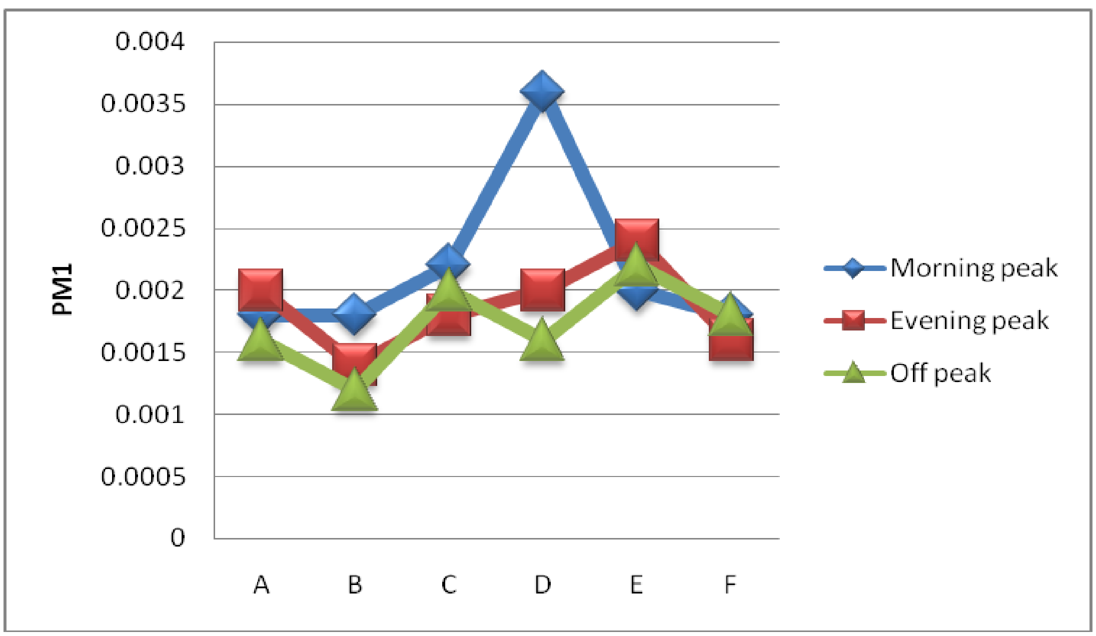

Figure 10. Showing concentration of PM_1 in sample locations.

of eight independent variables of PM_1 $PM_{2.5}$, PM_7, PM_{10}, TSP, NO_2, SO2, CO on the dependent variable of traffic count at Yenagoa. From the Table10, it was clear that though the correlation co efficient between PM_1 and traffic count of Yenagoa was positive (+0.246), its co-efficient of

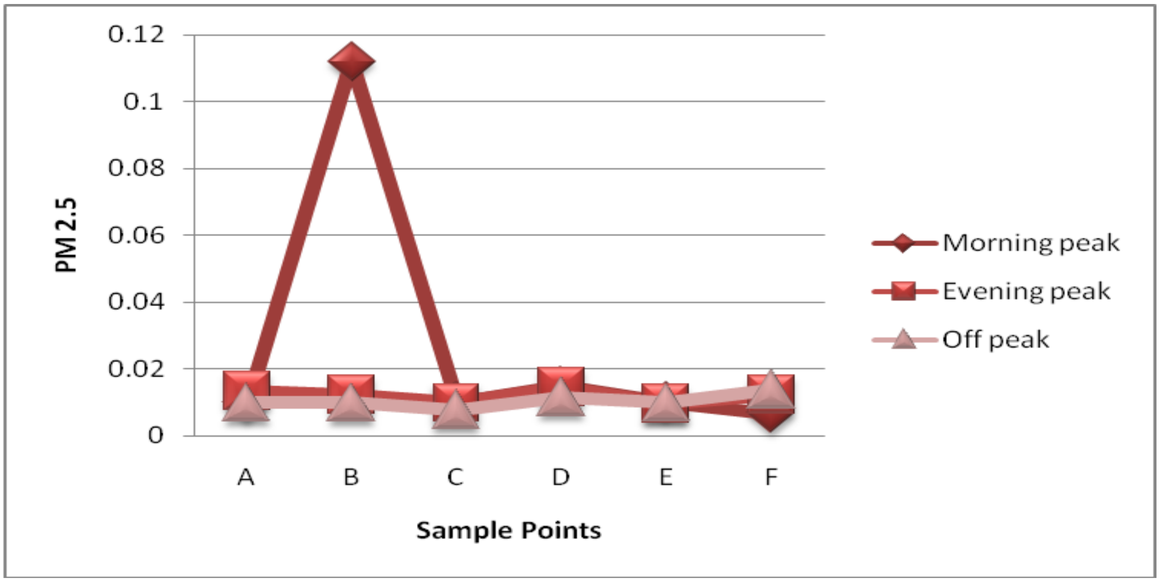

Figure 11. Concentration of $PM_{2.5}$ at different peak periods at sample locations in the study area.

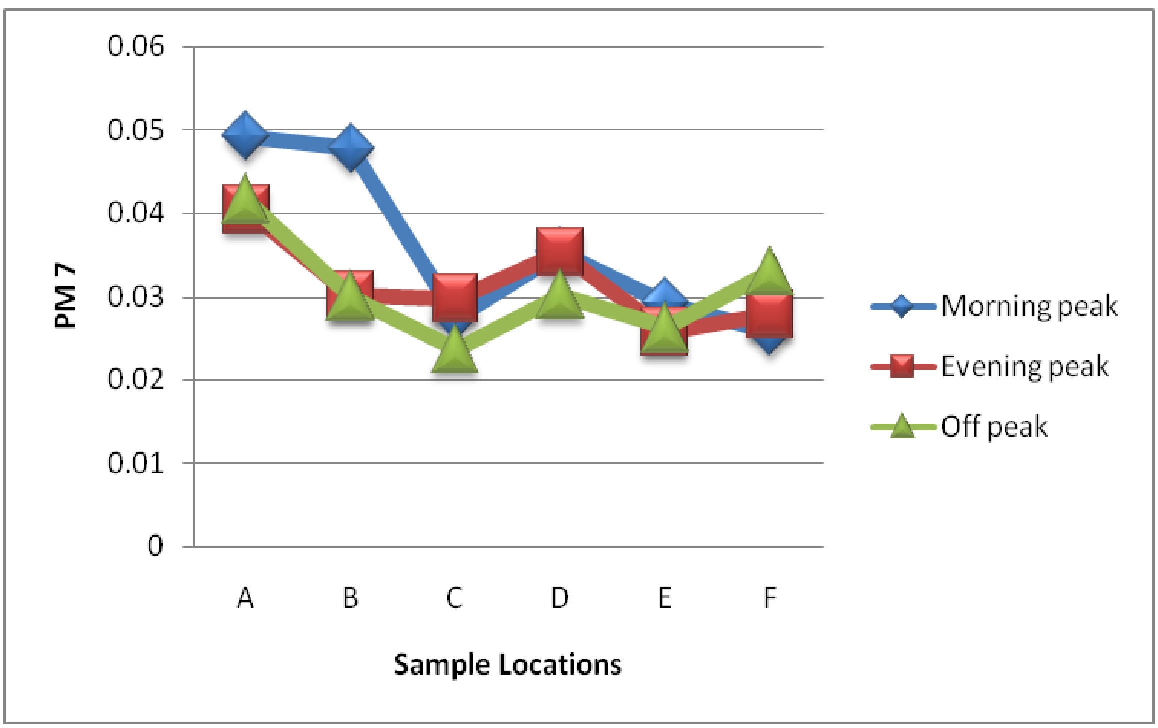

Figure 12. Concentrations of PM_7 at different peak periods.

determination (r^2) was 24.6%. This means that an insignificant 24.6% variation in traffic count is explainable by PM_1 concentration in the area. It should also be noted that velocity correlates positively with some of the independent variables except $PM_{2.5}$ PM_7 and TSP, but more significantly

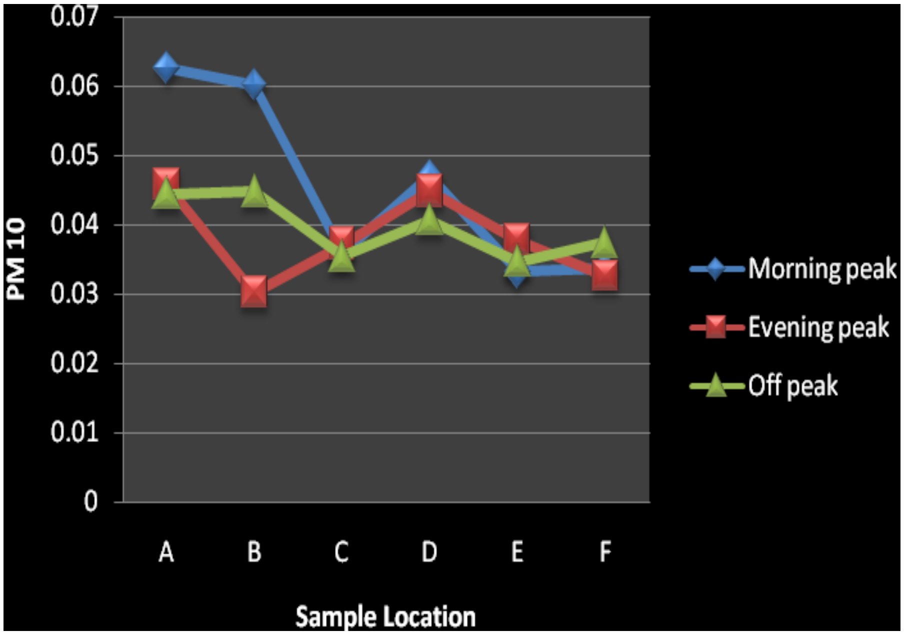

Figure 13. Concentration of PM $_{10}$ at different peak periods and sample locations in the study area.

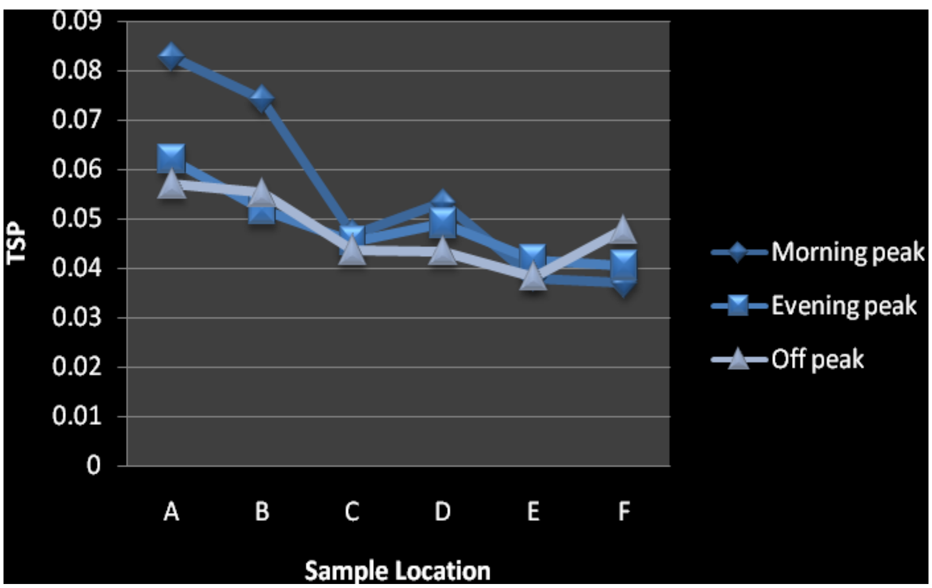

Figure 14. Concentration of TSP at different peak periods and sample locations in the study area.

with SO_2 having a correlation co-efficient of + 0.437 this means that it was a major pollutant. The traffic count in the study area was significantly correlated with CO, TSP, PM_7 and PM_{10}, $PM_{2.5}$, NO_2, and SO_2 and having 79.2%, 71.7%, 69.9%, 64.7%, 37.8%, 32.3% and 34.1% variation in traffic count was explainable by these independent variables.

The study revealed that CO (carbon monoxide) among other pollutants was the most pronounced pollutant in all the sampled locations in the study

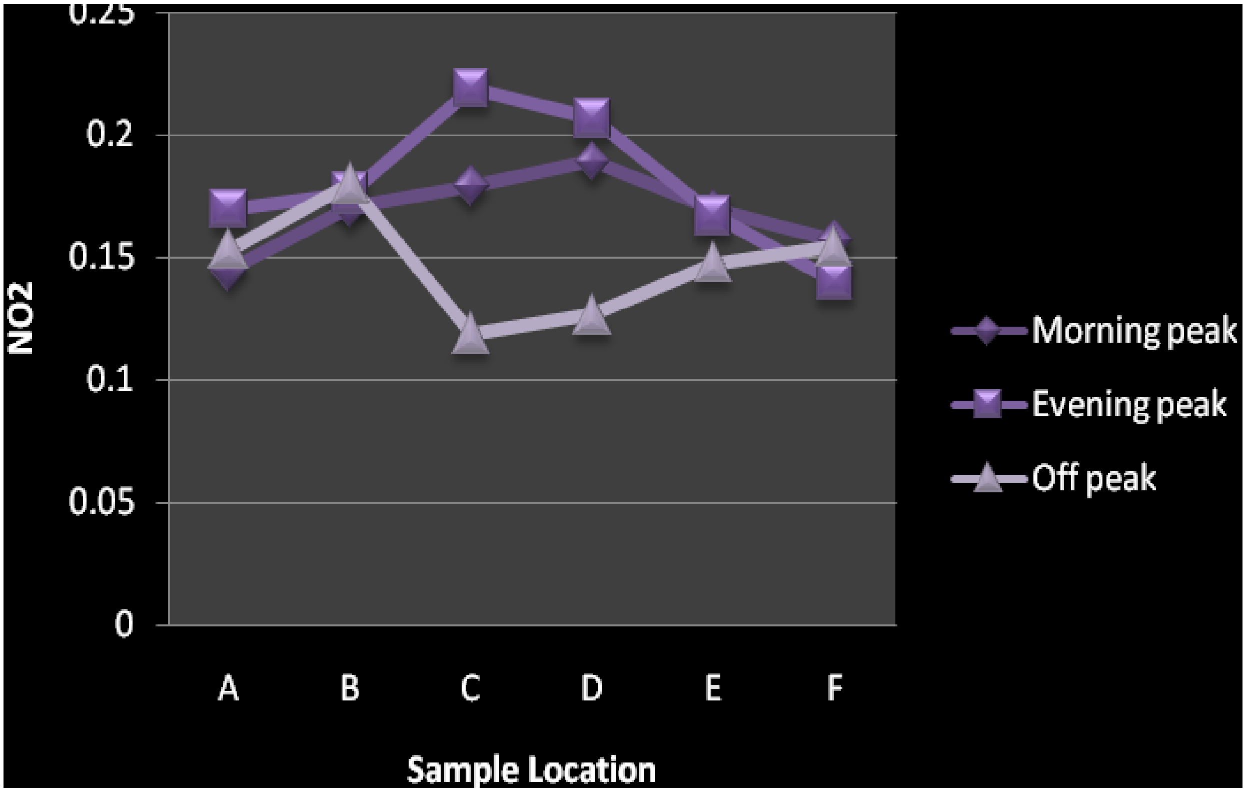

Figure 15. Concentration of NO_2 at different peak periods and sample locations in the study area.

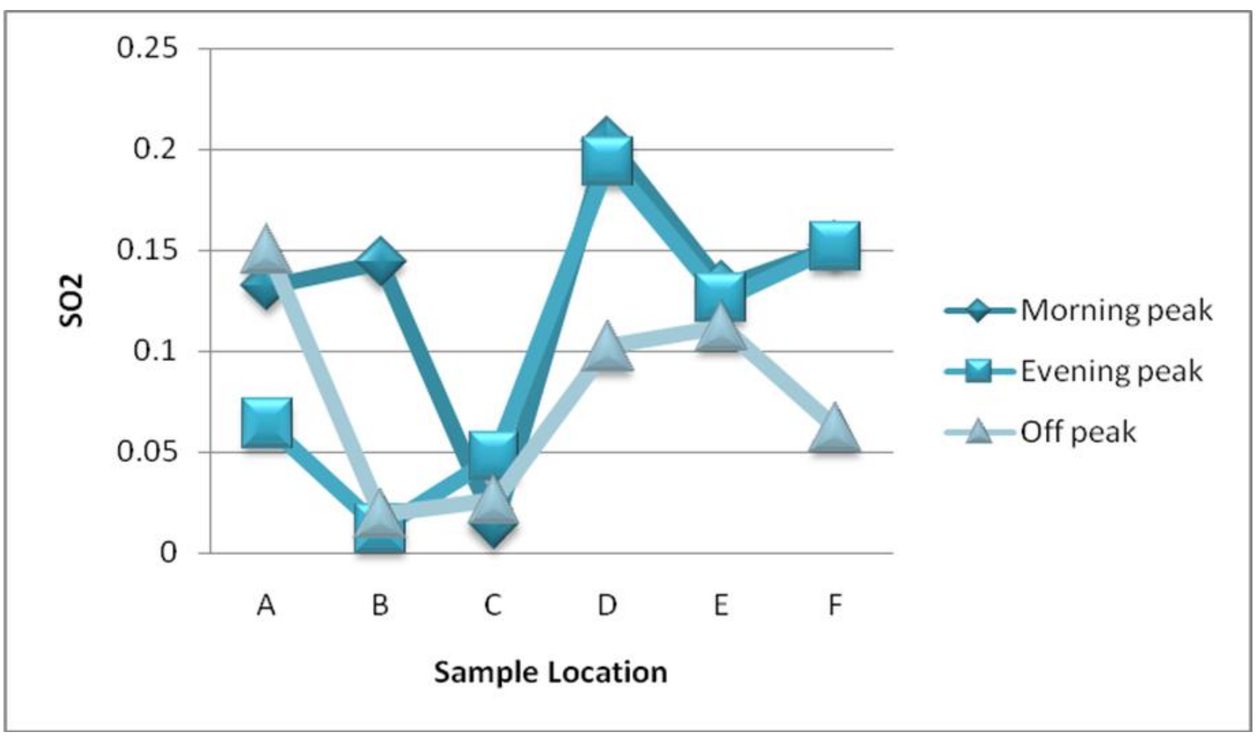

Figure 16. Concentration of SO_2 at different peak periods and sample locations in the study area.

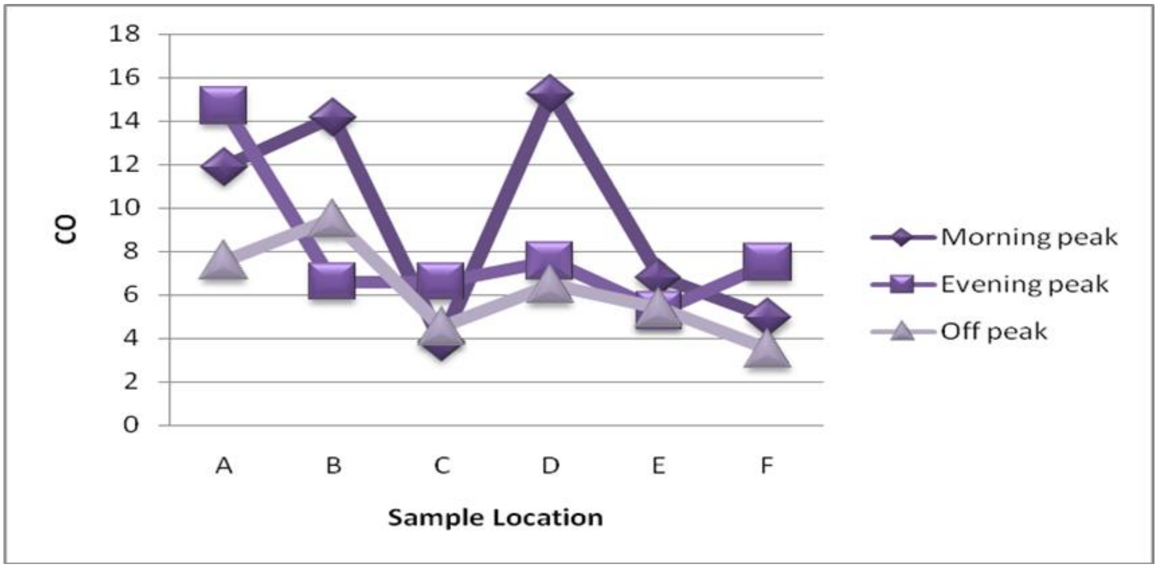

Figure 17. Concentration of CO at different peak periods and sample locations in the study area.

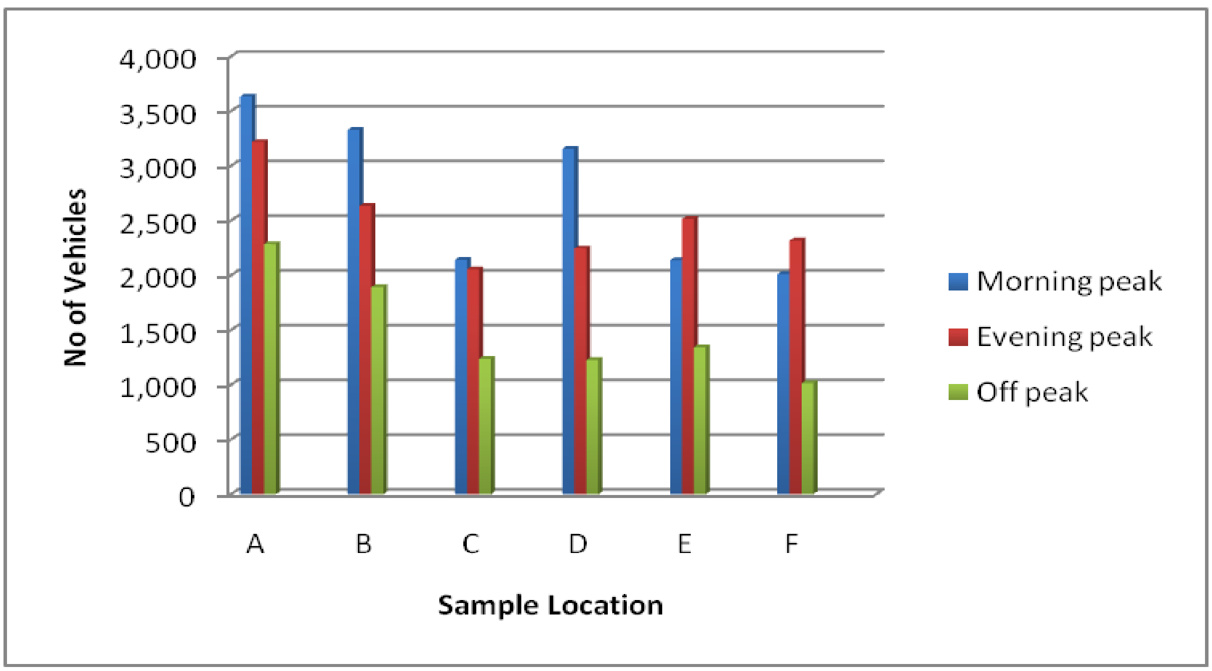

Figure 18. Showing traffic counts at different locations and time.

area. The CO concentration varied with time, but its highest concentration was more during the morning peak period. The assertion corroborates with the findings of Ubokobong (2014). Statistically, the result showed that there was statistically significant variation in pollutants concentration in the different sample locations in Yenagoa City.

This has great effect on the air quality in the area and as such could bring about respiratory ailments. The study also revealed that the noise level at the different sample locations varied with time and recorded highest during the evening peak at

Table 7. Multiple Regression Analysis of Traffic Count and Air Pollutants in the Study Area.

Model Summary										
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.792 a	.627	.604	476.52210	.627	26.922	1	16	.000	1.089

a. Predictors: (Constant), CO

b. Dependent Variable: Traffic count

Table 6. Traffic count relationship with time and space.

Sample Points	Morning peak (7:30am-9:30am)	Evening peak (4:00pm-6:00pm)	Off peak (1:00pm-3:00pm)	Total
	No of Vehicles			
A	3,634	3218	2,286	9138
B	3,329	2,634	1,891	6617
C	2,142	2053	1,235	5430
D	3,156	2,246	1,224	6626
E	2,138	2,515	1,341	5994
F	2,011	2,318	1,014	5343
Total	16410	14984	8,991	39148

Table 8. Hospital record of ailments associated with Co inhalation caused by traffic Congestion.

S/N	AILMENT	YEARS				SEX		AGES BRACKET	
		2015	2016	2017	2018	Male	Female	0-30yrs	31 and above
1	Pneumonia	6	15	6	2	22	7	18	11
2	Asthma	3	2	5	6	11	5	8	8
3	Stroke	2	8	4	10	14	10	7	17
4	Lung cancer	2	2	1	2	4	3	2	5
5	Emphysema	1	2	-	3	2	4	1	4
6	Headache	6	4	5	4	12	7	9	10
7	Nausea	2	3	-	2	2	5	4	3
8	Bronchitis	12	13	10	11	31	15	17	14
9	Coughing	5	8	5	10	10	18	8	20
10	Rhinitis	5	10	7	12	8	16	12	12
11	Hypertension	9	8	6	7	12	18	8	22
12	Neurosis	2	4	4	7	6	11	8	9
13	Skin Irritation	3	5	4	4	7	9	12	4
14	URTI	10	20	62	20	45	67	69	43
	Total	2076	2116	2132	2114	186	195	183	182

Hospital records from sampled hospitals for four years (Bayelsa State Health Management Board, 2018.).

Table 9. Analysis of Variance for pollutant concentration in the different sample locations.

ANOVA						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F crit**
Rows	30.2167	17	1.777453	1.037189	0.424074	1.709271
Columns	966.5242	7	138.0749	80.57023	3.88E-42	2.08743
Error	203.9328	119	1.713721			
Total	1200.674	143				

Table 10. Correlation Matrix for Traffic Count and PM_1 $PM_{2.5}$, PM_7, PM_{10}, TSP, NO_2,SO_2,CO.

Correlations										
		Traffic count	**PM1**	**PM2.5**	**PM7**	**PM10**	**TSP**	**NO2**	**SO2**	**CO**
Pearson Correlation	**Traffic count**	1.000								
	PM1	.246	1.000							
	PM2.5	.378	-.038	1.000						
	PM7	.699	-.032	.527	1.000					
	PM10	.641	.082	.545	.893	1.000				
	TSP	.717	-.091	.492	.921	.907	1.000			
	NO2	.323	.208	.084	.100	.068	.062	1.000		
	SO2	.341	.437	.190	.326	.330	.062	.041	1.000	
	CO	.792	.293	.459	.729	.741	.712	.224	.354	1.000

* 0.05 significant level.

Tombia/Imiringi Road by Melford Okilo road in Yenagoa City. More so, the study revealed that there was statistically significant difference in noise level in the sampled locations compared with national and international standards such as the NESERA and OSHA standards for workplace noise pollution, this revelation may also portend danger to the health of the residents of the study area if unabated.

CONCLUSION

The study revealed that upper respiratory tract infection (URTI) was the most pronounced ailment that the residents of Yenagoa city have suffered in the last four years. Although other respiratory based ailment was also observed such as Bronchitis, coughing and Rhinitis (Bayelsa State Ministry of Health, 2015-2018). The assertion corroborates the findings that traffic congestion with vehicular emission gives rise to high level pollutant concentration which affects the health of the residents of the city. The study recommends regular vehicular checks on emission limits to be enforced and subsequent withdrawal of high emission vehicles off the roads to stem pollution of the environment. The law on vehicular emission evaluation should be enforced strictly to stem the menace of Co inhalation and continuous air quality monitoring. The implementation of such traffic rules will greatly rid of the environment of noxious pollutants from automobiles and engender on environmentally friendly environment for the citizens.

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