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Comparative Assessment of Vehicular Emissions along Major Roads between Peak and Off Peak Periods in Yenagoa Metropolis, Bayelsa State, Nigeria

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ABSTRACT
The study examined the comparative assessment of vehicular emissions along major roads between peak and off peak periods in YenagoaMetropolis, Bayelsa State, Nigeria.Thirty bus stops were randomly selected along the four major roads (Mbiama-Yenagoa road, Otiotio/Okaka Road, Isaac Boro Road, SaniAbacha Road) whereby the concentrations of vehicular emissions (CO, NO_2, SO_2, PM_1, $PM_{2.5}$, PM_4, PM_7, PM_{10} TSP, CO, O_3) were recorded with a multi-gas monitor (Aeroqual 300 series) during both peak and off peak periods. Descriptive and inferential statistics were applied for the data analysis. Findings revealed that CO, NO_2,SO_2,$PM_{2.5}$, and PM10 were higher in Mbiama-Yenagoa Road during the morning peak period. Results also showed that PM7 ($F=2.989$; $p<0.05$) was significantly varied in the off peak periods (11am-2pm) among the selected bus stops. During the peak periods of the evening, the study discovered that the mean concentrations of $NO_2$was significantly varied among the bus stops ($F=3.287$; $p<0.05$). The study concluded that CO, NO_2, SO_2, O_3, $PM_{2.5}$, and TSP were higher than the WHO standard along the major roads in Yenagoa while PM_7 and PM_{10} were within the permissible levels. In addition, Mbiama-Yenagoa road and Otiotio/Okaka road were highly polluted with traffic emissions more than other major roads especially at both peak and off peak periods. The study thus recommended that vehicles causing the release of pollutants to the environment should be evacuated with serious promulgation and implementation of an environmental policy.

Keywords: Vehicular emissions; Multi-gas monitor; Peak period; Off peak period; Major roads

I. INTRODUCTION

People have seen air to be of imperative significance to the environment. Fresh air is essential to human endurance and prosperity, yet in the present urbanized world, clean air is something that is progressively elusive. Street transport has become by a long shot the significant wellspring of ecological contamination and gridlock in metropolitan regions. The persistent traffic development has raised worries over the effect of traffic emanations on human wellbeing and metropolitan natural quality, and has fuelled the interest for a rational administrative structure for the administration of traffic, air quality and outflow at metropolitan level, just as at territorial and public scales. Urban areas have for some time been known to be society's dominating motor of advancement and abundance creation, yet they are likewise its fundamental wellspring of wrongdoing, contamination, and infection. Bettencourtet al., (2007) showed that cycles relating urbanization to monetary turn of events and know-edge creation are exceptionally broad, being shared by all urban areas having a place with a similar metropolitan framework and supported across various countries and times however that there are efficiencies of scale; amounts reflecting abundance creation and advancement have expanding returns, though those representing foundation show economies of scale.

Ongoing evaluations show that 60–80 % of conclusive energy use all around the world is devoured by metropolitan regions (Global Energy Assessment, 2012) and more than70 % of worldwide ozone depleting substance discharges are delivered inside metropolitan regions (IEA, 2012). Lamsalet al. (2013) found that metropolitan nitrogen dioxide contamination, as other metropolitan properties, is a power law scaling capacity of the populace size. Nitrogen dioxide focus expands corresponding to populace raised to a type. The worth of the type fluctuates by locale from0.36 for India to 0.66 for China, reflecting territorial contrasts in modern turn of events and per capita outflows.

Fragkias et al. (2013) observed a close straight connection between populace size and fossil fuel byproducts recommends that enormous metropolitan regions in the U.S. are just somewhat a greater number of outflows proficient than little ones. For every year in their example, variety in populace size across urban communities in the U.S. metropolitan framework clarified roughly 70 % of the variety of CO2 discharges. Currently in 1973, Oke (1973) portrayed the connection among populace and metropolitan hotness island impact. The high thickness of structures and streets can cause supposed metropolitan hotness islands characterized as developed regions that are more sultry than adjacent provincial regions (O'Neill and Ebi, 2009). Fuller and Gatson (2009) showed that in Europe green space inclusion increments more quickly than city region, however that a decrease in green space accessibility per capita speeds up with expanding populace thickness, recommending that admittance to green space could decay quickly as urban communities develop, expanding the topographical segregation of individuals from freedoms to encounter nature. In urban communities, ecological openings like air contamination (Hoek, Krishnan, Beelen, Peters, and Brunekreef (2013); temperature (Guo, Gasparrini, Amstrong, Li, Tawatsupa and Tobias, 2014) and commotion (Basner, Babisch, Davis, Brink, Clark and Janseen, (2014) have been related with unfavorable wellbeing impacts, while bright radiation (UVR) (Lucas, McMichael, Armstrong and Smith (2008) and green space (Hartig, Mitchell, de Vries and Frumkin, 2014) have been related with both positive and negative wellbeing impacts, and are accordingly imperative to gauge and control. Today, multiple thirds of the European populace lives in metropolitan regions and this offer keeps on developing. The advancement of our urban communities will decide the future financial, social and regional improvement of the European Union (European Union, 2017). Never-ending suburbia and the spread of low-thickness settlements is one of the principle dangers to manageable regional turn of events; public administrations are all the more exorbitant and hard to give, regular assets are overexploited, public vehicle networks are lacking and vehicle dependence and blockage in and around urban areas are weighty.

Ecological issues comprise one of the critical difficulties of the 21st century, and metropolitan air contamination is a significant wellbeing peril around the world (Avogbe et al., 2011). Air contamination results from four principle sources namely industrialization, tobacco smoking, homegrown cooking and vehicular or apparatus fuel ignition (Tanimowo, 2000). Be that as it may, the degree of air contamination relies upon a nation's innovation and contamination control. Engine vehicles in non-industrial nations cause genuine air contamination since they are gathered in a couple of huge urban areas, furthermore, many are in poor mechanical conditions, and hardly any outflow norms exist. Transportation-related discharges are the predominant wellspring of air poisons, which add to the ecological issues today. In 2002, the cross country transportation sources were liable for 82% of the carbon monoxide (CO), 56% of the nitrogen dioxide (NO2), 45% of the unpredictable natural mixtures (VOCs), 12% of the lead (Pb) discharges, and 5% of sulfur dioxide (SO_2) (USEPA, 2003). Notwithstanding the models poisons, the transportation area was additionally the second biggest wellspring of carbon dioxide (CO2) discharges in the United States (Yu, Jia and Shi, 2009). It straightforwardly transmitted around 27% of absolute U.S. ozone harming substance emanations in 2003. Of the major ecological issues, transportation-related emanations are reasons for corrosive downpour, the nursery impact, ozone toxins, and so on Transportation-related emanations are significant in light of the fact that they contrarily affect living animals.

The engine vehicle motor emanates many kinds of contaminations including nitrogen oxides. (NOx), unpredictable natural mixtures (VOCs), carbon monoxide (CO), carbon dioxide (C02), particulates, Sulfur dioxide (SO2) and lead (Air Quality Information UK, 2014). Outflows are identified with utilization of the motor, predominantly the fuel type and the temperature of burning. Assuming the motor is 100% proficient, the results of burning will be CO2 and water (H2O). Notwithstanding, at low loads motors are wasteful and consequently the results of fragmented ignition overwhelm, for instance CO and VOCs in petroleum motors and carbon monoxide, VOCs and smoke in diesels.

Nonetheless, contaminations in the fuel, for example, nitrogen are oxidized to NO2. At high temperatures environmental nitrogen (N2) is additionally oxidized to NO2, thus at higher loads and rates, NO2 creation rules (Air Quality Information UK, 2014). Many investigations utilized openness to vehicular traffic force as their technique to assess openness, perceived as the quantity of ve¬hicles going through a specific street, during a particular timeframe. The greater part con¬sidered the yearly mean of every day traffic and just Wyler et al. (2000) and Furman and Laleli (2000) utilized vehicle/hour builds up to gauge openness. As indicated by the goal proposed in each study, coming up next were thought of: the traffic of the closest principle street (Reynolds et al., 2001); the traffic of the closest street (Medina-Ramón, 2008) or the traffic of streets (fundamental ones or not) remembered for distances (cradles) of up to 50 m (Green et al., 2009), 100 m (Medina-Ramón et al., 2008); 150 m (Meng et al., 2007) and 300 m (Medina-Ramón et al.,2008). The larger part depended on vehicular traffic comparable to the homes of people. One review thought about the work environment (Furman and Laleli, 2000) and another, schools (Janssen et al, 2003). The upsides of vehicle stream were gotten by broad count, not indicating the sort of vehicle, aside from the investigations by Janssen et al. (2003) and Wyler et al. (2000), which recognized the progression of vehicles from that of trucks. A sum of three investigations applied surveys and got oneself revealed traffic power in the city of home (Kuehni et al., 2006). In another systemic methodology, the proportion of traffic was gotten by duplicating the length of streets near the homes of the populace contemplated by the every day mean of vehicle stream on such streets (Meng et al., 2007). The thickness of vehicles gives an es¬timate of the capability of openness to emis¬sions from fuel vanishing when vehicles are left around evening time, when such dissipation is a significant wellspring of natural unpredictable gases, like benzene (Reynolds et al., 2002).. In one more review directed by Reynolds et al. (2002), the length of the roads in a support of 150 m/500 feet around an individual' geocoded address was added and this worth was along these lines separated by the cradle region.

The fast expansion in the quantity of vehicles is of a profound worry as for gridlock in Asaba. The diminishing in normal vehicle speed because of gridlock has prompted an increment in the complete vehicle exhaust emanations in the city. Clogged traffic hallways in thick spaces of the city are key supporters of the corruption of metropolitan air quality. As per observing information, vehicle exhaust has become one of the primary elements influencing the State capitals' air quality. Along these lines, there is need for an appraisal of the connection between the quantity of vehicles and vehicular poisons (in-situ) in and around the transport tops. Scarcely any examinations have inspected air contamination openness in Nigerian transportation conditions. Nonetheless, existing proof proposes that metro conditions might be related with raised degrees of air poisons. With regards to this; the action of driving might address a huge extent of everyday openness to these toxins for metro workers (Onat and Stakeeva, 2013). Consequently, this review is centering at the comparative analysis of vehicular emissions between off peak and peak periods nearby bus stations in Yenagoa Metropolis, Bayelsa State, Nigeria.

II. MATERIALS AND METHODS

The study was carried out in Yenagoa, Bayelsa State, Nigeria. The study area is located in latitudes between 4^0 51’ 30’’N and 5^0 13’ 30’’N and longitudes between 6^0 12’ 30’’E and 6^0 22’ 30’’E (Figure 1). The study locations experience a tropical humid climate with lengthy and heavy rainy seasons and very short dry seasons. The heaviest precipitation occurs during September with an average of 370 mm of rain. December on average is the driest month of the year; with an average rainfall of 2000mm. The southwest wind transports its moisture to the region. It blows through Southern Nigeria between the months of February through November. During this period, the region receives its rain. Only the months of December and January truly qualifies as dry season months in the city. The North East trade wind blows through the Sahara desert passes through the core Niger Delta between the months of November through February. During this period the places experience dry season and harmattan. The region is endowed with abundant sunshine and this is because it is located close to the equatorial region. The mean annual temperature of the region is 28^0C and the region records its highest temperature during the month of July and the lowest temperature in January (Adeyemo and Oyegun, 1999). Temperatures throughout the year in the city are relatively constant, showing little variation throughout the course of the year. Average temperatures are typically between 25°C-28°C in the city (Ogbonna et al., 2007). There are two major pressure and wind system in Nigeria. One is generated from subtropical high pressure cell. These cells are called anti–cyclones they generate and drive the north east trade wind and the south west winds.

Relief of the study area is undulating in other words the high and low lands, which

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characterizes the place. Most of the study area is lowland except some spots in the northern part of AkwaIbom State. However, Asaba is dominated by low lying coastal plains, which structurally belongs to the sedimentary formation of the recent Niger Delta, with an elevation less than 15.24m (Oyegun and Adeyemo, 1999). The low relief of the region results in strikingly gentle slope, which have the effect of making the flow velocity of the rivers very low. This situation results in the formation of well-developed rivers meanders (Umeuduji and Aisuebeogun, 1999).

The study area is underlain by the Coastal Plain sands having its place from the Pleistocenic Formation (Nwakoala and Warmate, 2014). The sediments are deposits comprising of gravel, clays, peats, sands and silt from the River Niger. The depositional order displays vast sandstones superimposing an interchange of sandstones and clays of slightly marine source which has developed to be marine clays. Sands constitute the prevailing and dominant type of rock in the study area.

The study made use of quasi-experimental and longitudinal research designs. This study made use of both primary and secondary data. The primary data were acquired from the fieldwork while the secondary data were acquired from relevant journals, books and magazines found in the libraries and internet. The primary source involved collecting data on the vehicular emissions at different peak periods of the day. The selected bus stop locations were tracked using Global Positioning Systems (GPS). Vehicular emissions investigated included Nitrogen dioxide (NO_2), Sulphur dioxide (SO_2), Particulate matter $(PM)_1$, $PM_{1.5}$, PM_4, PM_7, PM_{10}, Total Suspended Particles (TSP), Carbon monoxide (CO), and Ozone (O_3). The air quality parameters were recorded using a multi-gas monitor (Aeroqual 300 series) Gas Meter.

Standards of air pollutant parameters were obtained from World Health Organization (WHO). The study made use ofboth stratified and random sampling technique. The stratified sampling technique was used in form of grouping the bus stops in an entire city into those found along the Trunk A, B and C roads. Those in the Trunk A roads were used for the data collection in this study. Thereafter, random sampling technique was used to select those bus stops to be selected along each major road. Of the total number of bus stops along the major roads in each study location, 30 bus stops were randomly selected with a distance of at least 100m apart.

Data were collected in the morning (7-9am), afternoon (12-2pm) and evening (4-6pm). The morning and evening are termed peak periods while afternoon is termed off-peak period. The frequency and types (i.e. cars, buses, trucks/trailer) of vehicles was also determined. Descriptive and inferential statistics were used for the study. Descriptive statistics were used to explain to the mean values of the vehicular emissions. It was used to explain the comparison between the observed mean values of vehicular emission parameters and the WHO standard (WHO, 2006). The one-way analysis of variance (ANOVA)was used to determine the significant spatial difference in the level of the concentrations vehicular emissions among the bus stops. All analyses were done using Statistical Package for Social Scientist (SPSS) 20.0 version. The results of the analyses were presented in tables for clarity purpose.

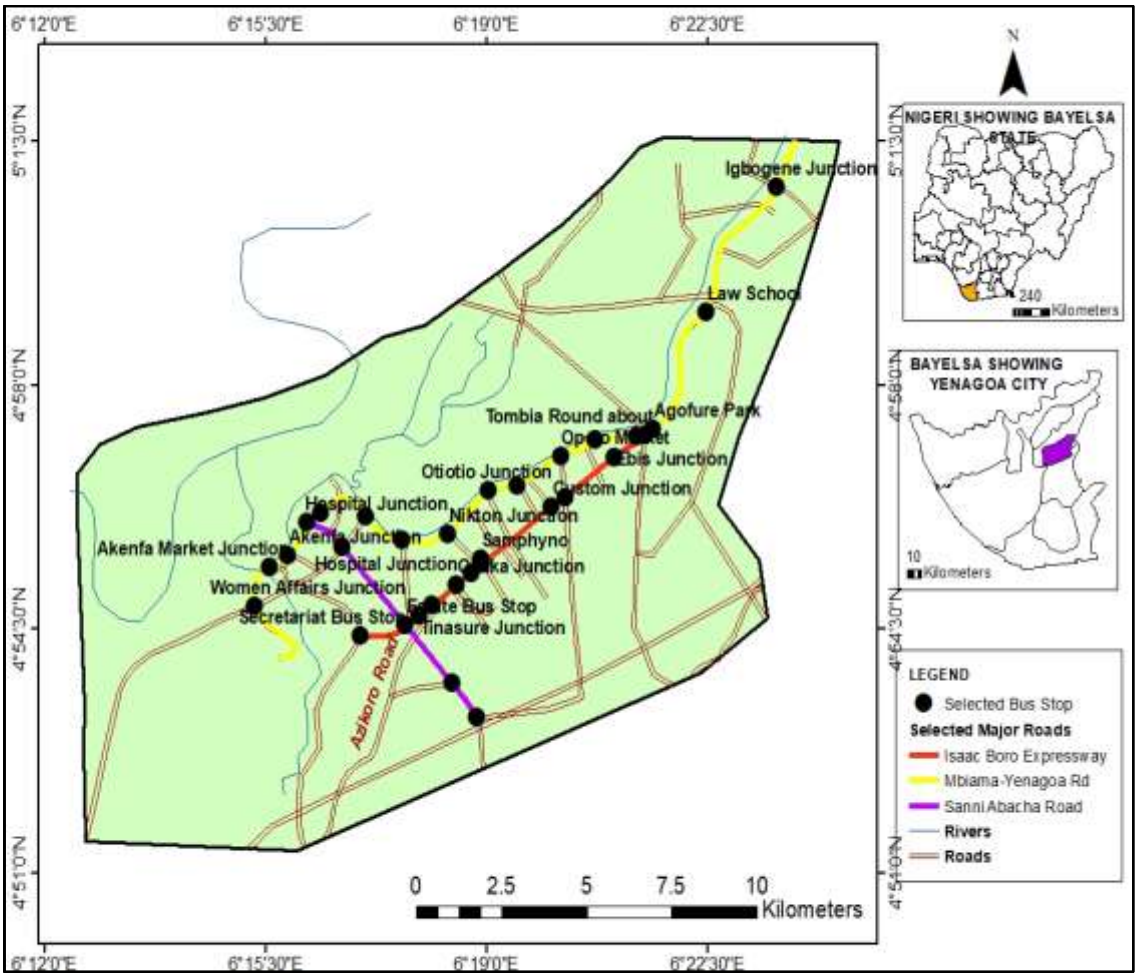

Figure 1.Yenagoa Metropolis showing Bus Stops

Table 1: Trunk ARoads and Bus Stops in Yenagoa Metropolis

State	**Trunk A Roads**	**Bus Stops**
Bayelsa	Mbiama-Yenagoa Road	Igbogene Junction
		Akemfa 3 by Winners Chapel
		Akemfa Junction by Police Station
		Akemfa Market
		Navy Bus Stop, Akempai
		Law School
		Human Right Junction Edepie
		Edepie School Bus Stop
		Tinasures Bus Stop Edepie
		Tombia Roundabout by AGOFUHRE
		Tombia Roundabout by NDU Park
		Okutukutu Bus Stop
		Alamieyeseigha Junction
		Opolo Market
		Custom Junction
		Ebis Bus Stop Mbio-Opolo
		Otiotio Bus Stop
		First Bank Bus Stop by Yenezegene
		Bay Bridge Bus Stop

		Sanphyno Bus Stop
		Nikton Junction
		Kpansia School
		Okaka Bus Stop
		Ekeki Motor Park
		Ebi's Bus Stop Amaranta
		Mkpi Junction
		Secretariat Bus Stop
		Women Affairs Bus Stop (Hospital Junction)
	Isaac Boro Expressway	Alamieyesegha Road Junction
		Opolo Roundabout
		Green Villa Junction
		Ebi's Road Junction MbioOpolo
		Otiotio Junction
		Bay Bridge Junction
		INEC Junction
		Sanphyno Junction
		Jasmine Road Junction
		Nikton Junction
		Yenezuegene New Road Junction
		Saptex Junction
		Okaka Junction
		CBN Bus Stop
		NCDBN Bus Stop
		Dewoo Junction
	SaniAbacha Road	Redeem Bus Stop
		Estate Bus Stop
		Diamond Bank Bus Stop
		Mkpi Roundabout Junction
		Hospital Junction

III. RESULTS AND DISCUSSIONS

Concentration of Vehicular Pollutants across sampled roads in Yenagoa (Peak Periods (7.00am-9.00am))

The mean concentrationsand variations of vehicular emissions in bus stops along the major roads in Yenagoa at the morning peak period are displayed in Table 2. It was discovered that the mean concentration of CO was highest along Mbiama-Yenagoa Road (18.5 ppm). The NO_2 concentration was slightly different among the bus stops but the highest (0.9 ppm) was still found in Mabiama-Yenagoa road. The mean concentration of SO_2 was highest (0.7 ppm) along Mbiama-Yenagoa road. O_3 recorded the same mean concentrations along the major roads SaniAbacha road the recorded the least concentration of 0.3 ppm. PM1 varied slightly among the bus stops along the major roads with the highest (2737ug/m^3) being recorded at Isaac Boro Road. Similarly, the highest PM2.5 was recorded along the Mbiama-Yenagoa Road (1124ug/m^3) with significant variation among the bus stops ($F=8.400$; $p<0.05$). In addition, PM4, PM7, PM10 and TSP are not significantly varied among the bus stops. Mbiama-Yenagoa Road recorded the highest mean concentrations of PM7 (23.8ug/m^3) and PM10 (12ug/m^3) while Otiotio/Okaka road recorded the highest PM4 (37ug/m^3) and TSP (788ug/m^3). Except PM_{10} and PM_7 that were lower than the permissible levels of WHO and that of PM1 and PM4 that were not found, the study discovered that the concentrations of CO, NO_2, SO_2, O_3, $PM_{2.5}$, and TSP were higher than the WHO standard.

Table 2: Vehicular Emissions in Bus Stops across sampled roads in Yenagoa (Peak periods 7.00am-9.00am)

Pollutants	**Yenagoa Roads**	Mean±SD	F-Value	p-Value
CO (ppm)	Mbiama-Yenagoa road	18.5±6.1	1.349	0.280
	Otiotio/Okaka road	14±4.1		
	Isaac Boro road	16.8±7.1		
	SaniAbacha road	14.4±1.4		
	WHO	5 ppm		
NO_2 (ppm)	Mbiama-Yenagoa road	0.9±1.0	0.830	0.489
	Otiotio/Okaka road	0.6±0.2		
	Isaac Boro road	0.6±0.2		
	SaniAbacha road	0.5±0.2		
	WHO	0.05 ppm		
SO_2 (ppm)	Mbiama-Yenagoa road	0.7±0.9	0.448	0.721
	Otiotio/Okaka road	0.4±0.9		
	Isaac Boro road	0.4±0.1		
	SaniAbacha road	0.5±0.2		
	WHO	0.08		
O_3 (ppm)	Mbiama-Yenagoa road	0.4±0.05	1.884	0.157
	Otiotio/Okaka road	0.4±0.09		
	Isaac Boro road	0.4±0.05		
	SaniAbacha road	0.3±0.06		
	WHO	0.09 (8 hour mean)		
PM_1 (ug/m^3)	Mbiama-Yenagoa road	2142±359.8	1.798	0.172
	Otiotio/Okaka road	2633±394.9		
	Isaac Boro road	2737±928.9		
	SaniAbacha road	2274±517.4		
	WHO	NF		
$PM_{2.5}$ (ug/m^3)	Mbiama-Yenagoa road	1124±155.2	8.400	*0.000
	Otiotio/Okaka road	1083±185.8		
	Isaac Boro road	617±219.1		
	SaniAbacha road	934±288.9		
	WHO	NF		
PM_4 (ug/m^3)	Mbiama-Yenagoa road	36.9±3.3	0.077	0.972
	Otiotio/Okaka road	37±4.8		
	Isaac Boro road	35.9±3.5		
	SaniAbacha road	36.7±7.6		
	WHO	NF		
PM_7 (ug/m^3)	Mbiama-Yenagoa road	23.8±4.4	0.065	0.978
	Otiotio/Okaka road	23.6±4.3		
	Isaac Boro road	22.8±4.3		
	SaniAbacha road	24.1±8.7		
	WHO	35		
PM_{10} (ug/m^3)	Mbiama-Yenagoa road	12±5.1	1.118	0.360
	Otiotio/Okaka road	9.5±3.5		
	Isaac Boro road	9.5±2.3		
	SaniAbacha road	8.8±3.4		
	WHO	50		
TSP(ug/m^3)	Mbiama-Yenagoa road	666±93.3	1.1797	0.172
	Otiotio/Okaka road	788±77.2		
	Isaac Boro road	683±166.1		
	SaniAbacha road	672±134.7		
	WHO	150-230		

*Variation is significant at p<0.05; NF= Not Found

Concentration of Vehicular Pollutants across sampled roads in Yenagoa (Off-Peak Periods (11.00am-2pm))

The vehicular emissions in Yenagoa during the off peak periods are displayed in Table 3. It was discovered that the mean concentration of CO was highest along Isaac Boro road but there was no significant variation among the bus stops ($F=0.344$, $p>0.05$). Similarly, NO_2 concentration was highest at Otiotio/Okaka Road with no significant variation among the bus stops. The mean concentration of SO_2 was slightly varied among the major roads in Yenagoa with the highest being recorded for Mbiama-Yenagoa Road (0.8 ppm). O_3 recorded the same mean concentrations along the major roads in Yenagoa during the off peak periods. PM1 was not significantly varied among the bus stops along the major roads ($F=0.358$; $p>0.05$) with the highest (2087ug/m^3) being recorded at Otiotio/Okaka Road while the highest PM2.5 was recorded along the Mbiama-Yenagoa road (1032.9ug/m^3). Isaac Boro recorded the highest PM7 and PM10 respectively; although with no significant variation. The TSP was not significantly varied among the bus stops with the highest concentration being recorded in Otiotio/Okaka road (608.9ug/m^3). Except $PM_{10}PM_7$ that were lower than the permissible levels of WHO and that of PM1 and PM4 that were not found, the study discovered that the concentrations of CO, NO_2, SO_2, O_3, $PM_{2.5}$, and TSP were higher than the WHO standard.

Table 3. Vehicular Emissions in Bus Stops across Sampled Roads in Yenagoa (Off-Peak periods 11am-2pm)

Pollutant	**Yenagoa Roads**	Mean±SD	F-Value	p-Value
CO (ppm)	Mbiama-Yenagoa road	8.1±3.2	0.344	0.793
	Otiotio/Okaka road	9.5±6.2		
	Isaac Boro road	10.0±6.3		
	SaniAbacha road	7.6±4.2		
	WHO	5		
NO_2 (ppm)	Mbiama-Yenagoa road	1.1±1.2	0.149	0.929
	Otiotio/Okaka road	1.2±1.2		
	Isaac Boro road	1.0±0.9		
	SaniAbacha road	0.9±0.9		
	WHO	0.05		
SO_2 (ppm)	Mbiama-Yenagoa road	0.8±1.4	0.831	0.489
	Otiotio/Okaka road	0.3±0.1		
	Isaac Boro road	0.4±0.1		
	SaniAbacha road	0.3±0.1		
	WHO	0.08		
O_3 (ppm)	Mbiama-Yenagoa road	0.4±0.1	0.199	0.896
	Otiotio/Okaka road	0.4±0.1		
	Isaac Boro road	0.4±0.1		
	SaniAbacha road	0.3±0.1		
	WHO	0.09		
PM_1 (ug/m^3)	Mbiama-Yenagoa road	1739.3±463.5	0.358	0.784
	Otiotio/Okaka road	2087.5±518.6		
	Isaac Boro road	2072±1300.5		
	SaniAbacha road	1887.9±561.5		
	WHO	Not Found		
$PM_{2.5}$ (ug/m^3)	Mbiama-Yenagoa road	1032.9±260.6	2.069	0.129
	Otiotio/Okaka road	830.8±249.7		
	Isaac Boro road	694.6±299.3		
	SaniAbacha road	911±271.7		
	WHO	25		
PM_4 (ug/m^3)	Mbiama-Yenagoa road	33±5.5	0.295	0.829
	Otiotio/Okaka road	34.9±6.1		
	Isaac Boro road	33±6.0		
	SaniAbacha road	32.2±5.4		
	WHO	Not Found		

PM_7 (ug/m^3)	Mbiama-Yenagoa road	15.1±2.5	2.989	*0.049
	Otiotio/Okaka road	15.1±2.1		
	Isaac Boro road	20.3±5.6		
	SaniAbacha road	16.1±4.5		
	WHO	35		
PM_{10} (ug/m^3)	Mbiama-Yenagoa road	4.3±1.8	0.367	0.777
	Otiotio/Okaka road	4.2±2.2		
	Isaac Boro road	5.4±3.0		
	SaniAbacha road	4.6±2.7		
	WHO	50		
TSP(ug/m^3)	Mbiama-Yenagoa road	564.3±130.6	1.305	0.212
	Otiotio/Okaka road	608.9±134.5		
	Isaac Boro road	564.7±267.3		
	SaniAbacha road	600±161		
	WHO	150-230		

*Variation is significant at $p<0.05$; NF= Not Found

Concentration of Vehicular Pollutants across sampled roads in Yenagoa (Peak Periods (4pm-7pm))

The vehicular emissions in Yenagoa during the peak periods in the evening time are displayed in Table 4. The analysis revealed that the CO concentration was highest along Mbiama-Yenagoa Road having 21.6 ppm while the lowest mean concentration of 15.6 ppm was recorded at Isaac Boro road. It was also revealed that the mean concentration of CO (ppm) in all sampled roads were higher than the WHO permissible limits of 5 (ppm) for a 24 hour mean concentration value of CO. It was revealed that the lowest value of 0.5 ppm of $NO_2$was recorded in SaniAbacha Road and highest value (0.9 ppm) was recorded along the Mbiama-Yenagoa Road. The mean concentrations of NO_2 in all sampled roads were higher than the WHO permissible limit of 0.05 ppm in the study area. Furthermore, it was observed that the mean concentration of SO_2 was also highest along Mbiama-Yenagoa road and the remaining routes had the same concentration. The mean concentration values of SO_2 in all sampled roads were higher than the WHO permissible limits of 0.08 ppm. The mean concentration of O_3 varied very slightly among sampled roads with minimum mean value of 0.3 ppm recorded along SaniAbacha Road. Moreover, the mean concentration of PM_1 across sampled roads showed that high value of PM_1 (ug/m^3) was recorded at Otiotio/Okaka road.

The concentrations of all particulate matters except PM_4 were highest along Mbiama-Yenagoa Road, although there was no significant variation among the bus stops. Total Suspended Particle (TSP) was revealed to have highest mean aggregate value of 788 ug/m^3 being recorded at Otiotio/Okaka road. The values of TSP measured across sampled roads in the study area were all higher than the WHO permissible limits for TSP.

Table 4: Vehicular Emissions in Bus Stops across Sampled Roads in Yenagoa (Peak periods 4 pm-7pm)

Pollutant	**Yenagoa Roads**	Mean±SD	F-Value	p-Value
CO (ppm)	Mbiama-Yenagoa road	21.6±4.5	2.818	0.059
	Otiotio/Okaka road	18.1±2.6		
	Isaac Boro road	15.6±3.9		
	SaniAbacha road	17.9±4.9		
	WHO	5		
NO_2 (ppm)	Mbiama-Yenagoa road	0.5±0.1	3.287	*0.036
	Otiotio/Okaka road	0.6±0.1		
	Isaac Boro road	0.8±0.3		
	SaniAbacha road	0.7±0.2		
	WHO	0.05		
SO_2 (ppm)	Mbiama-Yenagoa road	1.4±1.1	2.265	0.105
	Otiotio/Okaka road	0.4±0.1		
	Isaac Boro road	0.8±0.6		
	SaniAbacha road	0.8±0.9		

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	WHO	0.08		
O_3 (ppm)	Mbiama-Yenagoa road	0.4±0.1	1.113	0.362
	Otiotio/Okaka road	0.4±0.1		
	Isaac Boro road	0.4±0.1		
	SaniAbacha road	0.5±0.1		
	WHO	0.09		
PM_1 (ug/m^3)	Mbiama-Yenagoa road	2414±399	1.934	0.149
	Otiotio/Okaka road	2730±391		
	Isaac Boro road	2732.7±1076		
	SaniAbacha road	3485±1364		
	WHO	Not Found		
$PM_{2.5}$ (ug/m^3)	Mbiama-Yenagoa road	1049.8±150.2	0.605	0.618
	Otiotio/Okaka road	1075.9±230.2		
	Isaac Boro road	982.3±282.7		
	SaniAbacha road	1142.4±229.9		
	WHO	25		
PM_4 (ug/m^3)	Mbiama-Yenagoa road	39.9±5.2	1.000	0.408
	Otiotio/Okaka road	40.2±4.4		
	Isaac Boro road	41.5±6.8		
	SaniAbacha road	44±4.9		
	WHO	NF		
PM_7 (ug/m^3)	Mbiama-Yenagoa road	22.2±8.5	0.536	0.662
	Otiotio/Okaka road	24.8±3.7		
	Isaac Boro road	22.8±6.3		
	SaniAbacha road	20.47.5		
	WHO	35		
PM_{10} (ug/m^3)	Mbiama-Yenagoa road	14.2±4.6	1.600	0.214
	Otiotio/Okaka road	13.1±3.0		
	Isaac Boro road	11.1±3.6		
	SaniAbacha road	10.1±4.6		
	WHO	50		
TSP(ug/m^3)	Mbiama-Yenagoa road	727.25±93.1	1.557	0.224
	Otiotio/Okaka road	776.6±99.4		
	Isaac Boro road	763.3±244.9		
	SaniAbacha road	939.9±312.2		
	WHO	150-230		

*Variation is significant at $p<0.05$; NF= Not Found

IV. DISCUSSION OF FINDINGS

The findings of the study revealed that the concentration of carbon monoxide (CO) was higher in the study area compared with the WHO permissible limits and the high concentrations of vehicular CO pollutant varied among sampled roads in capital cities during peak periods. It can be rightly stated that high levels of CO concentrations are associated with high traffic volumes and vehicular movements. Several studies have shown the direct linkages between high traffic levels and high levels of CO along road networks in Nigeria. Such findings of Abam and Unachukwu (2009) and Ibeet al., (2020) expose the direct link between vehicular traffic movements and the concentration of CO along traffic routes. Their studies further established that CO concentrations increase in time and space with reference to increasing traffic movements. Furthermore, Habermann (2011) reiterate that increase in the number of vehicles also causes traffic to flow more slowly, leading to longer times spent in congestionsand, consequently, increasing fossil fuel burning and pollution.

Similarly, the concentration of NO_2, SO_2 and O_3 were found to be slightly higher than WHO permissible limit. This finding agrees with what was established by the United States Environmental Protection Agency (USEPA) (2007) that vehicular emission accounts for about 95% of the concentrations of carbon monoxide, nitrogen oxides, sulphur oxides and particulate matter in the atmosphere especially around traffic congested areas. That is, 51% concentration for carbon monoxide, 34% for nitrogen oxides, and 10% of particulate matter released each year. These have several health implications on urban dwellers as studies have discussed the health effects of exposures to high concentrations of pollutants which have adverse health effects. Thus, the emissions from vehicular traffic movements pose serious health threat to humans (Enemari, 2001; USEPA 2007; Alfred and Hyeladi, 2013).

In addition, vehicular movements along traffic routes feature several types of vehicles which contribute varying degrees of atmospheric pollutant concentrations. For instance, vehicles like trucks and trailers are known contributors to high CO concentrations due to the nature of their engines and exhaust pipes. These vehicles are categorized as heavy duty vehicles usually old and poor operating maintenance and conditions. All these have several implications on the release of fossil fuels into the environment. For instance, USEPA in 2001 submitted that emission of pollutants from motor vehicles is influenced by vehicle type and conditions as these have implications on the levels of emission of pollutants such as hydrocarbon, carbon monoxide, and nitrogen oxide. Consequently, high levels of nitrous oxides contribute to depletion of te ozone layer that shields the earth from harmful ultraviolet radiation. Ozone (O_3) is not directly emitted from vehicular pollutants but it is formed in the atmosphere through a complex set of chemical reactions involving hydrocarbons, oxides of nitrogen and sunlight. This means that the higher the concentration of CO and NO_2 the higher the influence they will have in the formation of more ozone in air. This finding agree the findings of USEPA (2016) that high concentration of ozone are formed from emission from cars, power plants, industrial boilers, refineries, chemical plants and others which chemically react in the presence of sunlight. Therefore, the concentration of ozone might increase in the study area due to the ever-increasing flow of traffic across sampled roads. Ozone at ground level is harmful to humans and the environment (USEPA, 2016).

The concentration of particulate matter (PM) showed significant variations in Asaba (PM_4, PM_7, PM_{10}) during the peak periods in the study area. The concentration of PM_1 and $PM_{2.5}$ was highest at sampled bus stops along Onitsha-Asaba-Benin roads during the morning time peak periods. The sampled bus stops recorded high PM concentrations which were attributed to high vehicular movement at the time of air quality sampling in the study area. The Onitsha-Asaba-Benin roads is a highly busy traffic route which is mostly characterized with a lot of commercial activities as this could have triggered the release of dust particles into the air during the period of measurement. However, the concentration of PM_4, PM_7 and PM_{10} were higher at sampled roads in Port Harcourt. The concentration of PM_4, and PM_7 recorded across sampled roads in Port Harcourt were higher than the WHO permissible limit; but the concentration of PM_{10} were found to be within WHO limits. Even though, WHO permissible limits were not found for PM_1 and PM_4 but from the recorded values which showed high concentrations is an indication that the particles in air is high as a result of vehicular and socio-economic activities in sampled bus stops. It thus means that activities around sampled bus stops may also have influence on the atmospheric pollutants in the study area.

Studies have concluded that activities that contribute to biomass combustion, use of electric generating sets, leakages from wastes stacks etc., other than vehicular emissions usually contributes to increasing pollution and particulate matter concentrations in cities (Hassan and Abdullahi, 2012; Wong et al., 2012; Ibe et al., 2016; Njoku et al., 2016). Therefore, as regards to clean air and health status of the people especially those residences in close proximity to the vicinity of these bus stops are at risk of environmental health. The peak periods in the study area showed higher concentrations of pollutants when compared to the off-peak periods. For instance the mean concentrations of CO (ppm), PM_1 and PM_4 showed minimum and maximum concentration values between 8.4 ppm and 41 ppm for CO; 1056 ug/m^3 and 2921 ug/m^3 for PM_1; and 33 ug/m^3 and 61 ug/m^3 for PM_4 during the peak periods and; minimum and maximum concentration values of 5.3 ppm and 28 ppm for CO, and 802 ug/m^3 and 2331 ug/m^3 for PM_1, and 33 ug/m^3 and 46 ug/m^3 for PM_4. This means that the peak periods contribute to more atmospheric pollutants than the off-peak periods. The level of air quality index (AQI) around the vicinity of bus stops in the study area may promote serious public health concerns. The measured atmospheric pollutants which include sulphur (IV) oxide (SO2), nitrogen (IV) oxide (NO_2), carbon (II) oxide (CO) and particulate matter (PM) are among the air pollutants normally used for air pollution index/air quality index (API/AQI) calculations (Ibe et al., 2016). This finding of the studyagrees with the findings of Ibe et al., (2020) that vehicular emission are higher during the morning periods that during the afternoon periods as the morning periods are regarded as rush hour periods. The result of the study indicated that elevated concentrations of CO was recorded in the morning as compared to afternoon and evening values within Okigwe area. The lower concentrations of CO observed in the afternoon could be attributed to reduced vehicular traffic, while the concentrations in the morning may be due to higher vehicular traffic during morning rush hours. The values of 40.50 – 44.40 ppm and 46.10 – 47.80 ppm respectively represent the 25% and 75% of the results recorded in the morning, afternoon and evening.

V. CONCLUSION AND RECOMMENDATIONS

The study can be concluded that the concentrations of CO, NO_2, SO_2, O_3, $PM_{2.5}$, and TSP were higher than the WHO standard along the major roads in Yenagoa. In addition, Mbiama-Yenagoa road was highly polluted with traffic emissions more than other major roads especially at the peak periods in the morning and evening. The study thus recommended that vehicles causing the release of pollutants to the environment should be evacuated with serious promulgation and implementation of an environmental policy.

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