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Research Paper

Spatial Analysis of the Relationship between Vehicular Count and Vehicular Emissions Along traffic corridors in Asaba, Delta State, Nigeria

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Abstract
The study examined the spatial analysis of the relationship between vehicular count and vehicular emissions along traffic corridors in Asaba, Delta State, Nigeria. Thirty bus stops were randomly selected along the four major roads (Onitsha-Asaba-Benin Road, Summit Road, Okpanam Road and Nnebisi 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 the CO concentrations was highest along Okpanam Road having 19.8 ppm while the lowest mean concentration of 8.4 ppm was recorded at sampled roads on Onitsha-Asaba-Benin road and NO_2 was highest along the Summit Roads. However, high values of PM_1 (ug/m^3) were recorded at Okpanam road while $PM_{2.5}$ revealed the highest mean concentration value of 1130 ug/m^3 at the Onitsha-Asaba-Benin road. However, Okpanam recorded the highest total vehicular count of 4283 (25.9%) and the lowest 3974 (24.1%) along Onitsha-Asaba-Benin road during the morning time peak period. Results also showed that generally, 26% of vehicles were found in the morning, 24.5% in the afternoon while 24.4% were found in the evening. There was significant relationship between vehicular emissions and CO ($r=0.461$; $p<0.05$) in the morning peak period; PM_{10} ($r= 0.385$) and O_3 ($r= -0.394$; $p<0.05$) in the afternoon off peak periods and SO_2 ($r= -0.368$; $p<0.05$) in the evening peak period. The study concludes that the increase in the vehicle count has significantly led to the increase in CO and PM_{10} and decrease in O_3 and SO_2. The study recommended that the government should promulgate laws that will apprehend the commuters using vehicles that are possible to emit vehicular pollutants such as CO into the environment.
Keywords: *Relationship, Vehicular counts, Vehicular emissions, Peak period, Off peak periods*

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I. Introduction

Air is of vital importance to human beings from their first gasp to their last breath. Clean air is vital to human survival and well-being, but in today's urbanized world, clean air is something that is increasingly hard to find. Road transport has become by far the major source of environmental pollution and traffic congestion in urban areas. The continual traffic growth has raised concerns over the impact of traffic emissions on human health and urban environmental quality, and has fuelled the demand for a coherent regulatory framework for the management of traffic, air quality and emission at urban level, as well as at regional and national scales. Cities have long been known to be society's predominant engine of innovation and wealth creation, yet they are also its main source of crime, pollution, and disease. [1], showed that processes relating urbanization to economic development and know-ledge creation are very general, being shared by all cities belonging to the same urban system and sustained across different nations and times but that there are efficiencies of scale; quantities reflecting wealth creation and innovation have increasing returns, whereas those accounting for infrastructure show economies of scale.

Recent estimates show that 60–80 % of final energy use globally is consumed by urban areas [2] and more than70 % of global greenhouse gas emissions are produced within urban areas [3]. As a result, also environmental pollution increases with urbanization. [4] found that urban NO_2 pollution, like other urban properties, is a power law scaling function of the population size: NO_2 concentration increases proportional to population raised to an exponent. The value of the exponent varies by region from0.36 for India to 0.66 for China, reflecting regional differences in industrial development and per capita emissions. [5] found a near-linear relationship between population size and carbon emissions suggests that large urban areas in the U.S. are only slightly more emissions efficient than small ones. For each year in their sample, variation in population size across cities in the U.S. urban system explained approximately 70 % of the variation of CO_2 emissions. Already in 1973, [6] described the relation between population and urban heat island effect. The high density of buildings and roads can cause so-called urban heat islands defined as built up areas that are hotter than nearby rural areas [7]. [8] showed that in Europe green space coverage increases more rapidly than city area, but that a decline in green space availability per capita accelerates with increasing population density, suggesting that access to green space could decline rapidly as cities grow, increasing the geographical isolation of people from opportunities to experience nature. In cities, environmental exposures such as air pollution [9]; temperature [10] and noise [11] have been associated with adverse health effects, while ultraviolet radiation (UVR) [12] and green space [13] have been associated with both positive and negative health effects, and are therefore important to measure and control. Today, more than two thirds of the European population lives in urban areas and this share continues to grow. The development of our cities will determine the future economic, social and territorial development of the European Union [14]. Urban sprawl and the spread of low-density settlements is one of the main threats to sustainable territorial development; public services are more costly and difficult to provide, natural resources are overexploited, public transport networks are insufficient and car reliance and congestion in and around cities are heavy.

Environmental problems constitute one of the key challenges of the 21st century, and urban air pollution is a major health hazard worldwide [15]. Air pollution results from four main sources namely; industrialization, tobacco smoking, domestic cooking and vehicular or machinery fuel combustion [16]. However, the level of air pollution depends on a country's technology and pollution control. Motor vehicles in developing countries cause serious air pollution because they are concentrated in a few large cities, besides, many are in poor mechanical conditions, and few if any emission standards exist. Transportation-related emissions are the dominant source of air pollutants, which contribute to the environmental problems today. In 2002, the nationwide transportation sources were responsible for 82% of the carbon monoxide (CO), 56% of the nitrogen dioxide (NO_2), 45% of the volatile organic compounds (VOCs), 12% of the lead (Pb) emissions, and 5% of sulfur dioxide (SO_2) [17]. In addition to the criteria pollutants, the transportation sector was also the second largest source of carbon dioxide (CO_2) emissions in the United States [18]. It directly emitted approximately 27% of total U.S. greenhouse gas (GHG) emissions in 2003. Of the major environmental problems, transportation-related emissions are causes of acid rain, the greenhouse effect, ozone pollutants, etc. Transportation-related emissions are important because they have significantly negative impacts on living creatures.

The motor vehicle engine emits many types of pollutants including nitrogen oxides. (NO_x), volatile organic compounds (VOCs), carbon monoxide (CO), carbon dioxide ($C0_2$), particulates, Sulphur dioxide (SO_2) and lead [19]. Emissions are related to use of the engine, mainly the fuel type and the temperature of combustion. If the engine is 100% efficient, then the products of combustion will be CO_2 and water (H_2O). However, at low loads engines are inefficient and therefore the products of incomplete combustion dominate, for example CO and VOCs in petrol engines and carbon monoxide, VOCs and smoke in diesels. As the temperature of combustion increases; the efficiency of conversion to CO_2 and water increases. However, impurities in the fuel such as nitrogen are oxidised to NO_2. At high temperatures, atmospheric nitrogen (N_2) is also oxidised to NO_2, hence at higher loads and speeds, NO_2 production dominates [19]. Many studies used exposure to vehicular traffic intensity as their method to evaluate exposure, understood as the number of vehicles passing through a certain road, during a specific period of time. The majority considered the annual mean of daily traffic and only [20] and [21] used car/hour counts to estimate exposure. According to the objective proposed in each study, the following were considered: the traffic of the nearest main road [22]; the traffic of the nearest road [23] or the traffic of roads (main ones or not) included in distances (buffers) of up to 50 m [24], 100 m [24]; 150 m [23] and 300 m [24]. The majority were based on vehicular traffic in relation to the homes of individuals. One study considered the place of work [25] and another one, schools [26]. The values of vehicle flow were obtained by general count, not specifying the type of vehicle, except for the studies by [26] and [19], which distinguished the flow of cars from that of trucks. A total of three studies applied questionnaires and obtained the self-reported traffic intensity on the street of residence [27]. In another methodological approach, the measure of traffic was obtained by multiplying the length of roads close to the homes of the population studied by the daily mean of vehicle flow on such roads [28]. The density of vehicles provides an estimate of the potential of exposure to emissions from fuel evaporation when vehicles are parked at night, once such evaporation is an important source of organic volatile gases, such as benzene [21]. In another study conducted by [21], the length of the streets in a buffer of 150 m/500 feet around an individual' geocoded address was added and this value was subsequently divided by the buffer area.

The rapid increase in the number of cars is of a deep concern with respect to traffic congestion in Asaba. The decrease in average car speed due to traffic congestion has led to an increase in the total vehicle exhaust emissions in the city. Congested traffic corridors in dense areas of the city are key contributors to the degradation of urban air quality. According to monitoring data, vehicle exhaust has become one of the main factors affecting the State capitals' air quality. Therefore, there is need for an assessment of the relationship between the number of vehicles and vehicular pollutants (in-situ) in and around the bus tops. Few studies have examined air pollution exposure in Nigerian transportation environments. However, existing evidence suggests that metro environments may be associated with elevated levels of air pollutants. In consideration of this; the activity of commuting may represent a significant proportion of daily exposure to these pollutants for metro commuters [29]. Thus, this study is focusing at the vehicular count and vehicular emissions in the vicinity of bus stops in Asaba.

II. Materials and Methods

The study was carried out in Asaba, Delta State, Nigeria. The study area is located in latitudes between 6^0 07' 30''N and 6^0 20' 30''N and longitudes between 6^0 37' 30''E and 6^0 45' 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[30].

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 [31]. 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 [32]. 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 [33].

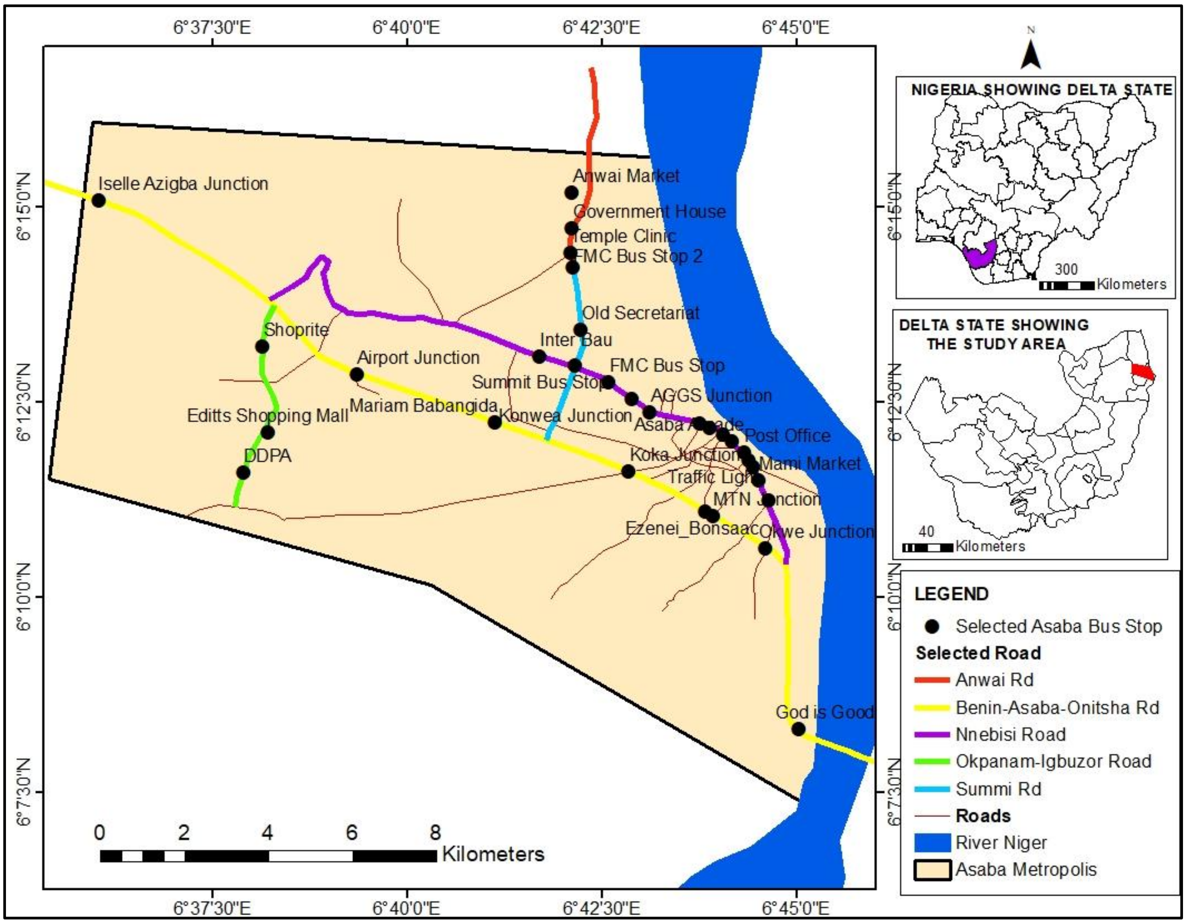

Figure 1: Asaba Metropolis showing Bus Stops and Major Roads

Relief of the study area is undulating in other words the high and low lands, which characterizes the place. Most of the study area is lowland except some spots in the northern part of Akwa Ibom 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 [31]. 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 [34].

The study area is underlain by the Coastal Plain sands having its place from the Pleistocenic Formation [35]. 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.

The study made use of both 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 vehicular emissions and number of vehicles. The relationship between the frequency of vehicles and the levels of concentrations of air pollutants was determined using correlation statistics. 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.

Table 1. Trunk A Roads and Bus Stops

State	Trunk A Roads	Bus Stops
Delta	Onitsha-Asaba-Benin Road	Toll gate
		God is Good
		Abraka
		Okwe Junction
		Federal College
		MTN Junction
		Ezenei/Bonsaac Junction
		Former Deputy Junction
		Koka Junction
		Summit
		Mariam Babangida Junction
		Airport Junction by Vanguard
		Estate Junction near Dublina Hotel
		Okpanam Junction
		Iselle Azagba Junction
	Nnebisi Road	Abraka Bus stop
		Federal College Junction
		Mami Market
		Traffic Light
		Post Office |Junction
		Grand Hotel Bus Stop
		Asaba Arcade
		Ogbeogonogo Market
		Mecab Bus Stop
		Ibusa Junction
		Asaba Station
		AGGS Junction
		Konwea Plaza Junction
		FMC Bus Stop
		Saint Patrick's College
		Inter Bau Roundabout
	Summi Road	Summit Bus Stop at DLA junction
		Old State Secretariat Bus Stop
	Anwai Road	FMC Bus Stop 2
		Temple Clinic
		Government House
		Anwai Market
	Okpanam Road	Shoprite Bus Stop
		Edith Supermarket
		DDPA
		Cabinet Junction
		House of Assemble Junction
		GABBS Junction
		DBS Junction
		The Doom Event Centre
		Delta City Supermarket
		Legislative Quarters
		Crunches
		Redeemer's Junction
		Redeem Junction
		Rain Oil
		Post Office Junction
		Plenty Sign Board
		Okpanam Junction

III. Results and Discussion

Concentration of Vehicular Emissions across sampled roads in Asaba

The mean concentrations of vehicular emissions in bus stops along the major roads in Asaba at the morning peak period, afternoon off peak period and evening peak period are displayed in Table 2. The analysis revealed that the CO concentrations was highest along Okpanam Road having 19.8 ppm while the lowest mean concentration of 8.4 ppm was recorded at sampled roads on Onitsha-Asaba-Benin road. It was revealed that the lowest value of 0.5 ppm of NO_2 (Nebisi and Okpanam roads in Asaba) and highest value was recorded along the Summit Roads. The mean concentrations of SO_2 along the roads were almost similar while the mean concentration of O_3 varied slightly among sampled roads with minimum mean value of 0.3 ppm recorded along Onitsha-Benin and Nnebisi roads.

However, the mean distribution of PM_1 across sampled roads showed that high values of PM_1 (ug/m^3) were recorded at Okpanam road. The distribution of $PM_{2.5}$ revealed that the highest mean concentration value of 1130 ug/m^3 was recorded at the Onitsha-Asaba-Benin roads. The distribution of PM_4 revealed that the mean concentration values varied slightly among sampled roads in the study area during the morning time peak periods with the lowest mean concentration value of 33.5 ug/m^3 recorded at Nnebisi roads. The information for the mean concentration of PM_7 across sampled roads in the study area is showed that the lowest mean concentration value of 20.5 ug/m^3 was recorded at Nnebisi roads in Asaba during the morning time peak periods. Analysis of PM_{10} also showed that the lowest mean concentration value of 5.9 ug/m^3 was recorded at Nnebisi roads during the morning time peak periods. Total Suspended Particles (TSP) which describes the aggregate of all suspended PM in air was revealed to have highest mean aggregate value of 839 ug/m^3 being recorded under the sampled roads in Onitsha-Asaba-Benin roads.

The vehicular emissions in Asaba during off peak periods showed that the mean concentrations of CO and NO_2 were highest along Summit Road. The mean concentration of SO_2 was highest in Nnebisi Road (0.5 ppm). PM_1 was highest (2331 ug/m^3) at Onitsha-Asaba-Benin Road while the highest $PM_{2.5}$ was recorded along the Nnebis Road (1157.3 ug/m^3). Okpanam Road and Summit Road recorded the highest PM_7 and PM_{10} respectively.

It was discovered that the mean concentration of CO was highest along Okpanam Road (20.6 ppm). The mean concentration of SO_2 and O_3 were highest in Ontisha-Asaba-Benin Road. Similarly, the highest $PM_{2.5}$ was recorded along the Onitsha-Asaba-Benin Road (1284 ug/m^3). Onitsha-Asaba-Benin Road recorded the highest mean concentrations of PM_4 (41 ug/m^3) and TSP (1283.4 ug/m^3) while Okpanam Road recorded the highest PM_7 (28.8 ug/m^3) and PM_{10} (15.7 ug/m^3).

Table 2: Vehicular Emissions in Bus Stops across along traffic corridors in the sampled roads in Asaba

		Peak Period (7am-9am)	Off Peak Period (11am-2pm)	Peak Period (4pm-7pm)
Emissions	**Roads**	Mean±SD	Mean±SD	Mean±SD
CO (ppm)	Onitsha-Asaba-Benin road	8.4±1.8	5.3±0.9	12.5±1.8
	Nnebisi road	10.6±3.2	6.8±2.0	12.2±4.1
	Summit road	19.2±7.9	7±2.0	15.1±4.2
	Okpanam road	19.8±7.2	6.2±2.0	20.6±2.6
NO_2 (ppm)	Onitsha-Asaba-Benin road	0.8±0.8	1.6±1.4	0.7±0.2
	Nnebisi road	0.5±0.1	2.3±1.7	0.7±0.3
	Summit road	0.7±0.1	2.4±1.5	0.6±0.2
	Okpanam road	0.5±0.1	1.5±2.0	0.6±0.1
SO_2 (ppm)	Onitsha-Asaba-Benin road	0.5±0.6	0.3±0.7	1.6±1.1
	Nnebisi road	0.4±0.1	0.5±0.2	0.8±0.3
	Summit road	0.4±0.1	0.4±0.2	0.5±0.1
	Okpanam road	0.5±0.1	0.4±0.1	0.5±0.1
O_3 (ppm)	Onitsha-Asaba-Benin road	0.3±0.03	0.3±0.1	0.5±0.1
	Nnebisi road	0.3±0.08	0.3±0.1	0.4±0.2
	Summit road	0.4±0.05	0.3±0.1	0.4±0.1
	Okpanam road	0.4±0.09	0.3±0.1	0.4±0.03
PM_1 (ug/m^3)	Onitsha-Asaba-Benin road	2921±99.5	2331±52.8	5075.9±485
	Nnebisi road	2680±765.8	2302.4±261.2	3999.5±1324
	Summit road	3296±1156.3	1976±282.5	4826±271
	Okpanam road	2391±1221	2121.9±300.7	2253.7±1227
$PM_{2.5}$ (ug/m^3)	Onitsha-Asaba-Benin road	1130±409.5	1120.1±57.2	1284.4±116.9
	Nnebisi road	894±338.1	1157.3±115.7	1135.3±1324.4
	Summit road	624±366.3	1143.2±116.7	1106.7±451.5
	Okpanam road	792±289.6	1134.1±114.6	875±102.6
PM_4 (ug/m^3)	Onitsha-Asaba-Benin road	36.8±2.6	35.7±4.1	41±3.1
	Nnebisi road	33.5±4.1	35.1±6.4	38±8.4
	Summit road	37.3±2.5	36.4±5.8	31.8±5.9
	Okpanam road	46.9±12.2	38.3±2.5	46.7±8.5

PM_7 (ug/m^3)	Onitsha-Asaba-Benin road	21.7±1.9	15.2±2.5	14.6±5.2
	Nnebisi road	20.5±3.6	14.8±2.5	14.3±3.8
	Summit road	24.7±2.0	15.4±2.5	20.5±3.03
	Okpanam road	31.3±10.9	15.8±2.6	28.8±5.8
PM_{10} (ug/m^3)	Onitsha-Asaba-Benin road	7.5±2.3	1.6±0.8	6.8±2.0
	Nnebisi road	5.9±0.9	3.1±2.3	7.1±1.6
	Summit road	8.5±1.9	3.5±2.6	9.8±2.9
	Okpanam road	14.6±6.6	3.3±2.5	15.7±5.0
TSP (ug/m^3)	Onitsha-Asaba-Benin road	839.5±44.4	700.7±7.3	1283.4±113.1
	Nnebisi road	726.8±172.6	703.9±50.8	1039.1±310.8
	Summit road	798.2±159	713±54.2	1198.8±101.6
	Okpanam road	655±192.6	773.1±42.8	643.6±253.3

Spatio-temporal Number of Vehicular Count across sampled Roads (Peak & Off-Peak Periods

The number of vehicles at bus stops during peak and off-peak periods in Asaba is displayed on Table 3. It was revealed that sampled roads in Okpanam recorded a total vehicular count of 4283 (25.9%) which was highest and the lowest vehicular count of 3974 (24.1%) along Onitsha-Asaba-Benin road during the morning time peak period. The off peak period during the afternoon period recorded highest vehicular count of 3944 (26.4%) still at sampled roads along Okpanam while the least vehicular count of 3497 (23.4%) was recorded at sampled roads along Summit in Asaba. Similarly, the results obtained for the vehicular count during the evening time peak period also showed highest traffic count of 4265 (26.1%) at sampled roads along Nnebisi in Asaba. However the lowest total vehicular count of 3844 (23.5%) was recorded along Summit roads in Asaba. Thus, the overall mean vehicular traffic counts were 563, 507 and 556 during the morning, afternoon and evening time of peak and off-peak periods in the study area. The summary in Table 4 shows that generally, 26% were found in the morning, 24.5% in the afternoon while 24.4% were found in the evening.

Table 3: Number of Vehicles at Bus Stops (Peak and Off-Peak Periods) in Asaba

Roads	Peak Periods between 7.00am and 9.00am				
	Number of Bus stops	Total Vehicular Count	% Vehicular Count	Statistics	
				Mean±SD	Overall Mean
Onitsha-Asaba-Benin	9	3974	24.1	442±117	563
Nnebisi	8	4214	25.5	527±138	
Summit	6	4026	24.5	671±155	
Okpanam	7	4283	25.9	612±147	
Total	30	16497	100.0		
	Off-Peak Periods between 11.00am and 2.00pm				
Onitsha-Asaba-Benin	9	3762	25.2	418±107	507
Nnebisi	8	3724	25.0	466±97	
Summit	6	3497	23.4	583±124	
Okpanam	7	3944	26.4	563±150	
Total	30	14927	100.0		
	Peak Periods between 4.00pm and 7.00pm				
Onitsha-Asaba-Benin	9	4040	24.7	449±143	556
Nnebisi	8	4265	26.1	533±125	
Summit	6	3844	23.5	641±159	
Okpanam	7	4203	25.7	600±140	
Total	30	16352	100.0		

Table 4: Summary of Number of Vehicular Count in Asaba

Capital Cities	No. of Bus Stops	Peak (7.00am-9.00am)		Off-Peak (11.00am-2.00am)		Peak (4.00pm-7.00pm)	
		Total Vehicular Count	% Vehicular Count	Total Vehicular Count	% Vehicular Count	Total Vehicular Count	% Vehicular Count
Asaba	30	16497	26.0	14927	24.5	16352	24.4

Relationship between Volume of Vehicular Count and Levels of Vehicular Emissions

The data on Table 5 show results for the correlation matrix between volume of vehicular Traffic and atmospheric pollutants in the study area. The correlation between volume of vehicular traffic and the concentration of atmospheric pollutants was not significant for all sampled pollutants during the peak periods between 7.00am and 9.00am; however correlation was significant between volume of vehicular traffic and concentration of CO (ppm) ($r=0.461; p<0.05$) in the study area. During the off-peak periods the relationship between volume of vehicular traffic and atmospheric pollutants was significant between traffic volume and concentration of O_3 (ppm) (r=-0.394;p<0.05). The correlation was also significant between traffic volume and concentration of PM_{10} (r=0.385; p<0.05) during the off-peak periods in the study area. The results also showed that correlation was significant between traffic volume and SO_2 (ppm) (r=-0.368; p<0.05).

Table 5. Correlation Matrix between Volumes of Traffic & Pollutants Concentration in Asaba

Atmospheric Pollutants	Morning (Peak periods 7am-9am)		Afternoon (Off-Peak periods 11am-2pm)		Evening (Peak periods 4pm-7pm)	
	r	r^2	r	r^2	r	r^2
CO (ppm)	0.461*	0.212521	0.332	0.110224	0.353	0.124609
NO_2 (ppm)	0.088	0.007744	0.049	0.002401	0.036	0.001296
SO_2 (ppm)	0.071	0.005041	0.126	0.015876	-0.368*	0.135424
O_3 (ppm)	0.212	0.044944	-0.394*	0.155236	-0.085	0.007225
PM_1 (ug/m^3)	0.028	0.000784	-0.155	0.024025	0.011	0.000121
$PM_{2.5}$ (ug/m^3)	0.253	0.064009	-0.238	0.056644	-0.075	0.005625
PM_4 (ug/m^3)	0.102	0.010404	0.179	0.032041	-0.148	0.021904
PM_7 (ug/m^3)	0.159	0.025281	0.319	0.101761	0.238	0.056644
PM_{10} (ug/m^3)	0.032	0.001024	0.385*	0.148225	0.136	0.018496
TSP (ug/m^3)	0.137	0.018769	0.261	0.068121	-0.002	0.000004

*Correlation is significant at p<0.05; r=correlation coefficient; r^2=Coefficient of determination

IV. Discussion of Findings

The volume of vehicular traffic count at the vicinities of bus stops revealed higher traffic count at some sampled bus stops. The traffic congestion in Asaba could be due to population increase with different human activities. More significantly, is also the fact that Asaba rising traffic can be linked to the fact that the capital city is a metropolitan city with improved commercial and industrial activities due to the presence of oil and gas activities which serves as magnets attracting population on a high scale into the city. The study agrees with [36] that large metropolitan areas will always be characterized by heavy traffic congestion due to the characteristics they possess.

The study discussed further by exposing the fact that peak-hour traffic congestion is an inherent result of the way metropolitan societies operate. It stems from the widespread desires of people to pursue certain goals that inevitably overload existing roads and transit systems every day. The sampled bus stops along sampled roads like Okpanam and Nnebisi roads are usually loaded with lots of vehicular movements especially during peak periods (morning and evening). The same reason applies here because a quick consideration of the population figures projected for Port Asaba in the last decade [37] shows higher population figures for Asaba in the recent times. It means rapid urbanization will mean increasing population which will in turn increase socio-economic activities that will necessitate the need for people to move from time to time especially during trip generating periods. The finding of [38] agrees with the finding of the study that traffic congestion is becoming worse in metropolitan areas as the population and urban growth increases. The study also discovered that more vehicular movement mean more pollutant concentration especially carbon monoxide from auto exhaust fumes. This was why higher CO concentrations were recorded in Ontisha-Asaba-Benin Road and Okpanam Road in the study area. As reported by [39] that in typical urban areas cars, buses, trucks, and off-highway mobile sources such as construction vehicles and boats produce at least half of the hydrocarbons and nitrogen oxides in the atmosphere.

The findings of the study revealed that the concentration of carbon monoxide (CO) was high in the study area especially when the concentration values across sampled roads are related with the WHO permissible limits. The sampled bus stops are therefore locations of high concentrations of vehicular CO pollutant which varied among sampled roads in capital cities during peak periods. Peak periods are periods that generate heavy vehicular movements especially at these sampled bus stops due to the fact that these bus stops are major road arteries that connect other major and minor road arteries in the study area. 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 [40] and [41] 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, [42] reiterate that increase in the number of vehicles also causes traffic to flow more slowly, leading to longer times spent in congestions and, consequently, increasing fossil fuel burning and pollution.

V. Conclusion and Recommendations

The study concludes that the increase in the vehicle count has significantly led to the increase in CO and PM_{10} and decrease in O_3 and SO_2. The study recommended that the government should promulgate laws that will apprehend the commuters using vehicles that are possible to emit vehicular pollutants such as CO into the environment. More research should be encouraged in a larger space like entire Local Government Area, State Senatorial Districts and States.

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