Inspection of the Impact of Vehicular Emissions on some Air Quality Parameters in Zaria Metropolis, Kaduna, Nigeria.

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ABSTRACT

This study examined the influence of traffic density on the concentrations of some air pollutants: particulate matter (PM), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO), carbon dioxide (CO_2) and hydrocarbons (C_xH_y) in four traffic hotspots which served as sampling points within Zaria Metropolis at morning peak, evening peak, and off-peak periods, respectively. Data was collected and analyzed using standard methods.

Results of the average traffic density showed that PZ Junction had the highest traffic density of 3257.330 ± 0.580 v/h. The mean concentrations of PM and CO_2 were below recommended standards. NO_2, SO_2 and CO mean concentrations were within the recommended standard while C_xH_y mean concentration was higher than the recommended standard. Mean concentrations of each of the pollutants was higher at peak traffic periods than at off-peak traffic periods. The pollutants showed high correlation with traffic density. Authors recommend improved road network and construction of modern roundabouts for reduction of peak period traffic.

(Keywords: air pollutants, impact, determination, traffic, density, vehicular emissions)

INTRODUCTION

Population explosion, rapid urbanization, and industrial development have led to a dramatic increase in vehicular usage during the last decade. These have provoked some serious concerns for the environment (Reza and Singh, 2010; Miranda *et al.,* 2015). The emission of pollutants by vehicles into the atmosphere as a result of traffic density emanating from high fleet growth, increased population, increased urbanization and economic improvement have caused serious damage to the environment (Akpan *et al.,* 2014).

Air pollution is the emission of toxic elements into the atmosphere by natural or anthropogenic sources (Bernstein *et al.,* 2004). Automobile transport emissions have been identified as key factors in the deterioration of the urban air environment, constituting up to 90% of urban air pollution (USEPA, 1994). The main by-products resulting from the combustion of vehicular fuels used for automobile transport are carbon dioxide and water but inefficiencies and high temperature inherent in engine operation encourage the production of many other pollutants of varying effects. Therefore, vehicular emission remains a threat to the environment which is expected to increase reasonably as vehicle ownership increases in the world. Over 600 million individuals globally have been estimated to be exposed to hazardous level of pollutants emanating from vehicular emissions (Abam and Unachukwu, 2009).

It is a known fact that vehicular emission leads to the accumulation of both primary and secondary pollutants in the atmosphere. The primary pollutants include carbon monoxide, carbon dioxide, nitrogen oxides, sulfur oxides, hydrocarbons, heavy metals and particulate matter. These primary pollutants usher in secondary pollutants such as photochemical smog (Reyes, 2006; Khitoliya, 2007), fog, ground level ozone, and peroxyacetylnitrate (PAN) which arise from the chemical reactions of primary pollutants possibly involving the natural component of the atmosphere especially water and oxygen.

Road vehicle emissions come from both light duty vehicles (gasoline powered vehicles) and heavy duty vehicles (diesel powered), the light duty vehicles emit more of hydrocarbons otherwise known as volatile organic compounds (VOC_S), and carbon monoxide whereas the heavy-duty vehicles emit more of nitrogen oxides (NOx) and particulate matter (Sawyer, 2010). According to the local emissions inventory (GDF, 2002) in Mexico City Metropolitan Area (MCMA), over 99% of carbon monoxide (CO), 83% of nitrogen oxides (NOx), 20% of ammonia (NH_3), and 38% of volatile organic hydrocarbons (VOC) that are emitted to the atmosphere originate from mobile (light duty and heavy-duty vehicles) sources. However, many researchers have also affirmed that vehicular emissions could have negative impact on the air quality of urban environment (Abam and Unachukwu, 2009; Utang and Peterside, 2011).

The World Health Organization (WHO) estimates 2.4 million fatalities due to air pollution each year (WHO, 2013). According to the latest report on air quality (EEA, 2013), air pollution implications are mainly due to high levels of particulate matter (PM) and ozone (O_3) in the atmosphere. These pollutants have been known to adversely affect plants, animals and human (Naveed *et al.,* 2010). For instance breathing of polluted air has been proved to have severe health effects such as asthma (Schwela, 2000) and increased cardiovascular risks (Hoffmann *et al.,* 2007).

Most countries have strengthened laws to control air quality in the past decade. Polluted air is considered a super-regional problem therefore, international conferences have recently developed different ways to improve and assure air quality employing global strategic perspectives (Curtis *et al.,* 2007). Despite such enormous scientific and legislative efforts to measure and improve air quality levels, many people are still exposed to hazardously pollute breathing air on a daily basis (Cohen *et al.,* 2005).

A lot of studies have been conducted on vehicular emissions, air quality and impact for instance examination of the concentrations of vehicular emissions at traffic congestion points in Kaduna and Abuja, Nigeria (Ndoke and Akpan, 1999); **v**isualizing air pollution research activity using density-equalizing mapping and scientometric benchmarking procedures (Zell *et al.,* 2010); modeling of the instantaneous traffic emission and the influence of traffic speed limits (Panis *et al.,* 2006); development of models that can account for speed fluctuations and allow instantaneous emission modeling (Rakha *et al.*, 2004; Cornelis *et al.*, 2005; El-Sgawarby *et al.,* 2005); study on the impact of traffic volumes on air quality in Uyo Urban, Akwa Ibom State, Nigeria (Akpan *et al.,* 2014) and spatio-Temporal variations in urban vehicular emissions in Uyo City, Akwa Ibom State, Nigeria in which the finding had implications for public health in the region under study as such calls for the need to control emissions of these obnoxious air pollutants in the city (Prince and Ubokobong, 2014).

Currently there is paucity of data on vehicular emissions, traffic density and air quality of Zaria Metropolis, Kaduna State, Nigeria. However, author had initially assessed the impact of vehicular emissions on the proximate composition of roadside *Amaranthus hybridus* in Zaria Metropolis, Kaduna State, Nigeria (Ekwumemgbo *et al.,* 2015). The objective of this study therefore, is to investigate the influence of traffic density on some air quality parameters: particulate matter (PM), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO), carbon dioxide (CO_2) and hydrocarbons (C_xH_y) within Zaria Metropolis, Kaduna State, Nigeria.

This study determines the emission level at traffic hotspot considering peak and off-peak periods. It is based on the hypothesis that vehicular emissions during peak and off-peak periods are different and that the concentration of the pollutants in the air of Zaria Metropolis could be influenced by traffic density leading to reduction in air quality.

MATERIALS AND METHODS

Study Area

This study was conducted in Zaria Metropolis, Kaduna State, Nigeria over a period of six weeks between the 4^{th} of March and the 14^{th} of April, 2013. The sampling points consisted of four (4) high traffic points which includes Rex Junction, PZ Junction, MTD Junction and Kwangila Fly-Over (Figure1). The exact positions of the points are $11^o6^125^{11}$ N, $7^o43^126^{11}$ E**;** $11^o6^117^{11}$ N, $7^o43^113^{11}$ E**;** $11^o7^126^{11}$ N, $7^o42^148^{11}$ E and $11^o813511$ N, $7^o42^173^{11}$ E, respectively.

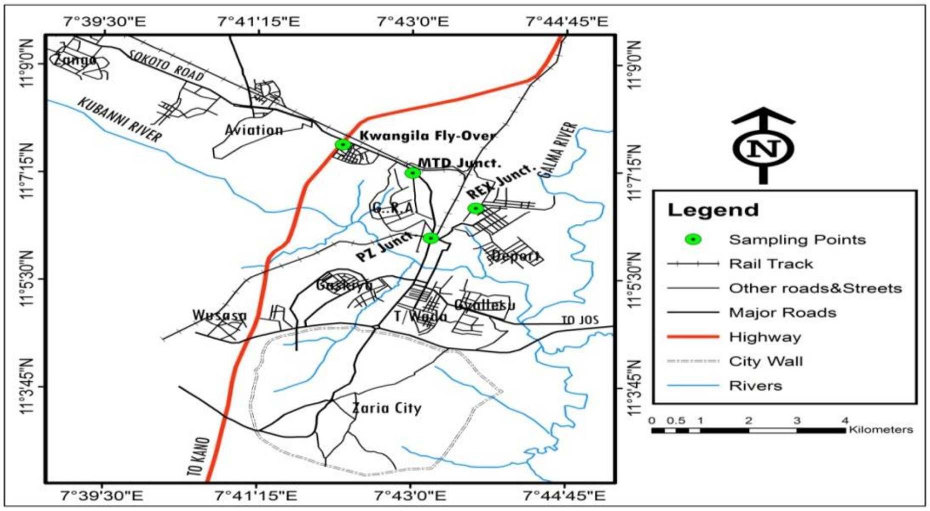

Figure 1: Map of Zaria Metropolis showing Sampling Sites (Ekwumemgbo *et al*., 2015)

Data Collection and Analysis

GP220X model Global Positioning System (GPS) was used in taking coordinates of the sampling locations. Collection of data from the sampling points was carried out in three time periods for three working days within the study time frame (4^{th} of March to 14^{th} of April, 2013)**.** These three time periods are as follows: 7.00 am – 10.00 am morning peak hours; 10.00 am – 1.00 pm off-peak hours; 4.00 pm – 7.00 pm evening peak hours. The data collection consists of the traffic flow survey and the environmental survey. The traffic flow survey involved the observation and collection of traffic flow data from the four traffic junctions by direct counting method (tally sheet method). The traffic density is expressed in number of vehicle per hour (v/h).

Particulate matter was measured using the Hazdust (HD 1000 model) emission analyzer. Nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO), and hydrocarbons (C_xH_y) were measured using the Growncon Gasman auto sampler (CE89/336/EEC model) which is an automated instrument while CO_2 was measured using the GE 2028 model gas analyzer (Ndoke and Akpan, 1999; Ekwumemgbo *et al.,* 2015).

Statistical Data Analysis

Data were presented graphically and further analysis was based on descriptive and inferential statistics. The descriptive statistics included measures of central tendency and variation (dispersion). The inferential statistical tool was simple regression analysis. Data collection was carried out in triplicate for each of the parameters.

RESULTS AND DISCUSSION

Air Pollutants

Particulate Matter (PM): The mean concentrations of PM for morning traffic peak period were 192.000 ± 3.000 µg/m^3, 181.000 ± 2.000 µg/m^3, 173.000 ± 2.000 µg/m^3 and 213.000 ± 2.000 µg/m^3 at Rex Junction, PZ Junction, MTD Junction and Kwangila Fly-Over, respectively. The mean concentrations for evening peak traffic period were 192.000 ± 2.000 µg/m^3, 193.000 ± 2.000 µg/m^3, 202.000 ± 2.000 µg/m^3 and 213.000 ± 1.000 µg/m^3 for Rex Junction, PZ Junction MTD Junction and Kwangila Fly-Over, respectively. During the off-peak, the mean concentrations were 125 ± 2.000 µg/m^3, 126.000 ± 1.000 µg/m^3, 120.000 ± 1.000 µg/m^3 and 139 ± 1.000 µg/m^3 at Rex Junction, PZ Junction MTD Junction and Kwangila Fly-Over, respectively, as presented in Table 1.

Nitrogen Dioxide (NO_2): The mean concentrations of NO_2 during morning peak traffic period were 0.040 ± 0.010 ppm, 0.041 ± 0.001ppm, 0.039 ± 0.003 ppm and 0.042 ± 0.004 ppm at Rex Junction, PZ Junction, MTD Junction and Kwangila Fly-Over, respectively. The mean concentrations for evening peak traffic period were 0.420 ±0.002 ppm, 0.043 ± 0.000 ppm, 0.040 ± 0.001 ppm and 0.045 ± 0.002 ppm at Rex Junction, PZ Junction MTD Junction and Kwangila Fly-Over, respectively, while during the off-peak, the mean concentrations were 0.023 ± 0.001 ppm, 0.033 ± 0.001 ppm, 0.029 ± 0.001 ppm and 0.035 ± 0.001 ppm at Rex Junction, PZ Junction MTD Junction and Kwangila Fly-Over, respectively, as presented in Table 1.

Sulphur Dioxide (SO_2): The mean concentrations of SO_2 during morning peak traffic period were 0.040 ± 0.010 ppm, 0.041 ± 0.000 ppm, 0.040 ± 0.000 ppm and 0.042 ± 0.001 ppm at Rex Junction, PZ Junction, MTD Junction, and Kwangila Fly-Over, respectively. The mean concentrations for evening peak traffic period were 0.040 ±0.001 ppm, 0.041 ± 0.000 ppm, 0.040 ± 0.002 ppm and 0.042 ± 0.002 ppm at Rex Junction, PZ Junction, MTD Junction, and Kwangila Fly-Over, respectively, while during the off-peak, the mean concentrations were 0.027 ± 0.001ppm, 0.037 ± 0.001ppm, 0.033 ± 0.000 ppm and 0.032 ± 0.002 ppm at Rex Junction, PZ Junction MTD Junction and Kwangila Fly-Over, respectively, as presented in Table 1.

Carbon Monoxide (CO): The concentrations of CO during morning peak traffic period were 14.300 ± 0.300 ppm, 16.800 ± 0.100 ppm, 14.600 ± 0.400 ppm, and 18.100 ± 0.200 ppm at Rex Junction, PZ Junction, MTD Junction, and Kwangila Fly-Over, respectively. During the evening peak traffic period, the concentrations were 14.700 ± 0.200 ppm, 17.300 ± 0.300 ppm, 15.100 ± 0.100 ppm, and 18.600 ± 0.100 ppm at Rex Junction, PZ Junction, MTD Junction and Kwangila Fly-Over, respectively, while during the the off-peak period, the concentrations were 11.000 ± 0.500 ppm, 12.000 ± 0.500 ppm, 10.000 ± 0.500 ppm and 11.500 ± 0.500 ppm at Rex Junction, PZ Junction, MTD Junction and Kwangila Fly-Over, respectively, as presented in Table 1.

Carbon Dioxide (CO_2): The mean concentrations of CO_2 during morning peak traffic period were 346.000 ± 2.100 ppm, 348.000 ± 2.000 ppm, 347.000 ± 2.00 ppm, and 347.000 ± 0.200 ppm at Rex Junction, PZ Junction, MTD Junction and Kwangila Fly-Over, respectively. During the evening peak traffic period, the concentrations were 347.000 ± 2.000 ppm, 349.000 ± 1.000 ppm, 348.000 ± 0.000 ppm, and 348.000 ± 2.650 ppm at Rex Junction, PZ Junction, MTD Junction and Kwangila Fly-Over, respectively, while during the off-peak period, the concentrations were 342 ± 0.000 ppm, 343.000 ± 1.000 ppm, 341.000 ± 1.000 ppm and 342.000 ± 1.000 ppm at Rex Junction, PZ Junction, MTD Junction and Kwangila Fly-Over, respectively, as presented in Table 1.

Hydrocarbons (C_xH_y): The concentrations of H_xC_y during morning traffic peak period were 0.060 ± 0.010 ppm, 0.070 ± 0.005 ppm, 0.060 ± 0.003 ppm, and 0.060 ± 0.000 ppm at Rex Junction, PZ Junction, MTD Junction, and Kwangila Fly-Over, respectively. The concentrations for evening peak traffic period were 0.060 ±0.020 ppm, 0.070 ± 0.010 ppm, 0.057 ± 0.001 ppm, and 0.060 ± 0.001 ppm at Rex Junction, PZ Junction MTD Junction, and Kwangila Fly-Over, respectively, while during the off-peak, the concentrations were 0.031 ± 0.000 ppm, 0.040 ± 0.001ppm, 0.030 ± 0.000 ppm and 0.001 ± 0.000 ppm at Rex Junction, PZ Junction, MTD Junction and Kwangila Fly-Over, respectively, as presented in Table 1

Traffic Density

Morning Peak Period: During morning peak traffic period, the traffic count for the various classes of vehicles at Rex Junction were 1024.67 ± 4.73 v/h, 498.33 ± 8.50 v/h, 28.33 ± 2.52 v/h, 1248.67 ± 9.29 v/h, and 45.33 ± 3.06 v/h for cars, minibuses, heavy-duty vehicles, motorcycles and tricycles, respectively. At PZ Junction, the traffic count were 1348.00 ± 3.61 v/h, 487.67 ± 1.53 v/h, 57.67 ± 2.08 v/h 1320.67 ± 1.53 v/h and 43.33 ± 1.53 v/h for cars, minibuses, heavy-duty vehicles, motorcycles and tricycles. Respectively. At MTD Junction, the traffic count were 1156.67 ± 12.90 v/h, 411.00 ± 6.93 v/h, 52.67 ± 3.66 v/h, 1223.00 ± 4.36 v/h and 33.67 ± 153 v/h for cars, minibuses, heavy-duty vehicles, motorcycles and tricycles, respectively.

Table 1: Air Quality Parameters Measurements (Field Triplicate analysis).

Sampling sites	PM ($\mu g/m^3$)	NO_2 (ppm)	SO_2 (ppm)	CO (ppm)	CO_2 (ppm)	H_xC_y (ppm)
Morning Peak						
Rex Junction	192.000 ± 3.000	0.040 ± 0.010	0.040 ± 0.010	14.300 ± 0.300	346.000 ± 2.100	0.060 ± 0.010
PZ Junction	181.000 ± 2.000	0.041 ± 0.001	0.041 ± 0.000	16.800 ± 0.100	348.000 ± 2.000	0.070 ± 0.005
MTD Junction	173.000 ± 2.000	0.039 ± 0.003	0.040 ± 0.000	14.600 ± 0.400	347.000 ± 2.000	0.060 ± 0.003
Kwangila Fly-Over	213.000 ± 2.000	0.042 ± 0.004	0.042 ± 0.001	18.100 ± 0.200	347.000 ± 0.000	0.060 ± 0.000
Off Peak						
Rex Junction	125.000 ± 2.000	0.023 ± 0.001	0.027 ± 0.001	11.000 ± 0.500	342.000 ± 0.000	0.031 ± 0.000
PZ Junction	126.000 ± 1.000	0.033 ± 0.001	0.037 ± 0.000	12.000 ± 0.500	343.000 ± 1.000	0.040 ± 0.001
MTD Junction	120.000 ± 1.000	0.029 ± 0.001	0.033 ± 0.000	10.000 ± 0.500	341.000 ± 1.000	0.030 ± 0.000
Kwangila Fly-Over	139.000 ± 1.000	0.035 ± 0.001	0.032 ± 0.002	11.500 ± 0.500	342.000 ± 1.000	0.030 ± 0.000
Evening Peak						
Rex Junction	192.000 ± 2.000	0.042 ± 0.002	0.040 ± 0.010	14.700 ± 0.200	347.000 ± 2.000	0.060 ± 0.020
PZ Junction	193.000 ± 2.000	0.043 ± 0.000	0.041 ± 0.000	17.300 ± 0.300	349.000 ± 1.000	0.070 ± 0.010
MTD Junction	202.000 ± 2.000	0.040 ± 0.001	0.040 ± 0.002	15.100 ± 0.100	348.000 ± 0.000	0.057 ± 0.001
Kwangila Fly-Over	213.000 ± 1.000	0.045 ± 0.002	0.042 ± 0.002	18.600 ± 0.100	348.000 ± 2.650	0.060 ± 0.001

At Kwangila Fly-Over, the traffic count were 1391.33 ± 7.31 v/h, 413.00 ± 6.08 v/h, 90.33 ± 3.79 v/h, 1254.00 ± 1.00 v/h and 25.67 ± 0.58 v/h for cars, minibuses, heavy-duty vehicles, motorcycles and tricycles, respectively, as presented in Figure 2.

Evening Peak Period: The traffic count for the various classes of vehicles during the evening peak traffic period at Rex Junction were 1025.67 ± 4.73 v/h, 502.00 ± 6.08 v/h, 29.00 ± 2.00 h/v, 1249.00 ± 9.29 v/h and 46.67 ± 2.25 v/h for cars, minibuses, heavy-duty vehicles, motorcycles, and tricycles, respectively. At PZ Junction, the traffic counts were 1349.00 ± 3.79 v/h, 488.67 ± 3.21 v/h, 57.33 ± 4.16 v/h, 1322.67 ± 1.53 v/h, and 46.00 ± 3.6 v/h for cars, minibuses, heavy-duty vehicles, motorcycles and tricycles, respectively. At MTD Junction, the traffic counts were 1157.00 ± 12.49 v/h, 410.33 ± 6.03 v/h, 51.67 ± 3.06 v/h, 1222.00 ± 7.00 v/h, and 34.67 ± 1.53 v/h for cars, minibuses, heavy-duty vehicles, motorcycles and tricycles, respectively. At Kwangila Fly-Over, the traffic counts were 1393.00 ± 7.21 v/h, 415.67 ± 6.66 v/h, 90.33 ± 5.69 v/h, 1257.33 ± 1.15 v/h, and 29.00 ± 2.00 v/h for cars, minibuses, heavy-duty vehicles, motorcycles and tricycles, respectively, as depicted in Figure 3.

Off-Peak Period: The traffic count for the various classes of vehicles during the off-peak at Rex Junction were 600.67 ± 5.03 v/h, 283.33 ± 2.08 v/h, 51.33 ± 1.53 v/h, 825.33 ± 6.11 v/h, and 23.00 ± 1.00 v/h for cars, minibuses, heavy-duty vehicles, motorcycles and tricycles, respectively. At PZ Junction, the traffic count were, 648.00 ± 5.57 v/h, 318 ± 7.02 v/h, 57 ± 2.00 v/h, 808.67 ± 7.57 v/h, and 29.33 ± 2.08 v/h for cars, minibuses, heavy-duty vehicles, motorcycles and tricycles, respectively. At MTD Junction, the traffic count were 574.00 ± 11.5 v/h, 304.67 ± 4.7 v/h, 51.33 ± 3.05 v/h, 839.67 ± 2.25 v/h, and 25.33 ± 1.53 v/h for cars, minibuses, heavy-duty vehicles, motorcycles and tricycles, respectively. At Kwangila Fly-Over, the traffic count were 637 ± 9.85 v/h, 300.00 ± 6.08 v/h, 58.66 ± 1.53 v/h, 799.00 ± 10.82 v/h, and 28.33 ± 2.08 v/h for cars, minibuses, heavy-duty vehicles, motorcycles and tricycles, respectively, as illustrated in Figure 4.

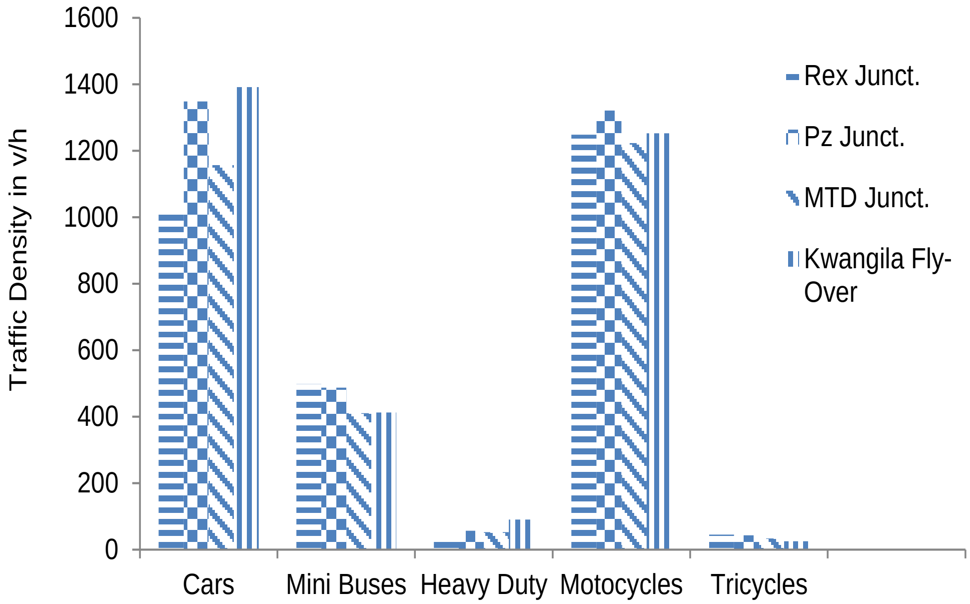

Figure 2: Morning Peak Traffic Density.

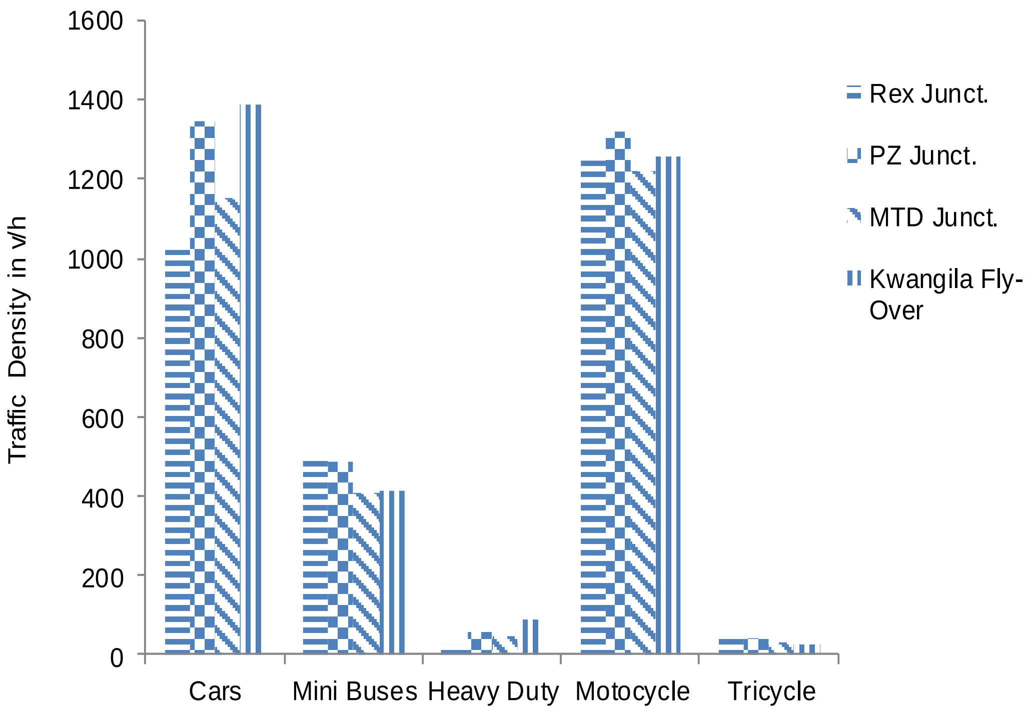

Figure 3: Evening Peak Traffic Density.

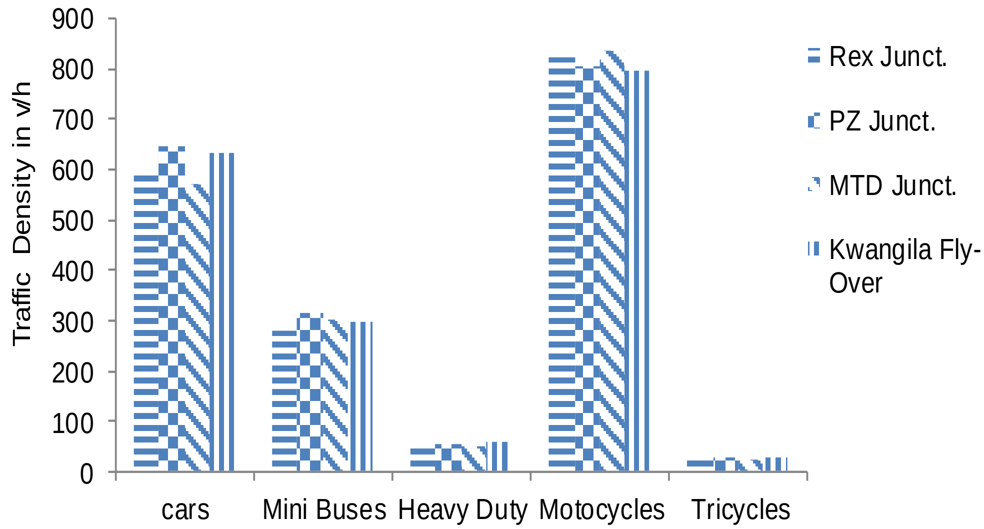

Figure 4: Off-Peak Traffic Density.

A comparison of the mean traffic density data obtained at each of the experimental sites during the morning peak traffic period, evening peak traffic period and off-peak traffic period shows that PZ Junction had the highest traffic density of 3257.33±0.58 v/h. This could be as a result of the fact that PZ Junction is centrally located with much commercial activities ranging from small, medium and large scale businesses; banks; Government establishments and so on. There was no significant ($p < 0.05$) difference in the traffic density of each of the classes of vehicles at each of the experimental sites during morning and evening peak traffic periods but the traffic density for all classes of vehicles during off-peak traffic period was significantly ($p < 0.05$) low when compared to the density obtained during peak traffic periods.

Correlation Coefficient of Air Quality Parameters and Traffic Density

From the regression analysis presented in Table 2 which shows the correlation coefficient (R) for each of the pollutants as they correlate with traffic density. PM showed a negligible correlation with traffic density at R = 0.30, 0.30 and 0.22 for morning peak, off-peak and evening peak periods, respectively. NO_2, SO_2, CO, CO_2, and C_xH_y showed high correlation with traffic density at R = 0.80, 0.80, 0.88, 0.82, and 0.72, respectively during morning peak traffic period. During the evening peak traffic period; NO_2, SO_2, CO, CO_2 and C_xH_y showed high correlation with traffic density at R = 0.73, 0.82, 0.89, 0.81, and 0.77, respectively.

During off-peak traffic period; NO_2, SO_2, CO, CO_2 and C_xH_y showed high correlation with traffic density at R = 0.77, 0.86, 0.79, 0.78, and 0.84, respectively. The low correlation for PM could be an off-chance situation since the Significance F is very large ranging from 0.69 – 0.78 for morning peak, off-peak and evening peak traffic periods. Generally, the high positive correlation of the parameters considered agree with already documented results which stated that increase in traffic density could increase the air pollutants load resulting from vehicular emissions (Wallington *et al.,* 2008).

Table 2: Correlation Coefficients of Air Quality Parameters and Traffic Density.

Coefficients	PM	NO_2	SO_2	CO	CO_2	H_xC_y
Morning Peak						
R	0.30	0.80	0.80	0.88	0.82	0.72
R^2 (%)	9.00	64.00	64.00	77.44	67.24	51.84
F	0.20	3.46	3.65	7.02	4.07	2.18
Sig. F	0.69	0.20	0.20	0.12	0.18	0.28
Evening Peak						
	PM	NO2	SO_2	CO	CO_2	HxCy
R	0.22	0.73	0.82	0.89	0.71	0.77
R^2 (%)	4.84	53.29	67.24	79.21	50.41	59.29
F	0.10	2.32	3.98	7.81	3.68	2.82
Sig. F	0.78	0.27	0.18	0.11	0.19	0.23
Off-peak						
	PM	NO_2	SO_2	CO	CO_2	HxCy
R	0.30	0.77	0.86	0.79	0.78	0.84
R^2 (%)	9.00	59.29	73.96	62.41	60.84	70.56
F	0.2	2.88	5.89	3.22	3.04	4.62
Sig. F	0.69	0.23	0.14	0.21	0.22	0.16

CONCLUSION

The concentrations of all the air pollutants analyzed were higher during peak traffic periods than during off-peak traffic period at all locations. The peak traffic period average concentration of PM and CO_2 were below NAAQS limit. NO_2, SO_2, and CO average concentrations at peak traffic periods were within the NAAQS limit range for NO_2, SO_2, and CO, respectively, while the average concentration of C_xH_y at peak traffic periods were higher than the NAAQS limit but below standard limit at off-peak traffic period.

The concentration of NO_2 SO_2, CO, CO_2, and C_xH_y showed high correlation with traffic density except for PM which showed a very low correlation. This implies that vehicular emissions can increase the concentration of air pollutants in Zaria metropolis and could lead to atmospheric pollution with increasing population influx and vehicular traffic.

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