An analysis of the level of vehicular emission in Kaduna Metropolis

Samaila Alhassan Sati[1]*

Aderemi Johnson Dare[1]

Abstract

Vehicular emissions are one of the major sources of air pollution in urban centres due to the use of petrol and diesel fuels. This study analysed the level of vehicular emissions in Kaduna Metropolis. A longitudinal research design was used. Data were acquired on the Road Network of Kaduna Metropolis, level of concentration of gases, Statistics of the motor vehicles movement at each sampling point, type of vehicle, make, age and the fuel used. Copies of the relevant questionnaire were distributed at eleven established sampling points (parks). Gaseous elements examined included Carbon Monoxide (CO), Volatile Organic Compound (VOC), Nitric Oxide (NO_2), Hydrogen Sulphite (H_2S) and Sulphur Dioxide (SO_2). The concentration of CO exceeded the accepted safe limits especially at morning peak periods. Toyota Liteace was the most used commercial vehicle; 74% of these vehicles are propelled by petrol fuel. Not less than 91% of drivers of such vehicles suffer from illnesses due to the polluted air at least once a month. Regular maintenance of commercial vehicles and awareness campaigns are suggested as measures to mitigate vehicular emissions. Government should establish a reliable and efficient mass transit system to reduce the number of individual vehicles and motorcycles on roads thus, reducing harmful emissions.

Keywords: Kaduna Metropolis, vehicular emissions, gaseous elements, fuel, parks

[1]Department of Geography, Faculty of Arts and Social Sciences, Nigerian Defense Academy, PMB 2109 Kaduna, Kaduna State, Nigeria.

*Corresponding Author's e-mail:ismailhassansati6@gmail.com

Received on January 21st, 2021/ Accepted on January 31st, 2022

Ghana Journal of Geography Vol. 14 (1), 2022 pages 1-22

Doi: https://dx.doi.org/10.4314/gjg.v14i1.1

Introduction

Incomplete combustion of fossil fuels leads to the release of carbon monoxide into the atmosphere, which is a pollutant that affects the quality of the entire atmosphere. This, in turn, affects all living things that depend on air for respiration (Ewing, 2001; Cervero, 2001). Carbon monoxide emissions from the exhaust of motor vehicles such as buses and cars have a negative effect on passengers and people that commute using this means of transportation. Exposure to these emissions either, for a short or long period, interferes with the circulation of oxygen in the human body. Cadle *et al*., (2000) reported death from professional drivers in London due to stomach and lung cancer (Lorry drivers), raised mortality rates from bladder cancer, leukaemia, and other lymphatic cancers (taxi drivers). A study in Vienna, Austria showed that diesel exhaust comprised 12 - 33 % of total PM in the air. Diesel exhaust is very strongly linked with lung cancer, especially for people who are occupationally exposed (Kpaka, 2003). The largest anthropogenic source of carbon monoxide CO in the United States is vehicular emissions (USA EPA, 2007). The Environmental Protection Agency, (EPA) in the United States reports that vehicular emissions account for 51% of carbon monoxide (CO), 34% of Nitrogen oxide (NO_2) and 10% of particulate matter released each year in the US (US EPA, 2007). Motor vehicles emit 70% of diesel exhaust Particulate Matter (PM) in California, and the department of public health indicated that exposure of 30 ppm for 8 hours may be a serious risk to the health of sensitive people (Subramani, 2012).
The proliferation and rampant use of private vehicles to commute within the urban environment have always created problems of congestion, accidents, parking, pollution, chaotic situation, and car dependency that are detrimental to passenger convenience (Kadiyali, 2005). However, it is the most ideal means of transport devised by man. Its advantages include quick travel, freedom to adhere to a fixed timetable, possibilities of carrying luggage at will, and the shared enjoyment of driving at will, whenever and to wherever (Atta, 2018). Most of the vehicles used for commercial transportation are imported into the country when quite old with worn out engines and low energy efficiencies. Consequently, such vehicles profusely emit exhaust gases, which may be harmful to both human health and the environment (Bateebe, 2011). Old vehicles are gross polluters of our environment (Subramani, 2012). Air pollution is caused by existing vehicular emissions is known to have already contributed to an increase in asthma, acute respiratory diseases, and even sometimes resulted in death (Lekwot *et al*., 2013). Vehicular emissions cause both short- and long-term problems associated with health effects. Yet, the most popular mode of transport for intra-urban commuters in Kaduna metropolis is by use of commercial vehicles, mainly mini-buses. Most of such vehicles are often old and lack adequate maintenance. Thus, it is an environmental hazard that requires investigation, since it may shorten the lifespan of those exposed to it. Kaduna Metropolis is an urban area with high traffic congestion, in which the general population is being exposed on daily basis to this poisonous gas called Carbon monoxide among others (Robert, 2015). The Nigerian Federal Environmental Protection Agency (FEPA) stipulated the minimum standard of 10 ppm for CO, 0.04 -0.06 ppm for NO_2 and 0.01 ppm for Sulphur Oxides (SO_2). However, public awareness of these standards is minimal.

Researches have been carried out on vehicular emission, especially regarding its health implications. However, most researchers restricted their studies to specific aspects, such as Gidde and Sonawane (2012), that investigated the relationship between air quality and traffic rate in a Metropolitan city. Lekwot, *et al*. (2013) carried out their study on Public health effects from vehicular emissions in Kaduna Metropolis focusing on the major roads. There was no particular reference to the role of commercial vehicles in this study although they are the major culprits. Robert (2015) only compared Carbon Monoxide Concentrations with Set standards measuring carbon monoxide (CO) concentrations in air at some selected traffic junctions in Port-Harcourt metropolis. The present work, therefore, seeks to address the information gap, which exists on the level of vehicular emissions from commercial vehicles and the extent or level of risks to which the health of the drivers is exposed as a result of their constant exposure to the hazard. Specific objectives of this study include: identifying the state of vehicular emissions from vehicles and the categories of vehicles that produce these emissions into the atmosphere, as well as examining the effects of vehicular emissions on the health of vehicle drivers and possible ways of reducing vehicular emission in Kaduna Metropolis.

Study Area

Kaduna Metropolis is the administrative centre of the state where most administrative and economic activities take place. The state is structured into 23 local government areas (LGAs) with 46 development areas. The Metropolis is made up of Kaduna North and Kaduna South Local Government Areas (LGAs) that make up the old Northern Nigerian Territory Board and the rapidly developing urban peripherals of Igabi and Chikun LGAs figure 1; (Dantudu, 2014). Figure 1 shows that the Metropolis is almost at the centre of Kaduna State surrounded by Soba, Kajuru, and parts of Igabi and Chikun LGAs. The study area lies between Latitudes 10^0 24' 00" and 10^0 28' 00 " North, and Longitudes 7^0 20' 00" and 7^0 28' 00" East (Figure 2). Its central location renders communication with the rest of the country relatively easy and facilitates the influx of people and agricultural inputs and produce into it. It lies on elevation ranging from 600 m to 650 m above sea level. The approximate aerial dimension of the metropolis is $262km^2$.

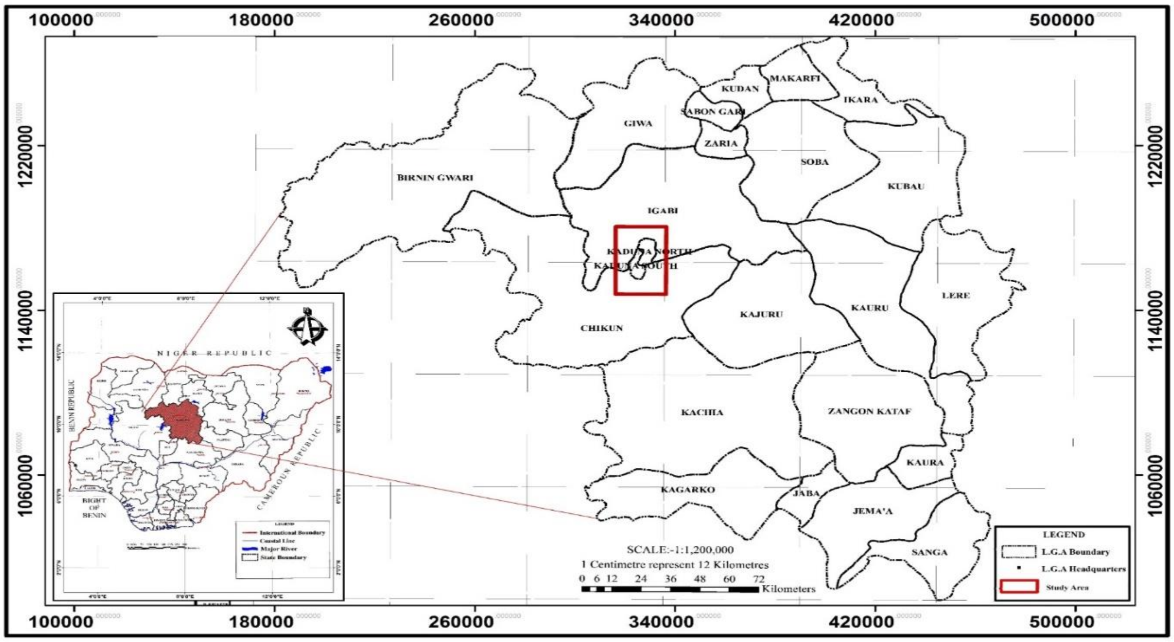

Figure 1: Kaduna State, showing the Study Area (Kaduna Metropolis)
Source: Kaduna Polytechnic Library (2016).

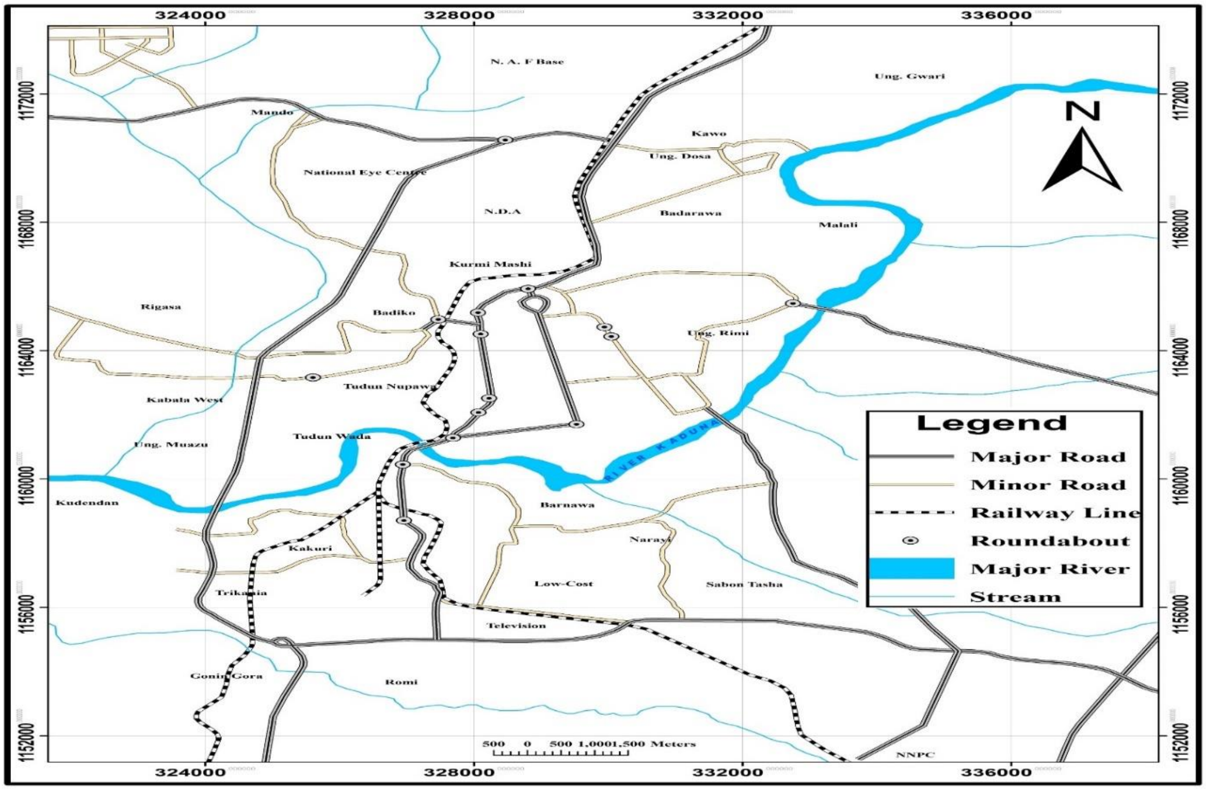

Figure 2: The Study Area (Kaduna Metropolis)
Source: Kaduna Polytechnic Library (2016).

Materials and Methods

Research Design

A longitudinal research design, which follows the same sample over time and makes repeated observations, was adopted for this study (Kalaian and Rafa, 2008; Ployhart and Robert, 2010).

Type and Sources of Data

Data Types

The data for this included both spatial and attribute data and they are as follows:

i. Road Network of Kaduna Metropolis from the Street Guide of Kaduna at a Scale 1:25,000;
ii. Local Government Areas and District boundaries from the Administrative Map of Kaduna State at Scale 1:500,000;
iii. The photographs of motor vehicle movements at sampling points for visual impression;
iv. The concentration level of gases (Ammonia, Carbon Monoxide, Volatile Organic Compound, Nitric Acid, Hydrogen Sulphite and Sulphur Dioxide) emissions from motor vehicle movements at sampling points;
v. Statistics of motor vehicle movements;
vi. The socio-economic data of both commercial and non-commercial drivers;
vii. Information on the type, make, age of vehicles, and types of fuel used;

The data for this study were obtained from different sources:

i. Field measurement: Levels of the gases (Ammonia, Carbon monoxide, Volatile Organic Compound, Nitric Acid, Hydrogen Sulphite and Sulphur Dioxide) emissions were obtained from the sampling points by use of MultiRAE 3000 Series Combustible Gases and Vapors.
ii. Counting: Motor Vehicle Count; Statistics of the motor vehicles movement at each sampling point were done using manual counting and recordings;

iii. Questionnaire: Socio-economic data from commercial bus drivers, One on one interview with drivers;
iv. Street Guide of Kaduna Metropolis at Scale 1:25,000 from Kaduna Polytechnic, Kaduna.

Sampling Frame and Technique

The sampling frame for this study was the registered commercial vehicles that ply the roads of Kaduna Metropolis. According to the Kaduna State Road Agency (KADRA), the official agency in charge of commercial vehicle registration in Kaduna state, the number of commercial vehicles in Kaduna metropolis is about 3705, while there are lots that are not registered with KADRA. The sampling design for this study was a simple random technique, which allowed respondents to be selected only by chance to avoid any kind of influence and to also allow for those that may decline to answer the questionnaire. The sample size was based on the size of registered commercial vehicles in Kaduna Metropolis, which was put at 3705. This figure is relatively large, hence the adoption of Singh's (2002) sample size formula:

Sample Size = $[(z^2 * p * q) + d^2] / [d^2 + (z^2 * p * q / N)]$

Where:

z = the expected confidence interval (90% adopted and 'z' Table value = 1.65)

p = the expected response (50%)

q = 1 – p

d = the tolerable limit s of error (taken to be 5% or 0.05)

N = Population

Hence, the sample size was calculated to be 253.

Since this study primarily targeted commercial vehicles, samples were collected from areas where they are usually concentrated (motor parks), the commonly used points of loading and offloading passengers.

Kaduna Metropolis is an urban area with high population density and infrastructure of the built environment. In Kaduna Metropolis, motor parks like Sabon Tasha Market, Gate- Kasuwa, Television Garage, Kakuri Market (Airforce), Kawo, Mando, Ungwan Sarki, Command Junction, Abuja Junction, Bakin Ruwa and Refinery Junction parks were observed to experience high traffic and frequent traffic congestion as earlier established by Atta (2018). Therefore, the authors established these parks as sampling points from which samples of vehicular emissions were collected, and copies of the questionnaire were distributed. The selection of these parks as sampling points was based on factors like traffic density, pollution status and traffic congestion. To determine the number of copies of the questionnaire to be administered in each park, a reconnaissance survey was earlier carried out by going to all the parks to understand what classes of respondents would be involved and establish the extent of each park. This enabled the distribution of the copies of the questionnaire based on the size of each park (Table 1).

Table 1: Questionnaire Distribution

Parks	Area (m^2)	Copies. of Questionnaire
Television Garage	15355.30	29
Gate – Kasuwa	4580.76	9
Kawo	25921.15	49
Mando	52217.53	98
Command Junction	3300.81	6
Abuja Junction	15163.53	29
Sabo Garage	5495.40	10
Kakuri Airforce	1451.37	3
Bakin Ruwa	2527.92	5
Refinery Junction	4916.28	9
Ungwan Sarki	3136.08	6
Total	134066.12	253

Source: Fieldwork (2018)

Questionnaire Administration

The survey instrument for data collection was the questionnaire with structured questions directed at the commercial bus drivers in Kaduna Metropolis to gather information about the socio-economic implications of the vehicular emission and to establish the real consequences of vehicular emission on the health of the drivers. The questionnaire had two sections. The first section collected personal information on each respondent. The second section contained technical questions relating to the health of the respondents. The questionnaire also sampled people’s views on what they think could be done to reduce these harmful exhausts emissions.

In the questionnaire administration, the simple random sampling technique was used. Since the respondents were both literate and illiterate, the researcher read and explained the contents of the questionnaire to the respondents as well as recorded their responses.

Instrument Calibration Methods

To obtain readings for the vehicular emission, the following steps employed.

Gas Test

MultiRAE 3000 Series Combustible Gases and Vapors (LEL-1) units were used; it was allowed to boot for about ten (10) minutes to complete MultiRAE 3000 Series booting cycle. This enabled proper normal instrument working operation. The MultiRAE 3000 Series commenced when the instrument showed 'GAS TEST' on the display. A countdown progress bar also appeared at the bottom of the display. The Trigger regulator then supplied gas to the MultiRAE 3000 Series whilst the progress bar started to count down. It took about thirty to forty-five (30-45) seconds to complete the progress bar. The instrument was then disconnected from the test gas and the unit returned to its normal mode. The MultiRAE 3000 Series unit compared with what it measured from the bottle with the standard gas values known to be in the bottle gave the reading.

Laboratory Calibration Test

MultiRAE 3000 Series calibration was performed at the Kaduna Refinery and Petrochemical Company (KRPC) Laboratory, using the stand-alone gas cylinders, which contained multi-gas mixtures for laboratory calibration of multiple gases at once, including common mixtures such as carbon monoxide, hydrogen sulfide, and combustibles for LEL sensor calibration. A test gas of known composition was applied to verify sensors response and alarm function. This process was repeated three consecutive times to ensure accuracy and to eliminate errors before the instrument was taken to the field for field calibration test as required before data collection.

Field Calibration Test

On arrival to the field, the MultiRAE 3000 Series unit was first set at Zero for 15 minutes before commencing the gas test, according to the manufacturer's instructions manual. MultiRAE 3000 Series unit was then switched on to ensure normal operation. Then, the flow plate clipped onto the front of the unit and the hose was attached from the trigger regulator. The outlet hose was then attached to the 'vent gas away' and the magnet swiped over the bubble label on the front of the unit, near the main button. The MultiRAE 3000 Series began the Gas Test and showed 'GAS TEST' on the display. A countdown progress bar also appeared at the bottom of the display. An alternate screen message also beeped up from the display and the button was pressed within 10 seconds to confirm Calibration. As the gas flowed, the MultiRAE 3000 Series allowed the sensors to respond and then adjust the value for each gas channel to match the stored calibration gas value within each sensor i-module. A confirmation massage beeped up on the display reading 'calibration successful', which means that all channels were calibrated successfully within the allowed time.

Method of Data Collection

The spatial and non-spatial (attribute) data were collected using the following methods:

Spatial Data / Attribute Data Collection

The existing administrative map of Kaduna State was acquired. From this map, the boundaries of the metropolis were extracted. The road network of the metropolis was extracted from the street guide of the Kaduna metropolis. The locations of important features like the markets, filling stations, garages/motor parks and institutions were also extracted from the street guide. All these extractions were done using ArcGIS 10.0 software. Proper understanding of the dynamics of an area as well as its orientation underscores the need for these data sets.

The bulk of the attribute data were obtained from the field through observations and measurements. Air samples were measured randomly within parks in the study area (Figure 3). Motor traffic count was conducted manually in each of the parks to obtain the volume of traffic at the sampling points. Both in and out coming motor vehicular movements were accounted. Motor traffic count enabled the estimation of vehicles that contribute to vehicular emission around a sampled point. The counting was done within the space of 45 minutes to avoid repetition.

The time frame for data collection from the sampling points was carried out concurrently in eleven weeks, one week per sampling point, at three (3) periods for a duration of seven (7) days of the week that is, from Monday to Sunday, which covered complete vehicular movements within the week at the sampling points. These timings were categorized as follows: 7.30 am – 9.30 am - morning peak hours, 12.30 pm – 2.30 pm -afternoon peak hours, and 4.30 pm – 6.30 pm - evening peak hours.

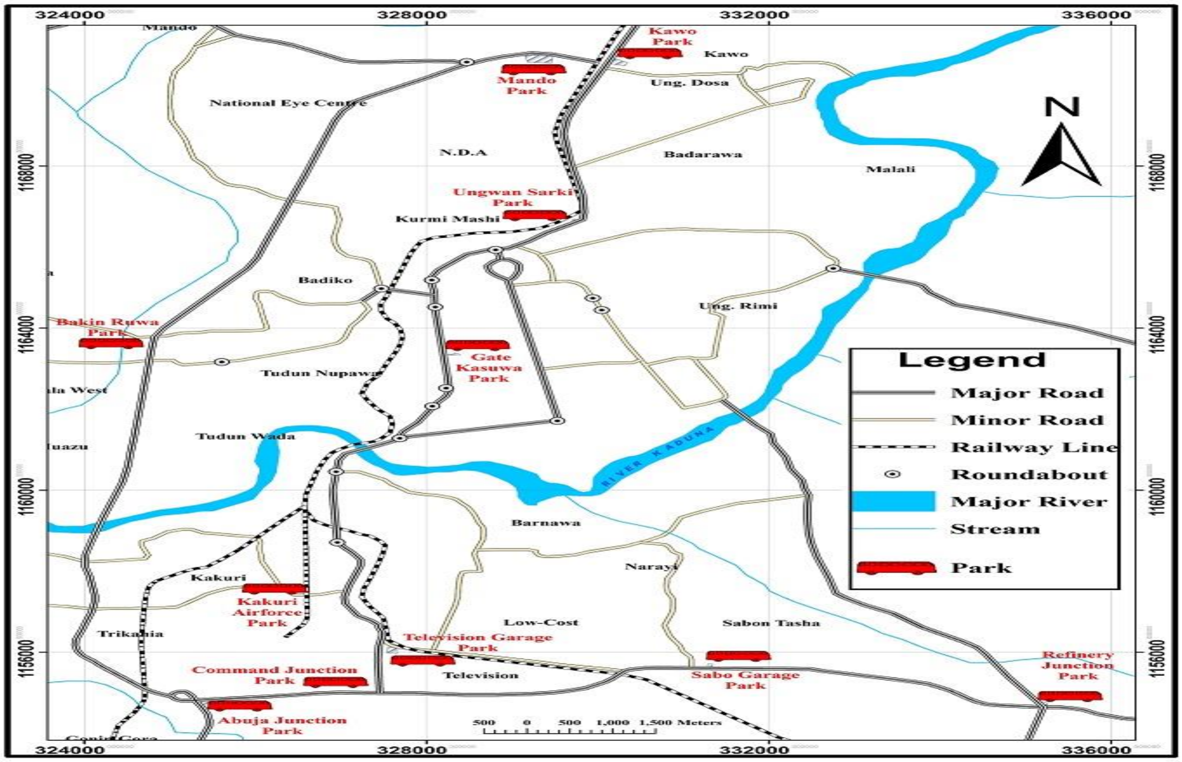

Figure 3: Locations of recognized parks in Kaduna Metropolis

Source: Fieldwork (2018)

Furthermore, data on the socio-economic and health impacts were collected on the field by administering the questionnaire to the sample population comprising drivers. The drivers' opinions on what they think should be done to reduce these harmful exhausts were also obtained and recorded in the questionnaire in one on one interviews with them.

Data Analysis

Results were presented as graphs, charts, and Tables. Data analysis involved the use of both descriptive and inferential statistics. In addition, Pearson's Correlation Coefficient, were used, significance was considered at $p \leq 0.05$. All analyses were done using Statistical Package for Social Scientists (SPSS) 20.0 version.

Results

Results obtained from the eleven motor parks in the study area indicated vehicular emissions of poisonous gases into the atmosphere. Safe limits of the gaseous elements above which exposures to them become toxic to man prescribed by the Federal Environmental Protection Agency (FEPA) were used as the reference standard. The gaseous elements analyzed and their limits are as follow: Carbon Monoxide (CO), 10 ppm; Volatile Organic Compound (VOC), 3 – 4 ppm; Nitric Acid (NO_2), 0.4 – 0.6 ppm; Hydrogen Sulphite (H_2S), 10 ppm; and Sulphur Dioxide (SO_2), 0.01 ppm (Okunade and Shittu, 2013).

Vehicle Counts

The number of commercial vehicles that come into and go out of the recognized parks in Kaduna Metropolis was determined. These data were collated simultaneously with that of emission samples. For each of the three peak periods, 45 minutes was used to count the commercial vehicles that come into and go out of the parks (Figure 4). From the results obtained, it can be deduced that the parks that are isolated solely for interstate transportation usually record their peak periods in the morning, while the parks that are linked to the intrastate transportation record continuous movements of vehicles.

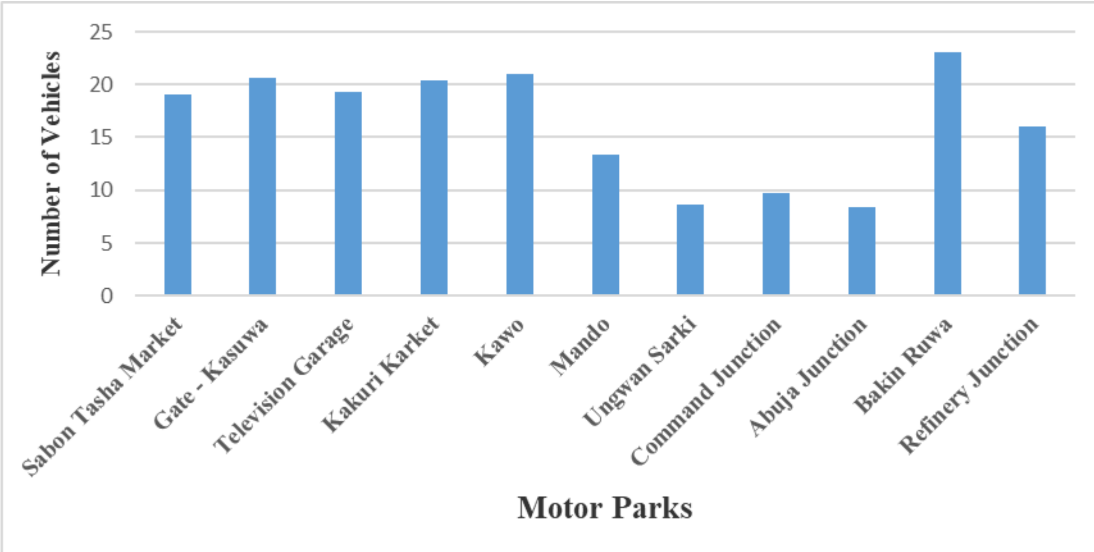

Figure 4: Vehicle counts from the Motor Parks

Source: Fieldwork (2018)

Figure 5 compares the three peak periods in terms of percentages representing the average number of vehicles per peak period. Not less than 46% of the daily vehicular movements in the recognized parks were found to be more during the morning peak period, which implies that the highest pollution is expected during the morning peak period due to the contribution of the highest gaseous emission to the atmosphere.

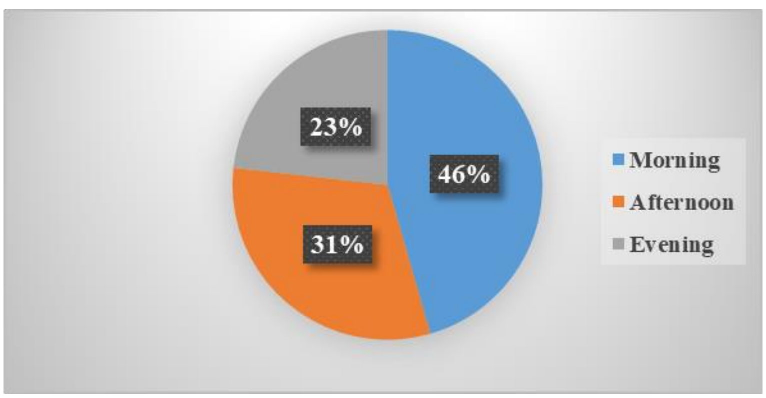

Figure 5: Vehicle counts for the three peak periods

Source: Fieldwork (2018)

Vehicular Gas Emissions

Results obtained indicated that the study area is heavily polluted with carbon monoxide (Table 2), with levels exceeding the FEPA acceptable limits. The highest pollution was recorded in the morning period, which means the metropolis is usually polluted heavily during the mornings with Carbon Monoxide. VOC, H_2S, and $S0_2$ were within FEPA acceptable limits, while $N0_2$ was slightly above the FEPA limit in Unguwan Sarki park.

Table 2: Gaseous Emissions during the Morning Peak Period

Parks	LGA	Vehicle Counts	CO (ppm)	VOC (ppm)	NO_2 (ppm)	H_2S (ppm)	SO_2 (ppm)
Sabon Tasha Market	Chikun	21	25	2	0.5	0.2	0
Gate – Kasuwa	Kaduna North	28	14	1	0.4	0	0
Television Garage	Kaduna South	35	19	3	0.4	0.9	0.011
Kakuri Karket	Kaduna North	21	10	1	0.5	0	0
Kawo	Kaduna North	34	27	1	0.3	0.1	0
Mando	Kaduna North	17	34	2	0.3	0.9	0.013
Ungwan Sarki	Kaduna South	18	13	3	0.7	0	0
Command Junction	Chikun	17	13	1	0.5	0	0
Abuja Junction	Igabi	15	10	1	0.5	0	0
Bakin Ruwa	Chikun	23	13	2	0.4	0	0
Refinery Junction	Chikun	16	21	2	0.4	0	0
Total		245	199	19	4.90	2.10	0.024
Mean		22	18.09	1.73	0.45	0.19	0.002
Standard Deviation		7	7.84	0.79	0.11	0.36	0.005

Source: Fieldwork (2018)

The gaseous emissions during the afternoon peak period are shown in Table 3. The levels of CO in all the parks were still higher compared with other gases analysed in the study area, which indicates that the atmosphere is still heavily polluted with CO during afternoon hours. This was especially seen in Sabon Tasha Market Park, Refinery Junction Park, and Mando Park (21 ppm) where movements are heightened in the afternoon. Parks like Unguwan Sarki, Abuja Junction, and Command Junction recorded the lowest emission levels. VOC and H_2S were still within acceptable limits, while NO_2 was slightly above acceptable limits. The majority of the parks (6) recorded 0 for $S0_2$.

Table 3: Gaseous Emissions during the Afternoon Peak Period

Parks	LGA	Vehicle Counts	CO (ppm)	VOC (ppm)	NO_2 (ppm)	H_2S (ppm)	SO_2 (ppm)
Sabon Tasha Market	Chikun	23	32	4	0.7	0.4	0.11
Gate – Kasuwa	Kaduna North	18	14	2	0.6	0.4	0
Television Garage	Kaduna South	11	12	1	0.4	0.3	0
Kakuri Karket	Kaduna North	23	18	3	0.5	0.4	0.11
Kawo	Kaduna North	23	17	1	0.3	0.1	0.13
Mando	Kaduna North	10	21	2	0.3	0.2	0.1
Ungwan Sarki	Kaduna South	6	9	1	0.2	0	0
Command Junction	Chikun	9	11	1	0.3	0	0
Abuja Junction	Igabi	8	10	1	0.3	0	0
Bakin Ruwa	Chikun	21	15	2	0.6	0.3	0.12
Refinery Junction	Chikun	16	23	2	0.6	0.5	0
Total		168	182	20	4.80	2.60	0.570
Mean		15	16.55	1.82	0.44	0.24	0.052
Standard Deviation		7	6.80	0.98	0.17	0.19	0.060

Field Work (2018)

During the evening, the peak period levels of the various gaseous elements generally reduced as observed by the researchers (Table 4). This reduction can be attributed to the reduction or absence of vehicular activities in some major parks. However, parks like Sabon Tasha Market, Gate-Kasuwa and Mando still emit considerable levels of CO above the acceptable limit. Unguwan Sarki and Abuja Junction had the least emission due to near-complete absence of activities in these parks towards the evening. The concentrations of all other gaseous elements investigated were within the FEPA acceptable limits. NO_2 emission was above acceptable limits in Bakin Ruwa, which may be because of increased movements of heavy-duty trucks along the Nnamdi Azikwe Road towards the evening.

Table 4: Gaseous Emissions during the Evening Peak Period

Parks	LGA	Vehicle Counts	CO	VOC	NO_2	H_2S	SO_2
Sabon Tasha Market	Chikun	13	18	2	0.6	0.1	0
Gate – Kasuwa	Kaduna North	16	17	4	0.4	0	0
Television Garage	Kaduna South	12	13	2	0.4	0.5	0
Kakuri Karket	Kaduna North	17	12	3	0.5	0	0
Kawo	Kaduna North	6	9	2	0.3	0.1	0
Mando	Kaduna North	13	14	3	0.3	0.5	0
Ungwan Sarki	Kaduna South	2	7	2	0.3	0	0
Command Junction	Chikun	3	8	1	0.5	0	0
Abuja Junction	Igabi	2	7	1	0.5	0	0
Bakin Ruwa	Chikun	25	13	3	0.8	0.4	0
Refinery Junction	Chikun	16	9	2	0.4	0	0
Total		125	127	25	5.00	1.60	0.000
Mean		11	11.55	2.27	0.45	0.15	0.000
Standard Deviation		7	3.86	0.90	0.15	0.21	0.000

Source: Fieldwork (2018)

To establish the total amount of pollutants emitted in Kaduna Metropolis, the mean values for the pollutants obtained during the three peak hours from each of the Motor parks were summarized and presented in Table 5. This Table outlines the average daily atmospheric pollution in the Kaduna Metropolis. The results obtained revealed that CO is emitted mostly from the Sabon Tasha Market and Mando Parks, which are two exit parks in the metropolis and pollution can be contributed from the moving trucks in addition to the commercial vehicles. VOC, $N0_2$, and H_2S were within FEPA acceptable limits. SO_2 emission was above the acceptable limit in Kawo Park and Bakin Ruwa.

Table 5: Gaseous Emissions for the Three Peak Periods

Parks	LGA	Vehicle Counts	CO (ppm)	VOC (ppm)	NO_2 (ppm)	H_2S (ppm)	SO_2 (ppm)
Sabon Tasha Market	Chikun	19	25.0	2.67	0.60	0.23	0.037
Gate – Kasuwa	Kaduna North	21	15.0	2.33	0.47	0.13	0.000
Television Garage	Kaduna South	19	14.7	2.00	0.40	0.57	0.004
Kakuri Karket	Kaduna North	20	13.3	2.33	0.50	0.13	0.037
Kawo	Kaduna North	21	17.7	1.33	0.30	0.10	0.043
Mando	Kaduna North	13	23.0	2.33	0.30	0.53	0.038
Ungwan Sarki	Kaduna South	9	9.7	2.00	0.40	0.00	0.000
Command Junction	Chikun	10	10.7	1.00	0.43	0.00	0.000
Abuja Junction	Igabi	8	9.0	1.00	0.43	0.00	0.000
Bakin Ruwa	Chikun	23	13.7	2.33	0.60	0.23	0.040
Refinery Junction	Chikun	16	17.7	2.00	0.47	0.17	0.000
Total		179	169	21	4.90	2.10	0.198
Mean		16	15.39	1.94	0.45	0.19	0.018
Standard Deviation		5	5.14	0.57	0.10	0.20	0.020

Source: Fieldwork (2018)

Relationship between Vehicle Counts and Vehicular Emission

This study revealed that there is a relationship between the number of vehicles in each of the Motor Parks and the level of concentrations of vehicular emissions. Using the Pearson's Correlation Coefficient, no statistically significant correlation was established between "Vehicular counts" and "Gaseous emissions" during the morning peak period. For the afternoon peak hours, a statistically significant positive correlation was observed between vehicular counts and gaseous emissions. This indicates that increase vehicle count caused increase in gas emissions. Statistically significant positive correlation was observed in only CO and VOC emissions during the evening peak hours.

Categories of Vehicles

The categories of vehicles used for commercial transportation in the study area as obtained from the administration of questionnaire revealed that Toyota Liteace is the most prominent vehicle used for commercial purposes (Table 6). The type of fuel used for commercial vehicles in the study area was found to be Premium Motor Spirit (74%), while one-third of these vehicles use diesel (26%). This is an indication that petrol (pms) propelled commercial vehicles are dominant in the Kaduna Metropolis, hence they contribute more to the vehicular emissions.

Table 6: Type of Commercial Vehicles

Vehicles	No. of Responses	% of Responses
Toyota Liteace	76	30
Toyota Coaster	13	5
Toyota Sienna	38	15
Suzuki mini	25	10
Nissan Serena	28	11
Mazda	18	7
Mercedes (614D & 608)	10	4
Citroen Jumper	5	2
Daihatsu	15	6
Others	25	10
Total	253	100

Source: Fieldwork (2018)

Results obtained from this study revealed that the majority of the commercial vehicles are more than five years, while a very few are less than one year old (Table 7). Regarding vehicle maintenance, drivers maintain their vehicles on weekly basis, some monthly, while some do not have a maintenance schedule. The level of vehicle maintenance augments the state or condition of the vehicle particularly in terms of its general comfort, efficiency, and performance. Maintenance here refers to regular servicing (changing of oil, in and cleaning of the vehicle, effecting repairs and or general overhaul) as soon as the need arises, and carrying out all such activities, which signify adequate vehicle maintenance as at and when due.

Table 7: Age of Automobile and Maintenance Frequency of Commercial Vehicles

Age	No. of Responses	% of Responses
Less than a year	26	10
1 -2 years	53	21
2 -5 years	76	30
More than 5 years	98	39
Frequency		
Weekly	96	38
Monthly	88	35
Half-yearly	0	0
Others (specify)	69	27

Source: Fieldwork (2018)

Effects of Vehicular Emissions on Human Health

There is growing evidence that links vehicle pollutants to human ill health. Results from our study on the effect of gaseous emissions from commercial vehicles on human health revealed that the majority of drivers suffer from different illnesses (Table 8). These include running nose, headache, sleeplessness among others, while some alluded to the fact that they have not suffered any of the listed effects of vehicular emission. The frequencies of these effects on the commercial vehicle drivers were also sought (Table 8). The frequencies of the attack of the effects of vehicle emission may not be unconnected to the duration of driving by the commercial vehicle drivers. Regarding the duration of exposure to exhaust gas per day, our results revealed different duration per day (Table 9). In accordance with the frequencies of the effects of vehicular emissions, there is usually the need to seek medical treatment. The frequencies of medical treatment of the commercial vehicle drivers also varied as shown in Table 9.

Table 8: Illnesses Suffered by Drivers and Frequency of Attack

Effects	No. of Responses	% of Responses
Sleeplessness	38	15
Running nose	68	27
Heavy eyes	33	13
Asthmatic attack	30	12
Headache	61	24
None	23	9
Frequency		
Daily	9	4
Weekly	37	16
Twice Monthly	51	22
Monthly	48	21
Others (Specify)	85	37

Source: Fieldwork (2018)

Table 9: Duration of Exposure to Exhaust Emissions per day and Frequency of Medical Treatment

Duration	No. of Responses	% of Responses
1– 5 hours	23	9
6 - 10 Hours	71	28
Above 10 Hours	159	63
Frequency		
Daily	15	6
Weekly	43	17
Monthly	48	19
Quarterly	43	17
Yearly	5	2
Whenever	99	39

Source: Fieldwork (2018)

Our study also assessed the average monthly income of drivers and percentage spent on health. Majority earned above 21, 000 naira ($58) monthly, while the least earned was found to be below 10, 000 naira ($27.7). Results from our study revealed that over 80% of drivers spend more than 10% of their monthly income on ill-health (Fieldwork, 2018).

Table 10: Average Monthly Income of Commercial Drivers and Percentage Spent on Health

Amount	No. of Responses	% of Responses
Below N10,000	15	6
N10,000 – N15,000	28	11
N16,000 –N20,000	68	27
N21,000 and Above	142	56
Percentage		
Below 11%	51	20
11 – 20%	61	24
21 – 30%	68	27
31 – 40%	58	23
Above 40%	15	6

Source: Fieldwork (2018)

Control Measures for Vehicular Emissions

Results obtained from this study showed that the majority of the commercial drivers had only primary education or none at all (Figure 6). The low level of education may be a major driver of the indiscriminate pollution of the environment with vehicular emissions in the study area. Despite the worrisome level of the education of the commercial vehicle drivers, this study assessed the drivers' level of awareness about air pollution and found that the majority are very much aware as shown in Table 11. Awareness of the effects of pollution and knowledge on how to address them were also assessed (Table 11).

Regarding the possibility of addressing air pollution, the commercial vehicle drivers were asked to suggest an effective way for reducing vehicular emission in the Kaduna Metropolis (Table 11). Our results showed that respondents chose regular maintenance as the panacea for vehicle emissions; some agreed that working on an awareness campaign is the solution, while others suggested regular fumigation of the environment and prevention of smoky vehicles from operating in any of the Motor Parks in Kaduna Metropolis. Furthermore, the drivers were also asked to suggest the roles Government can play in reducing pollution in the metropolis (Figure 7).

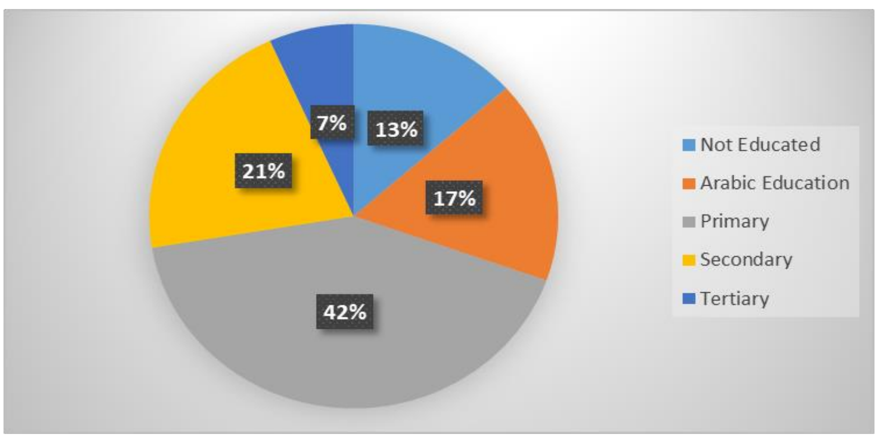

Figure 6: Level of Education of the Drivers
Source: Field work (2018)

Table 11: Awareness About, Effects, and Possibility of Addressing Air Pollution

Frequency of Awareness	No. of Responses	% of Responses
A lot; at a frequent basis	182	72
Occasionally	43	17
Sometimes	23	9
Rarely	5	2
Frequency of Effects		
Yes, of course	170	67
Sometimes	71	28
Not Really	9	4
Not at all	3	1
Options on Possibility		
Definitely yes	78	31
Yes	175	69
Not Very Necessary	0	0
No	0	0

Source: Fieldwork (2018)

Table 12: The Effective Way for Reducing Vehicular Emission

Options	No. of Responses	% of Responses
Setting standards for Automotive industries	58	23
Working on awareness campaign	73	29
Regular maintenance of vehicles	94	37
Others (Please specify)	28	11
Total	253	100

Source: Fieldwork (2018)

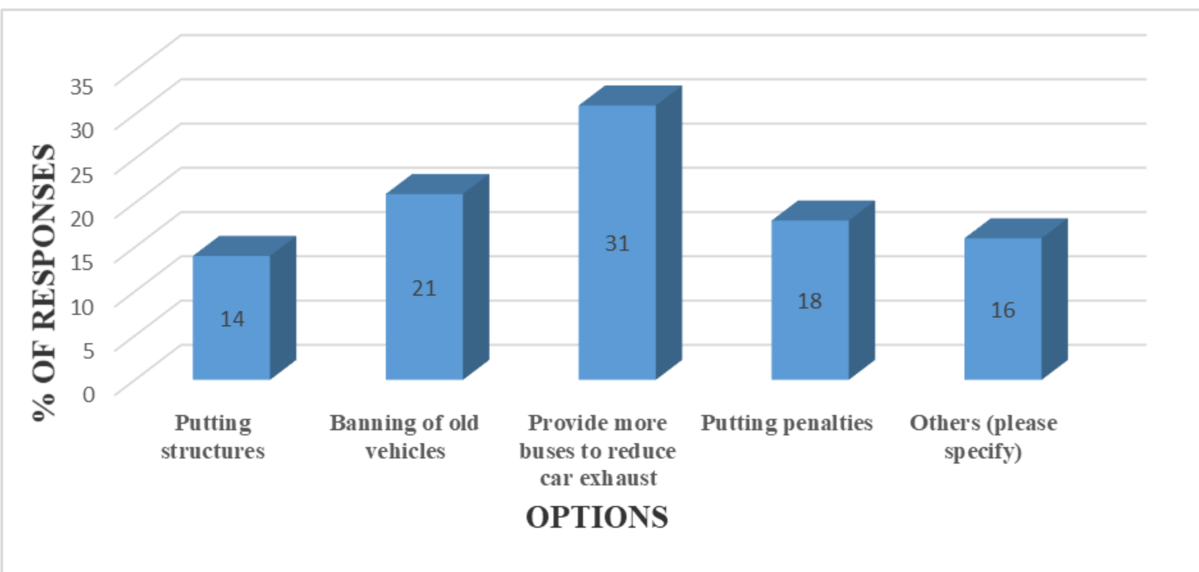

Figure 7: The Government role in reducing the pollution
Source: Fieldwork (2018)

Relationship between Level of Education and Awareness Attainment of Respondents about Air Pollution

Using the Pearson's Correlation Coefficient, the relationship between the level of educational attainment of commercial bus drivers and their level of awareness about the health implications of exposure to exhaust emission was assessed. Our results revealed that there was no significant relationship between these two variables.

Table 13: Relationship between level of education and the effects of air pollution

Correlations			
		Level of Education	Effect of Air Pollution
Level of Education	Pearson Correlation	1	-.663
	Sig. (2-tailed)		.337
	N	5	4
Effect of Air Pollution	Pearson Correlation	-.663	1
	Sig. (2-tailed)	.337	
	N	4	4

Source: Fieldwork (2018)

Discussion

In the process of combustion, vehicles emit into the environment exhaust gases, which create serious environmental and health concerns. These emissions contain carbon monoxide (CO), oxides of sulphur (SO_2), oxides of nitrogen (NO_2), Ozone (O_3), hydrocarbons and particulate matter. Some of these gases are called Green House Gases (GHGs) (Ameh et al., 2015). From the findings of our study, CO produced very high concentrations that exceeded the Nigerian air quality standard accepted safe limits, particularly during the morning peak period in all the Motor Parks. However, the other gaseous elements investigated were mostly within the Nigerian air quality standard accepted safe limits in all the parks. A few Motor Parks exceeded these limits. On the global scene, Seneca and Tausig (1994) drew a similar conclusion that transportation is the major source of air pollution accounting for over 80% of total air pollutants. The findings of high concentration of CO was also confirmed by WHO (2000), which reported that concentrations of CO are highest at near street intersections, in congested traffic, near exhaust gases from internal combustion engines and industrial sources, and in poorly ventilated areas such as parking garages and tunnels (WHO, 2000). The Environmental Protection Agency, (EPA) in the United States also supported this position with their reports that vehicle emissions account for 51% of carbon monoxide, 34% of Nitrogen oxides and 10% of particulate matter released each year in the US (US EPA, 2007). The present study discovered that the atmosphere in the Kaduna Metropolis is polluted; a stand that is corroborated by Lekwot *et al*., (2013) that said Kaduna Metropolis is suffering from poor air quality, mostly because of vehicular emissions or fumes. The reason for the poor air quality advanced by Lekwot *et al*., (2013) was examined in this study using the three peak periods. It was found that as the volume of traffic reduces from morning peak period through afternoon peak period to evening peak period, the level of concentrations of the pollutants also reduces making vehicular emission a major contributor to the poor air quality. When the relationship between number of vehicles and vehicular emission was subjected to the statistical test, the study showed that there is a significant relationship. This means the air pollution is caused by vehicular emission. To support this discovery, Ihom *et al*., (2016) opined that one of the major sources of air pollution in growing cities like Uyo, Nigeria is vehicular emissions. This is a clear indication that vehicle emissions are a major source of the environmental problem and must be controlled if acceptable air quality is to be assured.

Since vehicular emission is discovered to be a major source of air pollution, this study also examined the categories of vehicles that are used for commercial purposes in the metropolis and discovered that majority of the vehicles were Toyota Liteace, and 74% of the entire commercial vehicles are propelled by petrol fuel. The majority of today's vehicles use internal combustion engines that burn gasoline or other fossil fuels, and neglect to replace worn out or deteriorated components by Motorists, which results in poor engine performance, higher fuel consumption, engine damage with resultant excess emissions (Prather, 1995). This is probably the situation with the commercial vehicles in the Kaduna Metropolis going by the level of pollution. About 39% of these commercial vehicles were also discovered to be more than five years old and about 30% between 2 -5 years old. Most of the vehicles used are imported into the country when quite old with worn out engines and low energy efficiencies. Consequently, such vehicles profusely emit exhaust gases, which may be harmful to both human health and the environment (Bateebe, 2011). Subramani (2012) succinctly referred to old vehicles as gross polluters.

Given the alarming exhaust gas pollutions, this study examined the effects of vehicular emissions in Kaduna Metropolis. The study discovered that 91% of the commercial vehicle drivers have suffered from major health defects at least once a month, which is alarming. This study also discovered that 63% of the drivers are exposed to exhaust gas daily, which can be attributed to the constant illness from the effects of vehicular emission. This is a common occurrence in urban centres with a high level of commercial activity (Glen *et al.*, 1996; Johnson *et al*., 2000; Ackerman *et al*., 2002). Traffic-related pollutants have been associated with asthma development (Gordian *et al.*, 2006). Additionally, WHO/ECOTEX (1992) also revealed that high levels of carbon monoxide found in traffic-congested areas (20 to 30 mg/m^3) can lead to levels of 3% carbon oxyhemoglobin (COBH), which produce adverse cardiovascular and neurobehavioral effects and seriously aggravate the condition of individuals with ischemic heart disease (Hassan and Okobia, 2008). That is, Carbon monoxide causes blood clotting when it reacts with haemoglobin, which cuts the supply of oxygen in the respiration system after long exposure. Air pollution caused by existing vehicle emissions is known to have already contributed to an increase in asthma, acute respiratory diseases and even sometimes resulted in death (Lekwot *et al*., 2013). This is because these emissions produce lower air quality with resultant health implications on animal and human life (Ihom, 2014).

This study discovered that majority of the drivers are very aware of both the air pollution and its resultant effects despite their low level of education. This position was buttressed when no significant relationship between the level of educational attainment of commercial bus drivers and their level of awareness about the health implications of exposure to exhaust emission was observed. This means irrespective of the level of education of the commercial vehicle drivers, they are expected to be aware of the menace. Given this level of awareness, this study discovered that the problem of air pollution because of vehicular emission could be addressed.

Auto exhaust pollution has assumed a menacing proportion in the developing countries and its control should not be delayed any more especially in the Kaduna Metropolis, where its contribution is the major source of air pollution in the metropolis. Consequently, this study examined the effective ways for reducing vehicular emissions and discovered that regular maintenance was the panacea for vehicular emissions, as well as working on an awareness campaign. This means that commercial vehicle drivers should embark upon regular maintenance of vehicles. To complement the efforts of the commercial vehicle drivers in reducing vehicular emission, this study also examined the Government role in reducing the pollution and discovered that the provision of more buses to reduce car exhaust followed by banning of fume producing old vehicles can be effective. This means Government should put in place policies and programmes for the provision of larger/higher capacity buses for intra urban mass transit. As shown in Gazalli *et al*., (2013), Government should be determined to protect the environment and human health. This can be done by putting in place effective policies and programmes to reduce the effects of gaseous emissions from the automobile.

Conclusion

Gaseous elements from vehicular emissions especially CO were found to be the major source of air pollution and several illnesses in the Kaduna Metropolis. Their concentrations were far greater than the Nigerian air quality standard accepted safe limits. These emissions lower air quality with resultant health implications on animal and human life. Government should put in place a reliable and efficient mass transport system to reduce the number of motor vehicles and motorcycles on roads and therefore reduce the harmful emissions.

Declaration of interest statement: Authors declare no conflict of interest.

References

Ackerman, M., Davies, T., Jefferson, C., Longhust, J. and Marquez, J. (2002). Comparison of diesel and hybrid vehicle emissions by computer modelling. Urban Transport VIII; 60: 471-480

Ameh, J.A., Tor-Anyiin, T.A. and Eneji, I.S. (2015) Assessment of Some Gaseous Emissions in Traffic Areas in Makurdi Metropolis, Benue State, Nigeria. *Open Journal of Air Pollution*, 4, 175-183

Atta, Y. A. (2018). Spatial Analysis of Bus Stop Locations in Kaduna Metropolis, Nigeria, An MSC Geography Thesis, Department of Geography, Nigerian Defence Academy, Kaduna

Bateebe, I. P. (2011). Investigation of Probable Pollution from Automobile Exhaust Gases in Kampala City, Uganda. A Master of Science Thesis Submitted to KTH School of Industrial Engineering and Management Energy Technology EGI-2011-91MSC EKV853 Division of Heat and Power Technology SE-100 44 STOCKHOLM.

Cadle, S. H., Gorse, R. A Jr., Bailey, B. K., and Lawson, D. R. (2000). Real-world vehicle emissions: a summary of the ninth coordinating research council on-road vehicle emissions workshop. *Journal of the Air and Waste Management Association*, 50(2): 278-291

Cervero, R. (2001). Travel and the built environment: a synthesis. *Transportation Research Record* 1780, 87-113.

Dantudu, A. S. (2014). Assessment of the effects of communal conflicts on residential segregation in Kaduna metropolis. An unpublished MTech Dissertation, Department of Urban and Regional Planning, Federal University of Technology, Minna.

Ewing, R. (2001). Travel and the Built Environment, A Synthesis. *Transportation Research Record*, 1780; 87-114.

Gazalli, S. A. and Salami, K. A. (2013). Contributions of CO, NO2 and SO2 from automobile emission to environmental problems in Niger state, Nigeria *International Journal of Environmental Sciences*, 3 (5); 1457-1466.

Gidde, M. R. and Sonawane, P. P. (2012). Assessment of Traffic Related Air Pollution and Ambient Air Quality of Metropolitan Cities (Case Study of Pune City), *IOSR Journal of Engineering (IOSRJEN),* 2(6); 1382-1390

Glen, W. G., Zelenka, M. P. and Graham, R. C. (1996). Relating meteorological variables and trends in motor vehicle emissions to monthly urban carbon monoxide concentrations. *Atmospheric Environment*. 31(24): 4225-4232.

Gordian, M. E., Haneuse, S. and Wakefield, J. (2006). An investigation of the association between traffic exposure and the diagnosis of asthma in children. *J Expos Sci Environ Epi* 16:49-55.

Hassan, S. M. and Okobia, L. E. (2008). Survey of Ambient Air Quality in Some Parts of the Federal Capital Territory, Abuja, Nigeria, *Journal of Development and Society*, 1(4); 1-17.

Ihom, A. P., Agwu, O. E. and John, J. A. (2016). The impact of Vehicular Emissions on Air quality in Uyo, Nigeria. *Mechanics, Materials Science & Engineering Vol.6,* doi: 10.13140/RG.2.1.1813.7845

Ihom, P. (2014). Environmental Pollution Prevention and Control: The Current Perspective (A review). *Journal of Multidisciplinary Engineering Science and Technology*, 1(5): 93-99.

Johnson, L, Jamriska, M., Morawska, L. and Ferreira, L. (2000). Vehicle emissions in Australia: from monitoring to modelling.*Urban Transport VI*;6: 469-478.

Kadiyali, L. R. (2005). Traffic Engineering and Transport Planning. Romesh Chader Khanna, Nath Market Nai Sarak, Delhi-India

Kalaian, S. A. and Rafa M. K. (2008): Longitudinal Studies." In Encyclopedia of Survey Research Methods. Paul J. Lavrakas, ed., pp. 440-441

Kpaka V. (2003). Proliferation of natural gas vehicle in Nigeria - The way forward, www.vanguardngr.com/articles/2002/business/b730092003.htm

Lekwot, V. E., Dyaji, L. and Nwokedirioha, O. (2013). Public health effects from vehicular emissions in Kaduna Metropolis, Kaduna State, Nigeria. *International Journal of Environmental Science and Development Research;* (1), 01- 08.

Ployhart, R. E. and Robert J. V. (2010): Longitudinal Research: The Theory, Design, and Analysis of Change", *Journal of Management*, 36: 94-120

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

Robert, J. J. (2015). Comparison of Carbon Monoxide Concentrations with Set standards: A case study of Port-Harcourt metropolis, Nigeria. *The International Journal of Engineering and Science (IJES)*, 4 (10); 48-54

Seneca, J. J. and Tausig, M. K. (1994). American bias in environmental economics: Industrial pollution abatement and "incentives versus regulations" environmental politics, 7(2); 134-152

Singh, A. (2002). An assessment of the status of the World remaining closed forest. UNEP. Nairobi, Kenya, url.http://grip2.tr.usgs.gov. /publications/closed forest.pdf. Dated 2/2/2005

Subramani, T. (2012). Study of air pollution due to vehicle emission in tourism center. Article in *International Journal of Engineering Research and Applications (IJERA)* 2(3), 1753-1763.

United States Environmental Protection Agency (US EPA) (2007). "Mobile Source Emissions - Pollutants". <http://www.epa.gov/otaq/invntory/ overview/pollutants>.

World Health Organisation (WHO) (2000), Air quality guidelines 2000 (chapter on nitrogen dioxide), available at http://www.euro.who.int/document/aiq/7_ 1nitrogendioxide. pdf, accessed during November 2012

World Health Organization and Ecotoxicology Service (WHO/ECOTEX) (1992) "Motor Vehicle Air Pollution Public Health Impact and Control Measures" Edited by David Mage and Olivier Zali.