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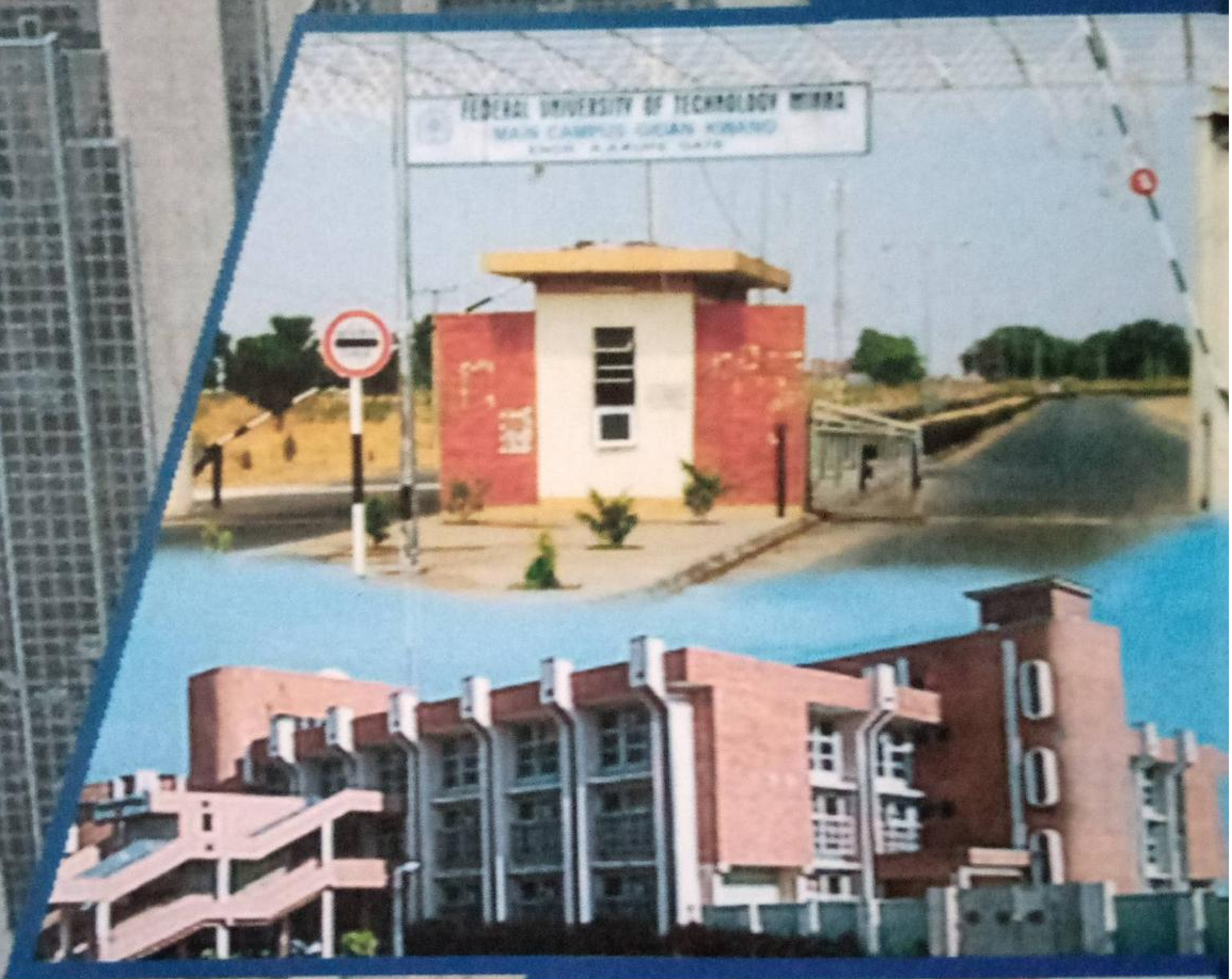

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Impact of Vehicular Carbon Emission on Ambient Air Quality in Minna, Nigeria

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Abstract
Movement of vehicles from one point to another is crucial to the enhancement of economic development of any society, and it leads to air pollution resulting from carbon emission. While there are substantial studies that had investigated this phenomenon, majority of it are conducted in more developed countries, and some developing countries including Nigeria. However, there is limited study on this subject in the north-central, Nigeria, which has experienced tremendous influx of different category of vehicles over the last one decade. Thus, in order to address this gap, the main objective of this paper is to assess the influence of vehicular carbon emission on ambient air quality in Minna town, with a view to ascertaining the level of carbon emission, and the variation of various emissions from different vehicular classes. For data collection, MSA Multi-Gas Detector, Smoke Meter and Handheld Gas Monitor were used to measure and determine the level of carbon emission around some roundabouts. Descriptive analysis and one sample T test were conducted. The findings of the study shows that average carbon emission around Tunga roundabout, Mobil roundabout, Kpakungu, and Obasanjo complex roundabout are 14.6ppm, 26.0ppm, 24.4ppm, and 20.8ppm respectively. All of these values are above the limit set by USEPA and WHO, and therefore classify as "highly unhealthy" limits. The study also found a highly significant variation in carbon emission around the roundabouts and various types of vehicles. The study recommends enforcement of relevant regulations on pollution control as it relates to vehicular carbon emission.

Keywords: Vehicles; Carbon emission; Pollution; Ambient air quality

Introduction

Vehicle emissions greatly affect the air quality in many cities, especially in developing countries (MEPPRC, 2011; and Chen *et al.*, 2016). For three decades now, number of vehicles has increased rapidly worldwide, and vehicle emissions have become an important source of air pollution in most urban areas (Mayer, 1999; Panis *et al.*, 2006; as stated by Wu *et al.*, 2011). According to Shancita (2014), a vehicle emits gases, such as NOx, CO and VOCs, from its tailpipe, and even during idling state.

A considerable number of gaseous hazardous compounds are present in diesel and gasoline exhaust being emitted by vehicles (Salami, 2007). Pollutants emitted from diesel and gasoline engines of a vehicle can be divided into three major elements: NOx (nitrogen oxide), CO (Carbon monoxide) and HCs (Hydrocarbons) and PM (Particulate Matters). NOx is composed mostly of nitrogen oxide (NO) and nitrogen dioxide (NO_2). In diesel exhaust, NO has a larger quantity than that of NO_2, though NO_2 is more contagious than NO (Rodrigue, 2016).

The environmental impacts of vehicle emission arises from transportation activities as a result of increasing mobility demands for passengers and freight, which are associated with growing levels of environmental externalities (Badejo, 2011). The growth of personal and freight mobility in recent decades have expanded the role of transportation as a source of emission of pollutants and their multiple impacts on the environment (Rodrigue *et al.*, 2016).

The adverse effects of vehicular carbon emission is heavily documented in the literature, and while the dominance of this kind of study is on many cities and towns in developed countries and some developing countries, very few have been conducted on cities and towns in Nigeria. There is clearly a dearth of this nature of study in Nigeria north-central region, which is currently experiencing increasing influx of vehicles of various categories. Therefore, in addressing this gap, the main objective of this paper is to assess the influence of vehicular carbon emission on ambient air quality in Minna town with the view to ascertaining the level of carbon emission and variation of various emissions from different vehicular classes. .

Study Area

Minna lies at latitude 9° 37' North and longitude 6° 33' East on a geography base of undifferentiated Basement Complex of mainly gneiss and magmatite. The Town has a mean annual precipitation of 1300mm, taken from an exceptionally long record of 50 years. The highest mean monthly rainfall is in September with almost 3000mm. The raining season starts on average between the 11th -20th April, and lasts between 190 and 200 days. Temperature rarely falls below 22° C. The peaks are 40° C (February-March) and 35° C (November-December). Minna City is both the administrative headquarters of Niger State and Chanchaga Local Government Area. The City has 2017 estimated population of 489,351. It covers approximately 1000Ha (Maxlock, 1980). According to the Niger State Board of Internal Revenue (BIR) (2017), a total of 13,729 vehicles were registered in Minna from September, 2013-December 2016. This includes motorcycles, tricycles, cars, buses, light and heavy trucks. Figure 1.1 shows street guide map of Minna showing major roundabouts, while figure 1.2 shows selected traffic light points.

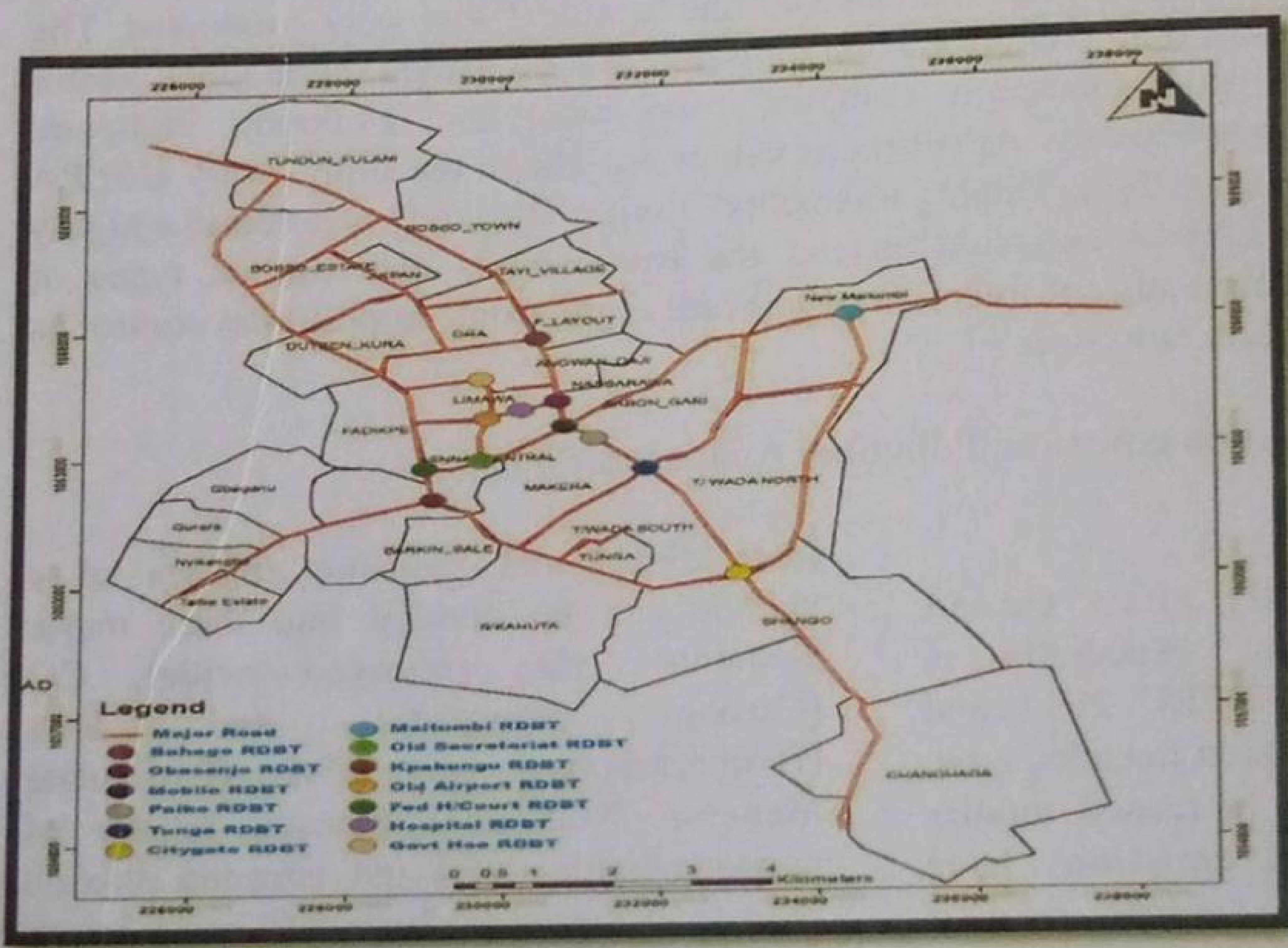

Figure 1.1: Street Guide Map of Minna Showing Major Roundabouts

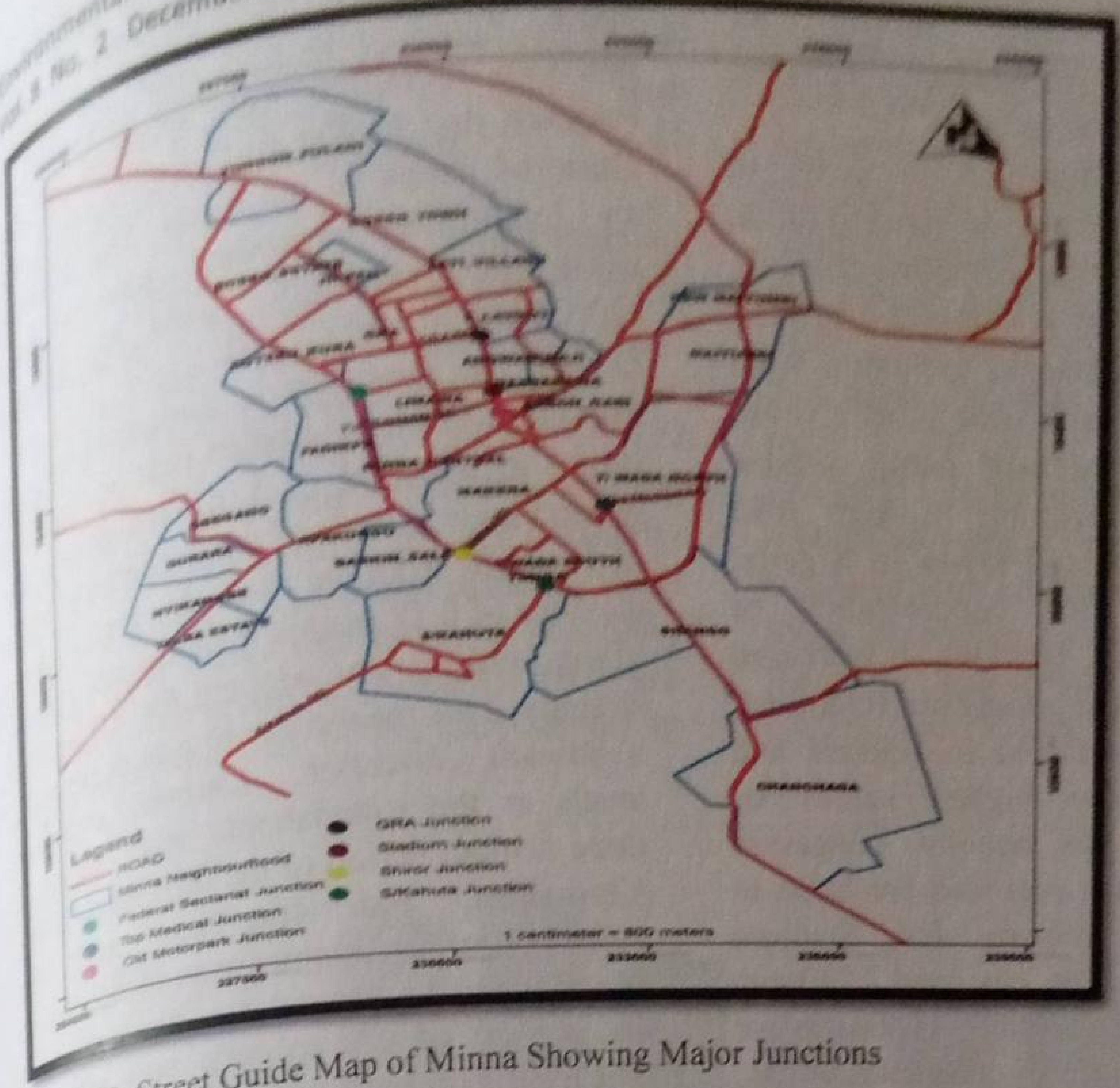

Figure 1.2: Street Guide Map of Minna Showing Major Junctions

Literature Review

Transportation and Greenhouse Gas Emission

Transportation is the major contributor of air pollution accounting for over 80 percent of total air pollutants (UN Habitat's State of the World Cities 2008/2009). According to USEPA (2014), greenhouse gas emissions from transportation accounted for about 26 percent of total U.S. greenhouse gas emissions, making it the second largest contributor of U.S. greenhouse gas emissions after the electricity sector. US Environmental Protection Agency (EPA) (2014) indicates that the transportation sector includes the movement of people and goods by cars, trucks, trains, ships, airplanes, and other vehicles. Majority of greenhouse gas emissions from transportation are carbon monoxide (CO), carbon dioxide (CO_2), sulphur dioxide (SO_2) and nitrogen oxide (NOx) emissions resulting from the combustion of petroleum-based products, such as gasoline, internal combustion engines. Fossil fuel usage is the primary source of CO_2. The transportation sector directly accounted for about 28 percent of total U.S. GHG emissions in 2006, making it the second largest source of GHG emissions after electricity generation (UN Habitat's State of World Cities 2008/2009). NESREA (2014) noted that air pollution can occur inside homes, schools, and offices; in cities; and across continents. Major air pollutants which can be experienced at any given time include: Oxides of Nitrogen (NO_X), Oxides of Sulphur (SO_X), Carbon monoxide (CO), Ozone (O_3), Hydrogen sulphide (H_2S), Methane (CH_4), Total Non-methane Hydrocarbon (TNMHC), Particulate Matter (PM) and Volatile Organic Chemicals/Compounds (VOCs).Vlieger *et al.*,(2010) stated that the largest sources of transportation GHGs in 2006 were passenger cars (34%) and light duty trucks, which include sport utility vehicles, pickup trucks, and minivans (28%). Together with motorcycles, these light-duty vehicles made up about 63% of transportation GHG emissions. The next largest sources were freight trucks (20%) and commercial aircraft (7%), along with other non-road sources, which combined totalled about 7%. These figures include direct emissions from fossil fuel combustion, as well as

HFC emissions from mobile air conditioners and refrigerated transport allocated to these vehicle types.

In Nigeria, little attention is given to pollution caused by mobile transportation which is a source of air pollution according to Abam (2009) and Nwachukwu (2012). The situation of increased pollution from mobile transportation source is as a result of increase in private and public vehicle ownership, thus resulting in high road congestion in cities and towns in Nigeria, and increase in the concentration of pollutants in the air, resulting in increased health risk of human population (Odotong, 2015). Studies conducted in Kaduna and Abuja cities show higher values of CO_2concentration in heavily congested areas: 1840ppm was recorded for Sabo in Kaduna city, 1780ppm for Stadium roundabout in Kaduna city, and 1530ppm for A.Y.A in Abuja city, 1160ppm for Asokoro in Abuja city (Hassan *et al.*, 2012).

Materials and Methods

Instrument for Data Collection:

The following instruments were used: Digital Camera, Hand held GPS (Garmin, etrex10 model), and the MSA Altair 5X Multi-gas Detector. The MSA Altair 5X Multi-gas Detector of version SW 1.27.06.50 is a portable hand held device used to measure the concentration of gases in the environment. The device monitors gases in ambient air, and is available with a maximum of four sensors, which can display readings for five separate gases (one Dual Toxic Sensor provides both CO and H_2S sensing capabilities in a single sensor), Oxygen (O_2) and 2 combustible gases including Pentane. For the purpose of this research, 7 of out of the 13 roundabouts in Minna were considered for the study. They are: Tunga roundabout, Kpakungu roundabout, Mobile roundabout, Obasanjo Complex roundabout, Maitumbi roundabout, Minna City-Gate roundabout, and Paiko roundabout. The factors considered for selection include; volume of traffic generated, hierarchy of the road, activities along/ adjacent the route, and busy nature of the roads. Also, 3 of the major traffic junctions out of the 7 junctions identified were selected for the research due to the traffic generated and clustered nature of the roads. The ambient air monitoring procedure was adopted using the description made by Harrop (2002) and Robert (2004).

During the atmospheric measurement, air samples were measured in part per million (ppm) at a height of 1 metres above the ground level at each of the graded distances of 1 metres from the road. An approximate distance of 0.27 metres from the tail pipe of idling vehicles was adopted for the second strategy. This measurement was done at the windward direction. Carbon emission levels at the roundabouts were taken at three distinct period of the day; 8am-10am, 12pm-2pm, and 4pm-6pm and the collection of air samples was measured on site. Second by second measurement with an interval of 2-3 seconds was adopted. The second by second emission data provides a better method for the development of models for estimating vehicular emission. A GPS receiver was used to record the positional status of all the major roundabouts and junctions. The collected data was analysed using SPSS 22, where descriptive analysis and one sample T test was conducted. The results of analysis are presented in charts and tables.

Results and Discussion

Average Level of Carbon Emission at Selected Roundabouts in Minna

The average daily carbon emission at the selected roundabouts in Minna ranges from 14.6ppm at Tunga roundabout to as high as 26.0ppm at Mobile roundabout. This is presented in Table 4.1. The result shows that the average carbon emission around selected roundabouts in the city is 19.7ppm. Mobile roundabout recorded the highest average carbon emission of 26.0ppm, followed by Kpakungu and Obasanjo Complex with 24.4ppm and 20.8ppm values respectively. These three (3) Roundabouts recorded higher carbon emission than Minna City-Gate roundabout. The average carbon emission at Minna City-Gate roundabout is 18.3ppm.

Paiko roundabout recorded 17.6ppm, Maitumbi roundabout recorded 16.3ppm, while the lowest value (14.6ppm) was recorded at Tunga roundabout.

The United States Environmental Protection Agency (USEPA, 2015) identified six levels of carbon emission, and their health implication. Going by their standard, six (6) out of the seven (7) selected roundabouts recorded carbon emission that falls under the very unhealthy level (see table 4.1). Carbon emission value recorded at Tunga roundabout is unhealthy for sensitive group of people (Asthmatic). Therefore, majority of the roundabouts in Minna experiences high concentration of CO_2 that is harmful to man. Excessive concentration of CO_2 in the atmosphere according Bascom, et al (1996) can reduce the oxygen carrying capacity of blood which might affect the sensitive organs of the human body such as the heart and brain. Similarly, USEPA (2015) reveals that acute exposure to vehicles' emission over a period of time reduces lung function. Furthermore, Balogun (2015) noted that vehicle that produces excessive smoke (smoke could be gray, blue, white or black depending on the engine's state) on the road can affect visibility, thereby causing Road Traffic Crash (RTC).

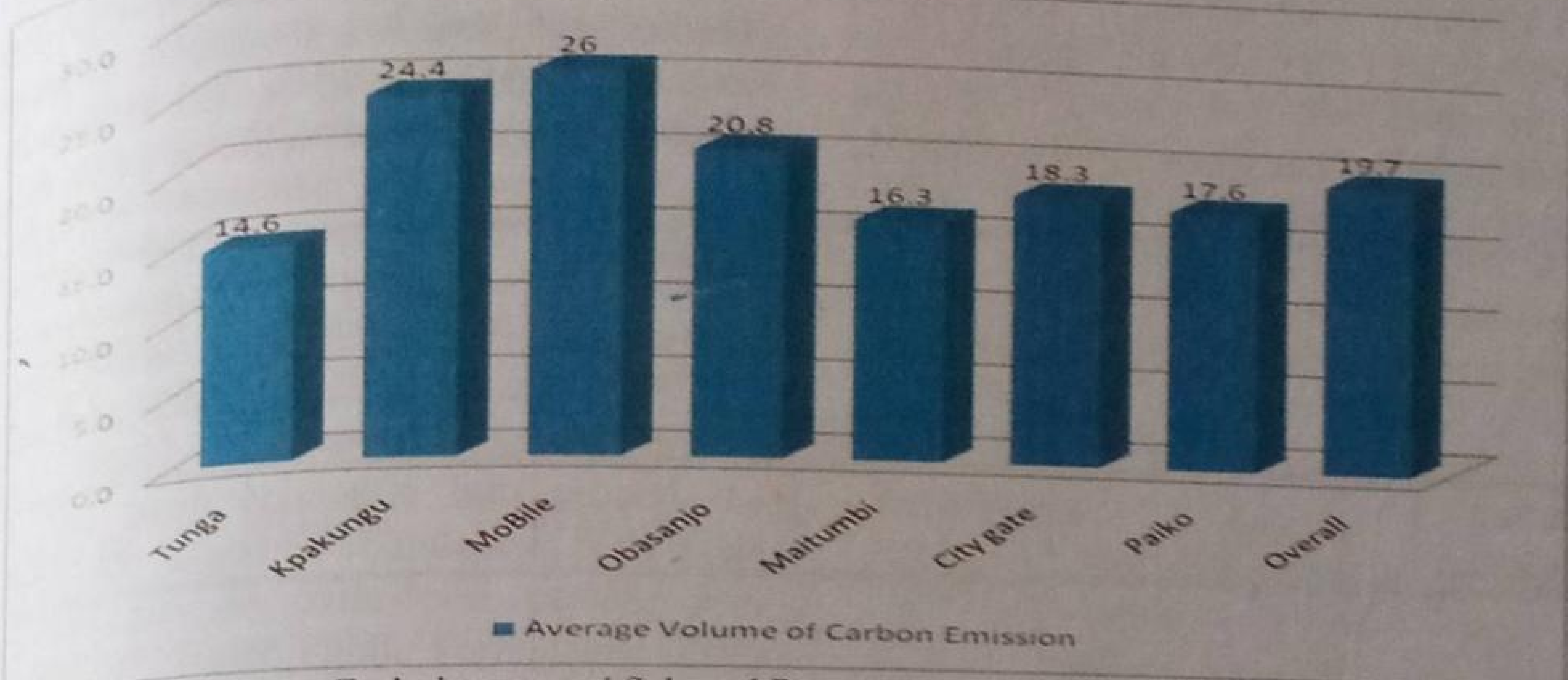

Figure 4.1: Vehicular Emission around Selected Roundabouts in Minna

Table 4.1 **Daily Average Carbon Emissions at Selected Roundabouts in Minna**

Roundabout Location	Daily Average Carbon Emission	Remark
Tunga	14.6	Unhealthy for sensitive groups
Kpakungu	24.4	Highly Unhealthy
Mobile	26.0	Highly Unhealthy
Obasanjo	20.8	Highly Unhealthy
Maitumbi	16.3	Highly Unhealthy
City Gate	18.3	Highly Unhealthy
Paiko	17.6	Highly Unhealthy
City Mean	19.7	Highly Unhealthy

Note that: 0-4.4ppmc = Good, 4.5-9.4ppmc = Moderate, 9.5-12.4ppm = Unhealthy for Sensitive groups, 12.5-15.4ppm = Unhealthy, 15.5-30.4ppm = Highly unhealthy, 30.5-50.4ppm = Hazardous (USEPA, 2015)

Variation in Volume of Carbon Emission Recorded At the Selected Roundabouts in Minna

Table 4.2 shows the variation in volume of carbon emission recorded at the selected roundabouts in Minna using one sample T Test. The one sample T test recorded a t value of 14.266 and a P-value of 0.000. Since the p-value is less than 0.001 at 95% confidence level, it therefore implies that there is a significant variation in the level of carbon emission recorded at the selected roundabouts in Minna.

Amount of Carbon Concentration Emitted by Vehicles in Minna

The carbon emission from nine major categories of vehicles was examined at idling state using the MSA Multi-gas Detector. The average volume of carbon emitted by vehicles at idling state is presented in Figure 4.2. The result shows that the average volume of carbon emitted by tanker/trailer, lorry/truck motorcycle, tricycle, private car at idling state are 153.43ppm, 232.13ppm, 236.12ppm, 289.39ppm, 343.17ppm respectively. Furthermore, the volume of emission recorded from luxury bus at idling state is 388.64ppm, Omni bus recorded 442.53ppm, pick-up van recorded 520.23ppm, while commercial cars recorded 627.04ppm. The result shows that the volume of carbon emission from vehicles is not a function of its size, but other numerous factors not considered in this study.

Variation in Volume of Carbon Concentration Emitted by Various Categories of Vehicles in Minna

Table 4.3 shows the variation in volume of carbon concentration emitted by various types of vehicles in Minna using one sample T Test. The one sample T test recorded a t value of 7.100 and a P-value of 0.000. Since the p-value is less than 0.001 at 95% confidence level, it therefore implies that there is a significant variation in the concentration of carbon emitted by various categories of vehicles in Minna.

Table 4.2. One-Sample Test

	Test Value = 0					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference: Lower	Upper
Carbon Emission	14.266	7	.000	19.71250	16.4450	22.9800

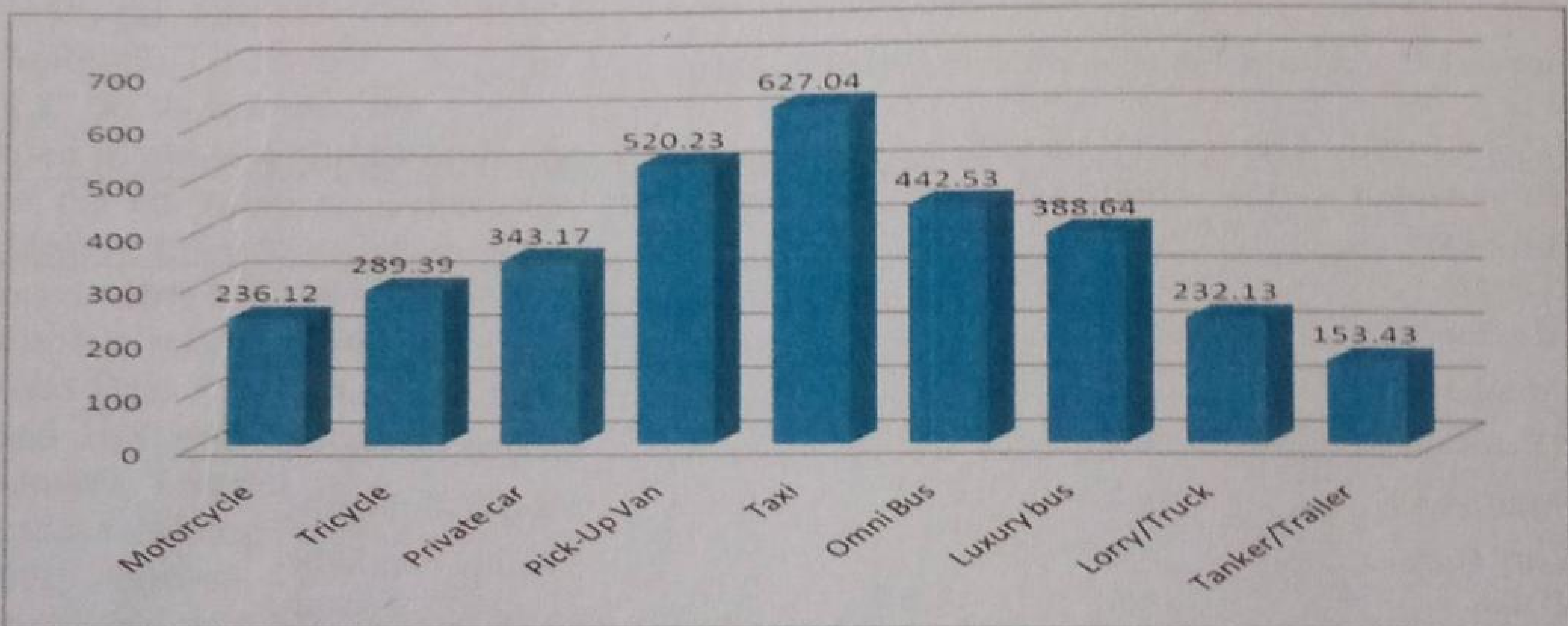

Figure 4.2: Carbon Concentration Emitted by Vehicles in Minna

Table 4.3. One-Sample Test

	Test Value = 0					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference: Lower	Upper
Emission	7.100	8	.000	359.18667	242.5343	475.8391

Conclusion and Recommendations

This study has shown that the amount of carbon emission (particularly CO concentration) by vehicles around the roundabouts and some junctions in Minna are above the recommended limits. It therefore confirmed the findings of Ndoke et al (2000) and Nwachukwu et al(2012) that vehicular emission contributes to the concentration CO in the atmosphere with its impact on the environment.

Based on the findings of the research, the following recommendations are suggested:

i. The Vehicle Inspection Office (VIO) should be strengthened by the State to enforce Excessive Smoke Violation (ESV) among the motorists.

ii. The use of intelligent traffic system should be introduced in Minna in order to reduce the idling time of vehicles in major Junctions.

iii. The Motor park at Mobile roundabout should be relocated to reduce both human and vehicular traffic around the Roundabout.

iv. The Obasanjo Shopping Complex is the main economic hub around the Obasanjo Complex roundabout. The State should provide multi-level parking lots based on Private Public Partnership (PPP) within the trekking distance of five (5) minutes, or 25 to 30 metres away from the Shopping Complex in order to reduce the rate of vehicular movement around the axis.

v. Residential buildings around the major Roundabouts should be relocated because of the carbon exposure, while residential development should be discouraged.

vi. There should be enforcement of setbacks for other buildings and informal economic activities at the major Roundabouts.

vii. The use of non-motorised transport system which is pollution free should be encouraged to replace the vehicles driven by fossil fuel.

viii. There is need for integrated approach to tackle air pollution relating to vehicular movement and climate change, thereby making use of the most cost-effective measures. A good example is vehicle maintenance, use of catalytic converter as pollution control device, and planting of trees or plants around the traffic hotspots to trap carbon.

ix. There should be awareness creation on the impact of carbon emission on major traffic hotspots in Minna. This will include production and distribution of information and communication materials on air pollution control in public places.

x. There should be enforcement of relevant of regulations on motor vehicle emission and pollution control as it relates to carbon emission.

xi. There is the need to address the transport demand issues through the use of intra mass transit system and discourage private vehicular use in the Town. This will reduce carbon emission and improve energy efficiency.

xii. Ring roads and Bye-passes should be constructed to avoid thoroughfare for vehicles that do not have business in the city of Minna.

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