ASSESSMENT OF THE SPATIO - TEMPORAL VARIATIONS OF VEHICULAR EMISSION AND AIR QUALITY IN MINNA, NIGER STATE, NIGERIA

BY

ONAOLAPO Emmanuel Opeyemi
M.Sc/SCI/26329/2012-2013
(M.Sc Environmental Management)

A THESIS SUBMITTED TO THE SCHOOL OF POST GRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA NIGERIA, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF SCIENCE IN ENVIRONMENTAL MANAGEMENT

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DECLARATION

I declare that the work in this thesis entitled **Assessment of The Spatio-Temporal Variations of Vehicular Emission and Air Quality in Minna Metropolis, Niger State, Nigeria** has been performed by me in the Department of Geography under the supervision of Dr. J.O Folorunsho and Dr.(Mrs) B. Abdulkareem. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously presented for another degree or diploma at this or any other Institution.

ONAOLAPO EMMANUEL OPEYEMI ._____ _____
Name of Student Signature Date

CERTIFICATION

This thesis titled **"Assessment of The Spatio- Temporal Variations of Vehicular Emission and Air Quality in Minna Metropolis, Niger State, Nigeria"** by **ONAOLAPO Emmanuel Opeyemi** meets the regulations governing the award of the degree of Master of Science (Environmental Management) of the Ahmadu Bello University, and is approved for its' contribution to knowledge and literary presentation.

Dr. J.O Folorunsho	_____	_____
Chairman, Supervisory Committee	(Signature)	Date
Dr. (Mrs) B Abdulkarim	_____	_____
Member, Supervisory Committee	(Signature)	Date
Dr. I. J. Musa	_____	_____
Head of Department	(Signature)	Date
Prof. K. Bala	_____	_____
Dean, School of Postgraduate Studies	(Signature)	Date

DEDICATION

To the evergreen memory of late ELDER JOSHUA B. ONAOLAPO.

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ABSTRACT

This study assessed the level of some selected air pollutants which are largely products of internal combustion in motor vehicle engines namely: nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and carbon monoxide (CO) in Minna. Number of vehicles were counted at morning, afternoon and evening time while Crowcon (Tetra 3) model number IECEx BAS 05.0059 was used for monitoring the concentrations of the three gases at the selected motorways which were labelled X and Z. The point X represented road intersections where samples were obtained within the metropolis (urban Area namely Top Medical junction, Kpakungu Roundabout, and Obasanjo Complex Roundabout), while point Z is the control station which is situated at the Government residential area ideal for less traffic flow in the city. Traffic volume ranged between 1775±06 at the various sampling points. The concentrations of CO, SO_2 and NO_2 ranged between 51.05±0.04 ppm, 0.119±0.017ppm and 0.115±0.029ppm respectively, they were found to exceed the stipulated threshold by Federal Ministry of Environment. Significant relationship ($p< 0.05$) was established between the volume of traffic and the concentrations of the sampled gases across the periods of the day at the selected motorways. There is also a significant difference ($p< 0.05$) between the sampled gases in the urban centre and the control point. Hence, traffic volume accounted for 30.5ppm, 38ppm, 20ppm of CO concentrations in the Morning, Afternoon and Evening respectively. 0.029ppm, 0.082ppm and 0.076ppm of NO_2 concentrations in the Morning, Afternoon and Evening respectively. While 0.119ppm, 0.093ppm and 0.084ppm of SO_2 concentrations were measured in the Morning, Afternoon and Evening respectively along the selected motorways. Urgent precaution that seeks to minimize the level of emission of pollutants from automobile is required in Minna to protect the teeming population especially road users against the adverse impacts of these pollutants.

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CHAPTER ONE: INTRODUCTION

1.1 Background to the Study

Issues of environment and its component parts have become a front burner from the policy makers, through the academia, the local communities and the general public. One common feature of the issues relating to the environment in Nigeria is that it is fast becoming unfriendly, unsustainable and endangers species (Phil-Eze, 2009) Human activities and the environment are inter-related. This is because any activity of man is done in the environment and the resultant effect is either positive or negative to man. Human activities are however diverse. According to Uchegbu (1998), negative effects arise from such economic and domestic activities of man. For instance, burning of fossil fuels, exhaust fumes: All these emit harmful pollutants like sulphur dioxide, carbon monoxide, etc, that cause acid rain, global warming, and the malfunctioning of human haemoglobin, etc. Ukpong (1994). The emittance of such gases is known air pollution.

Air pollution is defined as the presence in the outdoor or indoor atmosphere of one or more gaseous or particulate contaminants in quantities, characteristics and of duration such as to be injurious to human, plant or animal life or to property, or which unreasonably interferes with the comfortable enjoyment of life and property (Odigure, 1998) , Also Merriam-Webstar 2014 defined air pollution as the release into the atmosphere of gases, finely divided solids, or finely dispersed liquid aerosols at rates that exceed the capacity of the atmosphere to dissipate them or to dispose of them through incorporation into the biosphere. Air pollution can be classified into natural air pollution which includes windblown dust, volcanic ash, and gases, smoke and trace gases from forest fires, and anthropogenic air pollution which includes products of combustion such as nitrogen oxides (NO_x), carbon oxides (CO_x), sulphur dioxide (SO_x). (Saville, 1993).

Air quality in the urban centers all over the world are distinguished from those of the less built up areas by differences in carbon monoxide, volatile organic compounds, oxidants,

oxides of Sulfur , Nitrogen and particulate matter. These differences are attributed in large part to anthropogenic interference of nature. According to Tawari and Abowei (2012) Anthropogenic sources of air pollution is mostly related to burning different kinds of fuel from motor vehicles, marine vessels, aircraft, dust and controlled burn practices in agriculture and forestry management.

Most of the vehicles today use internal combustion engines that burn gasoline or other fossil fuels (Prather, Derwent, Ehhalt, Fraser, Sanhueza and Zhou, 1995). The ambient pollution over urban centres is characterized by higher concentrations of such chemicals beyond limit is introduced into the air by increased pollution from mobile sources. This includes: cars, buses, trucks as well as motor cycles, these has increased with per capital ownership over the years. For example, Abam and Unachukwu (2009) reported that the Federal Road Safety Commission of Nigeria (FRSC) had registered about six million (6,000,000) vehicles between 1999 and 2004 and that 70% of these were cars while 30% were buses and trucks. On the average, these have increased emissions from road transportation in Nigeria. The concentration level of these pollutants depends on the magnitude of local emission sources and the prevailing metrological ventilation of the area (Colls, 2002).

Emissions from vehicles have been verified to have negative effect on public health and the natural environment in and around the world, especially in urban areas where pollution levels are on the increase due to vehicular emission. Galen in 129- 199 AD, speculated that there was a change in the composition of the air which caused harm when inhaled. Chemicals found in polluted air could cause cancer, birth defects brain and nerve damage, and long-term injury to the lungs and breathing passages in certain circumstances. (Schwela 2000), reported that exposure to carbon monoxide can result in fatigue, headaches, dizziness, loss of consciousness, and even death at very high concentrations, Particulates are especially dangerous because they have been implicated in the development of lung cancer

and higher rates of mortality (Schwela, 2000).

Pollutants released into the atmosphere from vehicles include carbon dioxide (CO2), carbon monoxide (CO), sulphur oxides (SOx), nitrogen oxides (NOx), particulate matter (particles of smoke, soot, and dust), hydrocarbons and lead (Corbitt, 1999). These pollutants are produced when fuel is burnt under less than ideal conditions. Non uniform oxygen supply within the combustion chamber and lower flame temperature leads to incomplete combustion releasing CO, hydrocarbon (HC) and un-burnt particles in the exhaust (Garret and Newton, 2001).

From the report of the United states Environmental Protection Agency (USEPA) (2007), vehicles account for 51% of carbon monoxide, 34% of nitrogen oxides and 10% of particulate matter released each year in the US, Similarly in UK, the average concentration of NO_2 was found to increase by 35% from 1986 to 1991 due to increase in vehicular emission (Commission of the European Communities (CEC) 1992). In developing countries, Because of economic constraints, poorly maintained, older vehicles are often imported, leading to an automobile fleet dominated by a class of vehicles known as "super emitters" which release higher concentrations of harmful pollutants in comparison to properly maintained vehicles (Moen, 2008), these super emitters represent 10% of the vehicles on the road, yet generate 50% of emissions (Brunekreef 2005). Also, World Bank (1994) predicted that air pollution in some cities in Nigeria in 2000 would be as twice worse as in 1990 and nine times worse in 2020. There is an increase in population, together with increase in the number of vehicles on roads. The impact of motor vehicle emissions extend far beyond the local area, The transportation sector is the most rapidly growing source of greenhouse gas emissions-- that is, emissions of chemicals that have the potential to contribute to global warming (IPCC 1995), to attest to this, (National Research Council, 2010) published that carbon emissions from vehicles are a major source of atmospheric greenhouse gases (GHGs). Other related problems include damages to the ecosystem, damage to materials, buildings and the acid rain

phenomenon (Weathers and Likens, 2006).

Several attempts has been made to control vehicular emission worldwide, for example, Small and Kazim (1995), reported that Europe has lagged behind the US in emission controls on motor vehicles, Research conducted a decade and half ago has shown that transportation sources in the USA were responsible for 77% of CO levels, 80 -90% of NO_n, 36% of volatile organic compounds and 22% of particulate matter (USEPA, 1993). Similarly, in United Kingdom (UK) the average concentration of nitrogen dioxide 'NO_2' was found to increase by 35% from 1986 to 1991 due to increase in vehicular emission (CEC, 1992). Africa is worse off. In Nigeria, the government has banned the importation of vehicles over eight years old. Good as this policy may look like, what remains to be done is how to control emission from the existing old vehicles plying the streets and highways of Nigeria. Some of the policies are aimed at reducing overall vehicle use, so as to minimize congestion/or pollution. However, these policies really do little to reduce the twin effect of congestion and pollution. The need for a National Air Pollution Control strategy is brought about by Parts II and V of the Environment Management Act 2005 that requires the Ministry of Environment to develop strategies for pollution control and to provide permits to facilities discharging waste and pollutants into the environment. Obviously, air pollutants are amongst these and a strategy can provide guidance for the development of these permits.

Motor vehicles are major sources of these air pollutants, as industrialization and technological development continue there will be a corresponding increase in income and hence cities will experience a greater increase in the number of vehicles on the roads (Akpan and Ndoke, 1999).

1.2 Statement of the Research Problem

Air is known to be primarily essential for the existence of all forms of life. In most developing countries of the world; vehicular growth has not been checked properly by environmental regulating authorities leading to increased levels of pollution (Han, and

Naeher, 2006). The health challenges experienced by road users, passers-by, residents and business operators in traffic flash points, having high concentration of vehicular traffic during some periods of the day are worrisome issues. A comparison of the monitored and inventory emissions with acceptable standards (threshold) is useful in determining the extent of safety of road side business operators and hawkers in traffic intersection congested traffic points.

Several studies have found a relationship between the degree of exposure to vehicular emissions and adverse health effects, such as increase hospitalizations and mortality rate. Studies such as this are been carried out where urbanization brings about increases in population, which lead to corresponding increases in motor vehicles, either for private or for public transportation.

Jimoh and Ndoke (2007), assessed the Impact of Traffic Emission on Air Quality in Minna .The researchers obtained census of registered vehicles from the state licensing office, and questionnaire aimed at determining the age of vehicles. These were administered on a sampled population (50 for private cars, 100 for motorcycles, 200 and 50 for commercial cars and buses respectively). Findings from this research however shows that the concentrations of the gases measured are still within the limits stipulated by the WHO and FEPA. This implies that traffic emission in Minna, which has a population of about 300,000 people with 3,000 vehicles, is within the safe limit.

Furthermore, Koku and Osuntogun, (1999) studied the impacts of urban road transportation on the ambient air quality in three cities of Nigeria: Lagos, Ibadan and Ado – Ekiti all in South-west region of Nigeria. Air quality indicators namely CO, sulphur dioxide 'SO_2', NO_2, and total suspended particulates (TSP) were determined using automatic insitu gas monitors (Rae ii reuseable). Conclusions of this research show a growing risk of traffic-related problems in Nigeria cities and demand for serious air quality measures.

In a recent research by (Okunlola, Uzairu and Gimba 2012) on the assessment of the concentration of CO, SO_2, NO_2 and H_2S in Kano city, This study was conducted from

December 2009 to September 2010 that is, across the four main seasons: December, cold and dry; March, hot and dry; June, warm and wet; September warm and dry. Concentrations of gaseous pollutants data, CO, H_2S, SO_2, NO_2 and NH_3 were determined. It was observed that, with few exceptions at some sites, gases measured were above air quality index recommended by USEPA.

Also, Aliyu (2013) studied the ambient air quality along busy roads in zaria urban area, the researcher investigated air pollutants such as PM, CO, NO_2, SO_2, H_2s, Fl and NH_3 using geo information technology, they findingsof the researcher was displayed on a hazard map, the conclusion of the research showed that transport related pollution in Zaria can potentially be hazardous to health.

Hena (2014), investigated the contribution of Vehicle emissions along some selected busy roads in Kaduna metropolis with the aid of tetra 3 crowncon air quality device, pollutants such as CO, NO_2 and SO_2 was investigated. Head count of vehicles was also counted manually to check if relationship exists between traffic and the concentration level of emission measured. The end result of the research showed statistical evidence that vehicles contribute to air quality in the study area.

All the studies conducted on vehicular emissions from the review done were conducted outside Minna except that of Jimoh and Ndoke (2007) which coincides with this current study where average daily recordings from the study revealed that CO and CO_2 Concentration were a little below the limit stipulated by the Federal Environment Protection Agency. There is however, a strong possibility that the situation might have worsened due to the increase in vehicle ownership in the city, particularly the popular “tokunbo” vehicles. Moreover, the work conducted by Jimoh and Ndoke adopted two (2) open-air sampling method as well as a random selection on vehicles of population (50 for private cars, 100 for motorcycles, 200 and 50 for commercial cars and buses).but this might not be adequate for a fast growing city like Minna. From 2007 till date there is therefore no doubt that there has

been an increase in the total numbers of vehicles in the study area.

Therefore, this present work seeks to establish a more detailed approach to the contribution of motor vehicle emission in Minna metropolis by increasing the open air sampling points to three rather than one point employed by Jimoh and Ndoke, This present work will also measure other air quality gases like NO_2 and SO_2 which Jimoh and Ndoke did not measured creating a gap that this study intend to address.

This study therefore, seeks to address the following questions:

i. What is the concentration level of SO_2, CO and NO_2 in the study area?

ii. What is the relationship between the rate of traffic flow and concentration level of SO_2 , CO and NO_2 in the study area?

iii. Which pollutant has the highest concentration level at the sampling points?

iv. Is there any difference in the level of pollutants measured in the urban centre and control point?

1.3 Aim and Objectives

The aim of this study is to ascertain the level of vehicular emission and air quality in time and space within minna.

This will be achieved through the following objectives, which are to:

i. examine the weekly concentration level of SO_2, CO, NO_2 in the study area

ii. compare the difference between the frequency of traffic flow and concentration level of the pollutants

iii. examine the pollutants concentration level with time for all the variables across the sampling points.

iv. compare the pollutants concentration level at the urban sampling points with that of the control point.

1.4 Research Hypotheses

In order to carry out this study, the following hypotheses was tested and it is stated as:

$H_0$1: There is no significant difference in the concentration of the pollutants ($SO_{2,}$ CO and $NO_{2)}$ within the urban center and the control station.

$H_0$2: There is no relationship between traffic volume and the concentration of the pollutants at the various sampling points.

1.5 Scope and Delimitation

This study focuses on measuring the level of emission generated by vehicles in Minna Township and will be limited to major motor ways within the town which include Top Medical Junction, Kpankungu Roundabout, and Obasanjo Complex Roundabout .It will entail a direct measurement of some selected air quality indicators, largely products of internal combustion in motor vehicle engines which are $SO_{2,}$ CO and NO_2 in the study area without giving consideration to any weather parameter. The choice of this three air quality indicators is to reduce the overhead cost of this study. The field data was collected for 3 weeks in January, 2015 (the dry season). However, other possible sources of air pollutants like bush burning, refuse burning, domestic sources which may influence the outcome of this study cannot be controlled as they are beyond the scope of this study.

1.6 Significance of the Study

The mode of transportation in Nigeria is largely by road and air, with water transport in the coastal areas. The fleet of road vehicles has steadily increased since independence in 1960. According to the Vehicle inspection office in Abuja For example, an average of 900 cars are been registered weekly. (Moen 2008). Furthermore, Balogun and Federal Road Safety Commission (FRSC) (2008) stated that from 1988 to 2008, all fleets of licensed vehicles increased from 580,997 to 944,619. The resultant effect of this is increased emissions particularly with the prevalence of second-hand vehicles as old as 20 years being

imported to the country.

However, Exposure to traffic-related air pollutants has been linked to a wide variety of health concerns, including respiratory and cardiovascular problems, birth and developmental defects, and cancer (Health Effect Institute (HEI), 2010). For example, nitrogen oxides and sulfur oxides are associated with immune system impairment exacerbation of asthma and chronic respiratory diseases, reduced lung function, and cardiovascular disease (Schwela, 2000). The gases can also lead to a chain-reaction event that includes acid rain and smog. If left unchecked, the chemical aspect of air pollution could become the largest contributor to premature death in the world, higher than the rate of cancer, acquired immune deficiency syndrome (AIDS), automobile accidents, or any other cause of unnatural or premature. Also to make matters worse, the products of this vehicular emission which includes Nitrogen oxides (NO_X), Carbon oxides (CO_x) and Sulphur Oxide (SO_X) are major culprits associated with global warming. Moreover, the fuel composition makes it likely that the vehicles in use in Minna will release high levels of pollutants. Vehicular emissions are affected by fuel type, especially sulfur content. As the sulfur content increases, the fuel efficiency decreases and emissions of sulphur oxides, particulate matter, and volatile organic increases (World Bank 2003).

Thus, the outcome of this study will be of great importance to highlight the relationship between the public health and environmental sustainability. This will further help physical planners, environmental policy makers as well as Health policy makers coordinate their activities for better Decision and policy making especially in a developing city like Minna where there has been only few studies on air quality undertaken since 2007 till 2014.

CHAPTER TWO: CONCEPTUAL FRAMEWORK AND LITERATURE REVIEW

2.1 Introduction

This section focuses on vehicular emissions pollutants which are NO_2, SO_2 and CO in urban areas, its spatial and temporal variability. The review is aimed at establishing gap in knowledge as well as providing a conceptual frame work for this study.

2.2 Conceptual Frame Work

2.2.1 Air Pollution

Air is a part of the Earth's atmosphere, and one of its most important natural resources. Air is shared and used by all humans, animals and plants to sustain life, to affirm this claim, Garg (2006) reported that an average human being requires about 12kg of air each day, which is nearly 12 to 15 times greater than the amount of food consumed. In the atmosphere, the air which we breathe consist by volume of 78% nitrogen (N2) 21% oxygen (CO2) 1% Argon and 0.03 carbon dioxide. The layer of troposphere which most living things exist gets contaminated with such substance as chemical, acid rain, carbon monoxide from anthropogenic sources which alters the natural volume composition of the air.

Anjaneyulu (2005) defines air pollution as limited to situations in which the outer ambient atmosphere contains materials in concentrations which are harmful to man and his environment. Air quality degradation is not new – since the middle of the 19th century, but the concern about the environment is growing worldwide especially with the problem associated with it. Naturally, most people tend to associate air pollution problem with the coming of industrial revolution in the early 60's. Such problems in one form or another have plagued the human race for centuries. The earliest pollutant noted in the atmosphere was probably of natural origin. Ash, fumes, smoke and forest fires, sand and dust from windstorm in arid region, dews during dry season were part of our environment long before human, however, the industrialization of the society, the explosion of the human population and the

introduction of vehicles have cause exponential growth not just to goods but also air pollution (USEPA, 1998).

According to the world health organization (2001), motor vehicle has been identified as one of the major cause of air pollution in most cities of the world. Although the world leaders like china, United States, Russia, Mexico and Japan have created cushion effects, Nigeria is lacking behind even in Minna, studies have confirmed that the air is polluted and it has been attributed mainly to vehicular exhaust.

2.2.2 Traffic Air Pollutants

Transportation typically involves the combustion of fossil fuels to produce energy translated into motion, such as the power to move a car which comes from burning fuel in an engine Pollution from cars comes from by-products of this combustion process (exhaust) and from evaporation of the fuel itself. The combustion process involves the breaking down of Gasoline and diesel fuels which are mixtures of hydrocarbons, compounds which contain hydrogen and carbon atoms. In a perfect engine, oxygen in the air would convert all the hydrogen in the fuel to water and all the carbon in the fuel to carbon dioxide. Nitrogen in the air would remain unaffected. In reality, the combustion process cannot be perfect and automotive engines emit several types of pollutants. According to Ajayi and Dosunmu (2002), the exhaust, the crankcase, the fuel tank and the carburettor are the sources of unburned hydrocarbon (HC). However, the proportion of these various pollutants attributable to the transport sector varies significantly across different cities.

One of the major pollutants that humans are exposed to its harmful effect is carbon monoxide (CO). It is a colorless, odorless, non-irritant and tasteless poisonous gas. It is slightly lighter than air. It is highly toxic to humans and animals at high concentrations. The gas consists of one carbon atom and one oxygen atom connected by a triple bond which consists of two covalent bonds as well as one dative covalent bond. It is a product of

incomplete combustion of hydrocarbons (such as oil, gasoline, natural gas and coal) and occurs when carbon in the fuel is partially oxidized rather than fully oxidized to carbon dioxide (CO_2). while the compound exists naturally, it has likely been present since early in the earth's formation, it wasn't until a 14th century Spanish Chemist named Arnaldus de villanova described the gases from burning wood, which today is known as carbon monoxide (Chen,wang, McElroy, He Yantosea and Le sager, 2009).Gibbs, Betty, Dolaty, and Agent 1995;Glen, Zalenk, and Graham, 1996; Johnson and Gerhold 2001, Ackerman, Davies, Jefferson, Longhust and Marque, 2002;).pointed out that Carbon monoxide worst levels of pollution are seen in such urban cities as are densely populated. Carbon monoxide is present in small amounts in the atmosphere, chiefly as a product of volcanic activities but also from natural and man-made fires (such as forest and bushfires, burning of crop residues and sugarcane fire-cleaning).

Outdoor concentrations of carbon monoxide vary depending on how and where and when the gas is produced. For example, in urban areas, carbon monoxide levels are greatest in downtown areas where motor vehicle density is high, during peak commuting times, and in the passenger compartments of motor vehicles. Unfortunately, Carbon monoxide present an important environmental hazard, Carbon monoxide poisoning is the most common type of fatal air poisoning in many countries (Walker and Hay, 1999)

According to Ayoola (2012), if one breathes in air containing carbon monoxide (CO), this will lead to the replacement of the Oxygen (O_2) present in Oxy-hemoglobin (HbO_2) and become carboxy-haemoglobin (HbCO) which is a poisonous. It reduces the flow of oxygen in the bloodstream and is particularly dangerous which is ineffective for delivering oxygen to bodily tissues termed anoxemia (Fairburn,Tikuisis, Kane, McLellan, and Buick 1992; Omaye, 2002). It is easily absorbed through the lungs (Ernst and Zibrak, 1998).

The health effects of carbon monoxide poisoning is enormous, ranges from impaired mental alertness and performance, headaches, nausea, fatigue, and dizziness to coma and

death. Long-term (chronic) exposure includes: damage to the nervous system and death. Exposure of pregnant women to CO may cause low birth weight and nervous system damage to the offspring (Henry, Satran, Lindgren, Adkinson, and Nicholson 2006). Different people and populations may have a different carbon monoxide tolerance level (Thom, Raub, Mathieu-Nolf, and Hampson, 2000). On average, exposures at 100 ppm or greater is dangerous to human health (Chichkova and Prockop, 2007). Furthermore, Carbon monoxide has an indirect radiative forcing effect by elevating concentrations of methane and tropospheric ozone through chemical reactions with other atmospheric constituents (e.g., the hydroxyl radical, OH^-) that would otherwise destroy them (Noel, 1995), It is eventually oxidized to carbon dioxide through natural processes in the atmosphere. Carbon monoxide concentrations are both short-lived in the atmosphere and spatially variable.

Apart from the health implication of CO, it is also a major culprit associated with global warming which plays a role in the generation of ground-level ozone (Ukpebor, Eromomene, Odiase, and Okoro, 2010). This has attracted the attention of several scientific researchers in recent years. Akinyemi and Usikalu (2013) Investigated of carbon monoxide concentration from anthropogenic sources in Lagos, Nigeria The CO concentration was detected and measured with the aid of a digital carbon monoxide detector (model: DC01001) manufactured by general tools and Instrument, New York. The equipment is designed for CO detection in the range of 0 and 999 ppm, with 1 ppm resolution and accuracy of ±20% at 0 to 100 ppm; ±15% at 100 to 500 ppm; (at 20 ± 5°C, 50 ± 20% RH). Eight (8) different local council development authority's (LCDA) in Lagos, also Ariko, Sawa and Ibrahim (2014) studied the Variability in Carbon Monoxide Concentration in Kaduna Metropolis, Nigeria's-CO data loggers were used for data acquisition for a period of one month. 1hour mean of Carbon Monoxide concentrations for urban core and Control station

Sulphur dioxide is another recognized pollutant because of its role in forming cold time smog (Hermann, 1991). It is an acidic, irritant gas formed when sulfur is exposed to

oxygen at high temperatures during fossil fuel combustion, oil refining, or metal smelting. SO_2 is toxic at high concentrations, but its principal air pollution effects are associated with the formation of acid rain and aerosols (Haley, 2003) which in high concentrations can cause difficulties (Arch, 1954; Hermann, 1961; Purnendu, 1991). The pollutant causes constriction of the airways by stimulating nerves, nose, throat and airways of the lung (Frank, 1964; Wolff, Dolovich, Rossman, and Newhouse 1975). People with asthma are more susceptible to the adverse effects of the gas as high concentrations may result in the fall of lung function in asthmatics and may lead to tight chest, coughing,wheezing and phlegm at high levels. It is a gas considered more harmful than other gases (Beilke and Elshout, 1983; Duesing and Duesing, 1980; Howell, 1983; Hutchinson and Havas, 1980). The effects are worse when exercising and the most vulnerable groups are healthy children, adults with lung disease and asthmatics. Other sources of sulphur dioxide apart from the combustion of fossil fuels, incineration of refuse, and the production of elemental sulphur (Cullis and Hirschler, 1980; Moller, 1984) include decay of organic wastes and refuse in the surroundings (Ayodele and Bernard, 2006).

Different researchers have employed different methods to examine the concentration of sulphur oxides (Stratman, 1954; Fritz and Yamamura, 1955; Jacobs, 1959: Perry and Tabor, 1962; Terraglio and Manganelli, 1962; Avrabami and Golding, 1968; Kumar and Balasubramah, 1992; Gregory, David, Beltz, Bandy, Ferek, and Thornton, 1993; Bloomquist, Bandy, Thornton, and Chen, 1993; Eisele and Tanner, 1993; Saltzman, Yuon and Matrai, 1993; Vasilenko, Kovalyov and Rubstova, 1993). By bubbling air through dilute H_2O_2 solution. West and Gaeke (1956) used the colorimetric method for the Determination of air borne sulphur dioxide. The hydrogen peroxide method of determination was used by Greenburg and Jacob (1956a and b). Huggen (1962) employed the impregnated filter tape for the measurement of sulphur dioxide. Kozlyaeva (1989) reported the determination of air borne sulphur dioxide using evacuated flasks for its collection. This study reports level of

Vehicular sulphur dioxide as well as other pollutants at different road intersections of Minna Municipal environment using automatic gas sensor. Ayodele and Mohammed, (2001) reported the ambient SO_2 concentration over Kano municipality is in the range 14 - 22 _g/m3 with a coefficient of variation of 12.74% using automatic gas sensor.

Nitrogen oxides, or NOx, are the generic term for a group of highly reactive gases, all of which contain nitrogen and oxygen in varying amounts. Many of the nitrogen oxides are colorless and odorless. However, one common pollutant, nitrogen dioxide (NO2) along with particles in the air can often be seen as a reddish-brown layer over many urban areas. Nitrogen oxides form when fuel is burned at high temperatures, as in a combustion process. The primary sources of NOx are motor vehicles, electric utilities, and other industrial, commercial, and residential sources that burn fuels. In the air, NOx reacts readily with common organic chemicals, and even ozone, to form a wide variety of toxic products, some of which may cause biological mutations. Examples of these chemicals include the nitrate radical, nitroarenes, and nitrosamines. NOx causes a wide variety of health challenge, it irritate the lung and alter its defense mechanisms, thereby increasing a person's risk for respiratory infections. Its role in the formation of photochemical oxidants and smog has attracted the attention of several scientific researchers in recent years.

Particulate Matter (PM) is a widespread air pollutant, consisting of a mixture of solid and liquid particles suspended in the air. It includes naturally occurring dust and pollen as well as soot and aerosols from combustion activities such as agricultural burning, transportation, manufacturing, and power generation. (Varney and McCormack, 1971, Smith, 1975, Miller, 1994 and Botkin and Keller, 1998). Botkin and Keller (1998) stressed that much particulate matter is easily visible as smoke, soot or dust, and other particulate matter is not easily visible. The most harmful particles are not the large particles, which are mostly removed in the upper airways, but the small particles that may be deposited deep in the lungs. PM is a mixture with physical and chemical characteristics varying by location. Common

chemical constituents of PM include sulfates, nitrates, ammonium, other inorganic ions such as ions of sodium, potassium, calcium, magnesium and chloride, organic and elemental carbon, crustal material, particle-bound water, metals (including cadmium, copper, nickel,vanadium and zinc) and polycyclic aromatic hydrocarbons (PAH). The resultant health effects of particulate matter are determined by their size distribution, bulk chemical microbiological concentration and composition (Hetland, Cassee, Refsnes, 2004; Griffin, Garrison and Herman, 2001). plethora respirable particle (PM2.5) concentration have been shown to have insidious effect on the respiratory and cardiac health of humans (Dockery, Pope III, Xu, 1993; Gwyno, Burnett,Thurston, 2000; Pope, Burnett andThun, 2002) attenuate visibility and also affects the structural integrity of plant (Bergin, Greenwald and Xu, 2001).

According to (WHO 2013), it is estimated that approximately 3% of cardiopulmonary and 5% of lung cancer deaths are attributable to PM globally. In the European Region, this proportion is 1–3% and 2–5%, respectively, in various sub regions. Furthermore results emerging from a recent study indicate that the burden of disease related to ambient air pollution may be even higher. This study estimates that in 2010, ambient air pollution, as annual PM2.5, accounted for 3.1 million deaths and around 3.1% of global disability-adjusted life years.

2.2.3 Nigeria Air Quality Standards

Humans can be adversely affected by exposure to air pollutants in ambient air. (Schwartz, 1994; Hemminki and Pershagen, 1994; Knox and Gilman, 1997; Moen, 2008). In response, The Federal Ministry of Environment through the national agency responsible for setting and maintaining environmental standards in Nigeria, Formally Federal Environmental Protection Agency (FEPA) Now National Environmental Standards and Regulations Enforcement Agency (NESREA), has adopted an extensive body of legislation which establishes health based standards and objectives for a number of pollutants in air.

These standards and objectives are summarized in the table below Tables 2.1 and 2.2 below. These apply over differing periods of time because the observed health impacts associated with the various pollutants occur over different exposure times.

Table 2.1: Nigerian Ambient Air Quality Standard

Pollutants	Time of Average	Limits
Particulates	Daily average of hourly values	250µg/m^3
	1 hour	600µg/m^3
Sulphur dioxide (SO_2)	Daily average of hourly values	0.01ppm (26µg/m^3)
	1 hour	0.1ppm (260µg/m^3)
Non-methane hydrocarbon	Daily average of 3 hourly values	160µg/m^3
Carbon monoxide	Daily average of hourly values	10ppm (11.4µg/m^3)
	8 hourly values	20ppm (22.8µg/m^3)
Nitrogen oxide	Daily average of hourly values	0.04ppm – 0.06ppm
	(range)	(75.0µg/m^3-13µg/m^3)
Photo chemical oxidants	Hourly values	0.06ppm

Source: (Federal Environmental Protection Agency (FEPA), 2000).

Table 2.2: Guidelines for Nigeria Ambient Air Limits for Convectional Pollutants Tolerance Limits for Ambient Air Pollutants

Pollutants	Long – term mg/m^3	Limits +(hours)	Short – term mg/m^3	Limits + (mins.)
Carbon monoxide	1.0	24	5.0	30
Chlorine	0.03	24	0.1	30
Chloroform	10.0	24	50.0	30
Fluorides	0.012	24	0.055	30
Hydrocarbons (total)	0.01	24	-	-
Hydrogen sulphide	0.008	24	0.008	30
Lead	0.005	24	0.02	30
Lead sulphide	0.001	24	-	-
Nitric acid	0.008	24	0.008	30
Nitrogen dioxide	0.085	24	0.085	30
Nitrogen monoxide	0.4	24	0.8	30
Nitrogen oxide	0.004	24	0.1	30
Oxidants	0.08	24	0.1	30
Ozone	0.1	24	0.2	30
Soot	0.05	24	0.1	30
Sulphur dioxide	0.05	24	0.5	30
Sulphuric acid	0.1	24	0.5	30
Suspended particulate	0.15	24	0.5	30

Source: (Federal Environmental Protection Agency, 2000).

2.2.4 Sources of Air Pollutants

The major pollutants are generated from anthropogenic sources (Otti, Nwajuaku and Ejikeme, 2011), For example, smoke from the industrial cities of Lagos (Apapa, Amuwo Odofin axis) Kano (Bompai), Port Harcourt gas flaring and refineries (Otti, Nwajuaku and Ejikeme, 2011). These pollutants includes: sulphur dioxide, which are emitted from chemical processes and from fuel combustion, while the major pollutant from automobiles is carbon monoxide. These sources emit both primary (directly into the air) and secondary pollutants (formed by chemical reactions within the atmosphere) into the atmosphere (Pooley and Mille,

1999). However, according to Mayer (1999), Pooley and Mille (1999) and ADB (2006) most of the airborne particulates are emitted from the combustion engines from vehicles contributing at least 70-75% of the total air pollution. This happened due to the increase of the number of registered road vehicles every year which then become a dominant source of urban air pollution (Brimblecombe, 1999; D'Angiola, Dawidowski, Gomez, and Osses, 2010). The emission contains carbon monoxide (CO) and sulphur dioxide (SO_2),. The common air pollution sources in Nigeria aside traffic emission are; biomass combustion, bush burning, refuse burning, generator emission, gas flaring, industrial emissions and indiscriminate refuse disposal. The table 2.3 below shows the percentage distribution of principal pollutants from various sources.

Table 2.3: Sources of the Principal Pollutants in an Average Urban City

Pollution Sources	CO	NO_x	HC
Gasoline vehicles	90%	52%	40%
Domestic	5%	3%	2%
Power stations	1%	26%	<1%
Industry	4%	11%	56%
Others	-	8%	1%

Source: European Fuel Oxygenates Association (2013).

Biomass in form of firewood, coal, bamboo trunks and dead leaves are commonly used sources of cooking fuel. Of all these the most frequently used is firewood. Trees are very important in Nigeria. Not only do they preserve the environment by protecting the soil and retaining water by their root system, but they also can provide the local population with food and domestic fuel. Population pressure and the resulting increase of the demand for fuel have led to forgetting about the environment and to concentrate on only one function: the fuel source. This inexpensive resource of domestic fuel provides between 85% and 99%

(Ryan and Openshaw, 1991). The air pollutants emissions from wood combustion depend on the type, condition and combustion conditions but for low fueling rates typical of household. Cooking (a few Kgh^{-1}) (Smith, 1983).

Bush burning has been practiced from time immemorial and in many societies has been accepted as an integral part of traditional farming system. Bush burning is one of the major air pollutants that are emitted during bushfire and these include Carbon monoxide, Carbon dioxide, oxides of Nitrogen, and oxides of Sulphur, particulates and Hydrocarbon as a result of incomplete combustion of cellulose materials (Stern, 1976). Apart from soil destruction and desert encroachment caused by the effect of bush burning, it also has a marked increase in global warming due to the emission of NO_2, SO_2, SO_3, NO, CO and CO_2 gases which have tremendous effect on the Ozone layer. (Jamala and Shehu, 2011). The causes of bushfires are both natural and anthropogenic. Climatic factors especially dry spells; nature of vegetation and wind speed all play an important role. When there is a prolonged dry season, and where the potential evaporation exceeds the rain fall during the year, the natural vegetation becomes dry and therefore vulnerable to fire incidence. Human activities such as land clearing and burning of bush by herdsmen in order to stimulate germination of new grasses are also causes of uncontrolled and indiscriminate bushfires.

In most developing countries of the world such as Nigeria, Refuse disposal is a major environmental problem in the communities particularly in the urban areas. The refuse is usually from multiple sources. According to The Federal Ministry of Environment (2012), such refuse are from different categories; Municipal solid wastes which comprise domestic waste, trade and commercial refuse (from schools, hospitals and clinics) and street cleansing waste; industrial wastes, consisting of refuse generated from industrial operations and by solidification of liquid and gaseous effluents and building construction wastes, which are mainly inert from demolition, excavation and construction activities including domestic, municipal, agricultural and industrial sources. One of the environmentally unfriendly

methods of managing the waste is by open burning either on nearby lands or open dumps within the residential vicinities. The composition of the refuse, age of the dump and intensity of the flame usually determines the nature of the air pollutants. Often times the air within refuse burning sites is inundated with VOCs, CO_n, SO_n, NO_n, total hydrocarbons (THCs), as well as various classes of toxic and hazardous compounds viz polycyclic aromatic hydrocarbons(PAHs), dioxins, PCBs (Polychloro Biphenyls) and heavy metals such as lead, nickel and mercury (ibid).

Global Gas Flaring Reduction Initiative (2002) reported that Nigeria flares 17.2 billion^3 m of natural gas per year in conjunction with the exploration of crude oil in the Niger Delta, This was affirmed by Cedigaz (2000), that Nigeria holds the highest record (19.79%) of natural gas flaring globally and is responsible for about 46 % of Africa's total gas flared per tonne of oil produced. Similarly, analytical assessment of the statistical bulletin of the Central Bank of Nigeria (2004) showed that the average rate of gas flaring in Nigeria during the period 1970-1979 stood at 97%, while 97% and 95% were flared between 1980 and 1989, and 1990 to 1999 respectively. Between 2000 and 2004 51% was flared. Gas flaring is a major contributor to the stock of green house gases in the atmosphere thus adding to the climate change chaos and by far the main source of carbon dioxide emissions in sub-sahara Africa (Global Fuel Economy Initiative (GFEI), 2010). further reported that gas flaring wastes destroyed resources in the natural environment and thus deprived the rural people in developing economies cleaner and cheaper source of energy resources. Apart from the release of green house gases into the atmosphere, gas flares are said to release about 45.8 billion kilowatts of heat into the atmosphere Etiosa and Matthew (2007).

Nigeria has oil and non oil related industries including refinery, petrochemical, liquefied natural gas, chemical fertilizer, aluminum smelter, paper, cement, flour, wood, battery and textile industries etc which are major sources of greenhouse gas emissions. Greenhouse effect occurs when CO_2 and other greenhouse gases that are relatively,

transparent to incoming Short-wave solar radiation absorb and emit the Long-wave radiations from the earth's surface and reflect downwards some of these re-emitted radiation towards the lower atmosphere (Horsfall and Spiff, 2001). The pollution from these industries adds to the burden of gaseous and particulate pollutants in the air. There is also air pollution emitted from indiscriminate dumping of solid waste which decomposed to a number of gases, that are present in the exposed dumping solid waste, including ammonia (NH_3), carbon dioxide (CO_2) carbon monoxide (CO), hydrogen (H_2), hydrogen sulphide (H_2S), methane (CH_4), nitrogen (N_2) and an exposed solid waste can produce some odorous material in the atmosphere (methane and carbon dioxide), can also be released by both convective flow and diffusion to different strata of soil (Prasad, 1995).

2.2.5 Causes of Air Pollution from Transportation

(Gorham, 2002) reported that a number of factors can be identified as influencing the amount of emissions attributable to the transport sector, They include: (a) the amount that vehicles are used in a given country or metropolitan area, including the extent to which this use can be called "excessive" (b) the age of the vehicle fleet and the technology used within it; (c) the extent to which vehicles are properly maintained; (d) the availability of appropriate fuels and the extent to which they are used properly; and (e) atmospheric, climatological and topological conditions. (Gorham, 2002).

a. Excessive vehicle use. Level of activity or vehicle use is an important factor to take into account in the overall analysis of transportation emissions, particularly in those cases where long-run solutions are envisioned to help avoid the development of a problem. In a number of developed countries (where data and information are more readily available), studies have shown that growth in activity has either significantly increased the amount of CO2 emitted in the sector or substantially dampened the reduction of CO2 emissions that would have occurred, the latter because of efficiency

improvements during the last three decades of the twentieth century. In the absence of a policy to address vehicle use, growth in vehicle kilometers travelled in developing countries is projected to average between 2.5 and 4 per cent per year between 1990 and 2030.

b. Age of fleet and technology used. Older vehicles are associated with higher emissions of both global and local pollutants than newer vehicles, both because performance deteriorates as a function of age and because older vehicles are more likely to use obsolete, higher emitting technology.

c. Poor maintenance of vehicles. Deterioration of emissions characteristics is linked to maintenance practices of owners, particularly for local pollutants, where catalytic exhaust after-treatment technology is used. Misfuelling of catalyst-equipped gasoline vehicles with leaded fuel, even once or twice, can seriously damage the ability of the catalyst to operate properly, and these catalysts can also degrade over time because of other natural contaminants in fuels. Without an effective system in place to ensure that these systems are well maintained, emissions due to neglecting exhaust after-treatment maintenance are likely to increase.

d. Unavailability or improper use of appropriate fuels. Fuel is a factor for a number of reasons. Regulatory authorities may inappropriately specify fuel types for a given area's conditions, leading to unnecessary emissions of certain kinds of pollutants. Vehicle owners may misfuel, out of ignorance or in response to a poorly established price signal. Dishonest retailers might adulterate or substitute fuels, again often in response to an unfortunate price signal.

2.2.6 Factors that increases Air Pollutant

According to Roberts (2004), there is an interaction between meteorological condition and air pollution phenomenon where high temperature stimulates the level of airborne particulates concentration. Air pollutants may be dispersed via air, water, soil, The pathways

of dispersion vary greatly, depending upon both the emission source and the pollutant concerned. Rates and patterns of dispersion also depend to a large extent upon environmental conditions. Pollution dispersal in the air is affected by many factors: meteorological conditions (especially wind speed, wind direction and atmospheric stability), the emission height (e.g. ground level sources such as road traffic or high level sources such as tall chimneys), local and regional geographical features, the source (e.g. fixed point, such as a chimney, or a diffuse number of sources such as cars and solvents). (EEA, 2013). During dispersion pollutants undergo a wide array of changes and transfers.

Many pollutants therefore show extremely complex dispersion patterns, especially in environments such as cities and towns where there are a large number of emission sources and major variations in environmental conditions. This complexity means that it is often very difficult to model or measure pollutant patterns and trends, and thus to predict levels of human exposure. Temporal variations in pollution levels are important. In many cases long-term trends exist, reflecting underlying changes in the rates of emission (e.g. as a result of technical or economic changes, or due to policy intervention). Superimposed upon these there may be annual variations, reflecting year-to-year differences in climate or source activity. Many pollutants also show marked seasonal, weekly and daily patterns, owing to cycles of activity and short-term climatic and other effects. Major, short-term pollution episodes may also occur as a result of sudden, accidental releases. Therefore measurements of exposure will vary according to when, where and for how long air monitoring is carried out.

Hydrocarbon (HC) emissions can be influenced by ambient temperature. Very low ambient temperatures (e.g., below 20^0F or -6.67^0C) can influence emissions at ignition and cause the catalytic converters, in vehicles that have it, to cool during short stops. Very high ambient temperatures can also have a secondary influence on exhaust emissions because engine load is increased by air conditioner use. Effects can include higher Nitrogen oxides.

The amount of water vapour in the air can affect nitrogen oxide gaseous emissions in older and malfunctioning vehicles (Utang and Peterside, 2011).

Wind speed is the rate of the movement of the wind per unit time. The concentrations of all pollutants are lower at higher wind speeds (Levy, 2003). Traffic emissions are substantially greater in cold weather (high humidity) because cars need more fuel to start at cold temperatures and some emission control devices such as oxygen sensors and catalytic converters operate less efficiently when they are cold (Tubal, Estoque, Holdsworth, and Villarin, 2002).

2.2.7 Health Effect Associated with High Concentrations of Transport-Related Pollutants

Amidst growing concern for air quality, several studies have found a strong correlation between air pollutants and state of Health, for example (Abbey, Mills, Peterson and Beeson, 1991; Abbey *et al*., 1993; Bates and Sizto, 1987; Lippmann, 1989). Found Acute and chronic lung function responses to sulphur dioxide exposure .also (Nriagu, 1978; Peng, Dominici, Barriuso, Zeger and Samet, 2005; Osibogun, 2006). linked to varying cardiopulmonary and cardiovascular diseases, hyperactivity, neurobehavioral effects and even death to severe exposure to sulphur dioxide.

Similarly, (Walker and Hay, 1999) argued that Carbon monoxide poisoning is the most common type of fatal air poisoning in many countries, It combines with hemoglobin to produce carboxyhemoglobin (COHb) which is ineffective for delivering oxygen to bodily tissues termed anoxemia (Fairburn, Tikuisis, Kane, McLellan and Buick, 1992; Omaye, 2002. For example, a study on toll-booth operators in Taiwan found significantly higher prevalence of headaches (44.4%) compared to controls (Chen, 2002), In another study by Moen (2008), in the city of Abuja Nigeria, high prevalence of headaches and fatigue was recorded for traffic wardens, this reported symptoms implies that the general health status of wardens

investigated is poor and was related to carbon monoxide exposure. Furthermore, epidemiological studies have shown that a rise of 10μg m^{-3} of PM_{10} could increase mortality case up to 1% (Steward, Owen, Donovan, Mackenzie, and Hewitt, 2005). As a whole, air pollution is an episode that causes disruption in daily living, physical discomfort, and illness and reduces life expectancy.

Particulates are more toxic because of their ability to penetrate deep into the respiratory tract, particles with diameter of 10 μm or more are filtered when inhaled through the nose.(Oke and ukpebor 2013) While bigger particles remain in the throat, the smaller ones (PM2.5 or PM1) get in the trachea and in the respiratory system. They are more toxic because they often consist of heavy metals and cancer causing organic compounds (Hörmann, Pfeiler, and Stadlober, 2005).

According to ATSDR (2002) Nitrogen oxide causes eye irritation, respiratory tract disease, lung damage, Decreased pulmonary functions and hearing stress. Nitric oxide in large concentration also reacts with haemoglobin in a similar way as carbon monoxide, thus resulting in oxygen deprivation effects. Symptoms of acute poisoning often expressed by people in traffic jams include headache, loss of vision, decreased muscular coordination and nausea.

Studies conducted in Ethiopia, Mozambique, and Kenya have established higher prevalence of asthma in urban school children exposed to traffic pollution compared to rural children (Yemaneberhan, 1997; Mavale-Manuel, 2004; Ng'ang'a, 1998). Furthermore, In Ethiopia, individuals living closer to roads experienced more wheeze at levels comparable to those observed in developed countries with twice the traffic volume, resulting from the high proportion of super emitters (Venn, 2005).

2.3 Review of Related Studies

Over the years, there has been a lot of concern over air pollution. Transportation/motorization has been verified as a major driving force of air pollution (World Bank, 1995; Garba and Garba, 2001). The growing risk of increased pollution from mobile transportation source is alarming. Congestion on Nigeria city road and increase in the concentration of pollutants in the air, have consequently increased health risk on human population.

In specific studies relating to the Nigerian experience, mobile source emissions have tended to be the largest contributor to urban emission inventories in many locations. According to Ndoke, Akpan, and Kato (2006) on the contributions of vehicular traffic to carbon dioxide emissions in Kaduna and Abuja, Northern Nigeria confirmed that Nigeria air quality is poor. In this study, the quantity of carbon dioxide (CO_2) contributed by automobile emissions to the environment was determined at some areas in Kaduna and Abuja in Northern Nigeria. Five census stations were selected in each of the two towns. In Kaduna, Jabi road in Ungwan Rimi, Kawo Motor Park, Stadium roundabout, Sabo and Kasuwa (Kaduna Main Market), were selected for Kaduna, while Asokoro (behind ECOWAS), Area One junction, A.Y.A. junction, Wuse market bus-stop, and Mabushi round-about were selected for Abuja. A gas sampling pump and tubes that could detect carbon dioxide were used to detect the quantity of CO_2 in the environment at a certain time. The results obtained show a variation in the amount of CO_2 in the environment. Areas with relatively heavy congestion show a high concentration of CO_2, while areas with minimal traffic show a lower concentration of CO_2. Sabo in Kaduna has an average concentration of 18.40ppm being the highest, while Asokoro (behind ECOWAS), Abuja has the least average concentration of 11.60ppm.

Furthermore, Ojolo, Oke , Dinrifo and Eboda (2007) focused on congested areas of Lagos where heavy vehicular emissions are common. The sample areas are densely populated. They were observed both in the day and night. The sample areas are Oshodi,

Mushin and Apapa, while Fola Agoro was used as a control location since it has low levels of pollution. In these study areas, concentration of pollutants such as carbon monoxide, sulphur oxide, nitrogen oxides, organic acids, and hydrocarbons (obtained mostly from exhaust gases) in the atmosphere is high.

In the investigation, the following effects and impacts were assessed: the effects of emission on the health of the people living in the sampled location; the effects of emissions on buildings and structures; the effects of emission on vegetation in the sampled location; and analysis of the rainwater samples located in the study locations. The effect of emission on health: was determined through the use of questionnaires. This was prepared and administered on 100 selected individuals each who live or work in the study areas. The data obtained from the questionnaires were analysed based on the information obtained from them. The result obtained from this study shows that on the average, 28.3%, 16.6%, 23.3%, 18.3%, 13.3% of the population studied were respectively affected by sleeplessness, running nose, heavy eyes, asthmatic attack, and headache respectively. The location (distance from the coast type of fuel, availability of industries, and concentration of traffic) were identified to determine the impacts of these emissions on the ecosystem.

Abam and Unachukwu (2009) studied the vehicular emissions and air quality standards in Nigeria and concluded that traffic related pollution is on the increase. This paper reported the results of the investigation of vehicular emissions in selected areas in Calabar, Nigeria. Three areas MP1, MP2, and MP3 were considered with nine sampling points (SP1 – SP9) in each area placed 8.0m away from the edge of the road in downwind direction. Priority parameters: CO, NO2, SO2, PM10 and noise level were monitored. Other relevant parameters monitored includes ambient temperature, wind direction, wind velocity and traffic count. The CO, SO2, NO2 and PM10 where determined using standard method. CO was monitored using a portable analyser model 2002, made in USA, in compliance with USEPA method. The CO was investigated for 24 hours and the Total weighted Average (TWA) of

CO was calculated. Samples of SO2 were collected using APM 410 and 415 sampler (model 2001 manufactured by VBU ltd., India) and analysed by calorimetric method in accordance to USEPA method, 40 CFR 50 Appex. The duration of sampling at individual sampling points was 3 days on 24 hours duration. NO2 and PM10 were collected also for 3 days and 24 hour duration. The sampling methods were in accordance to NIOSH method CAS 10102-43-9 and USEPA method 40 CFR 50 Apex.

Metrological parameters like: Ambient temperature, wind direction and wind velocity were monitored with a portable weather station (Davis Ventage Pro-2, USA). These metrological parameters were monitored for 3 days on 24 hours. The noise level was monitored with digital sound meter (Rion N- 27, made in JAPAN) with data logging. Traffic count was manually done, counting the vehicles passing on the road for 10 minute in every hour from which hourly traffic was calculated. The results of CO, NO2, SO2, PM10 and noise level were in the range of 3.3-8.7ppm, 0.02 – 0.09ppm, 0.04 – 0.15ppm, 170 - 260μ g/m^3 and 58.5 -72.4dB respectively. The highest level obtained for the air pollution indicators for CO was: 8.7ppm, 7.6ppm and 7.4ppm at SP_1 for day 1, 2 and 3. The concentration of SO_2 was highest at SP_2 with values 0.10ppm and 0.12ppm. Emission concentration for NO_2, PM_{10} and noise level was found to be highest at SP_2 where traffic intersections and traffic count is high.

All the five monitored air pollutants when compared with Air quality index were in the range of: CO – poor to moderate and moderate to poor in different locations. SO_2 – was from very poor to poor, NO_2- from very poor to poor, PM_{10} and noise level was poor at all locations. The overall comparison of data for different sections show that concentration of pollutants is highest at (SP_{1-3}) and (SP_{8-9}) and this is was due to volume of traffic and pollution in the three areas MP_1, MP_2, and MP_3. The study concludes that transport-related pollution in Calabar is indeed significant with possible severe health consequences.

In a more recent study, Investigation of Air Pollution from Automobiles at Intersections on Some Selected Major Roads in Ogbomoso, South Western, by Ojo and Awokola (2012), the researchers considered Major roads along Ogbomoso North and South Local Government areas due to high traffic volume always experienced on this roads and the location of commercial activities along these roads. Four sampling routes were considered with ten sampling points, labeled (SP1 – SP10) and placed 2.0m away from the edge of the road. The method adopted for the collection of air samples was the use of a locally made air sampler which consisted of aspirator bottle (20-25 litre capacity) cork, retort stand, glass and tubes. These pollutants were collected using different absorbing reagents Hydrogen Peroxide for SO2, Sodium Nitrite for NOx, and Distilled water for CO. The duration of sampling at individual sampling points was 5 days on a 12 hours basis. The CO, SO2 and NOx were determined using standard method in compliance with USEPA method. The conclusion of the research shows that the mean concentration of CO, SO2, NOx pollutants were found to be much higher when compared with the Federal Ministry of Environment limit.

Akanni, (2010) studied the Spatial and seasonal analyses of traffic-related pollutant concentrations in Lagos Metropolis, Nigeria. The methodology of study involves stratified selection and identification of seven dominant land use zones and random selection of 28 almond trees from four sites on each land use selected. Dominant land use were determined from land cover features generated from the 1967 (1:50,000) topographic base maps and were overlaid with land use images of Lagos metropolis subset to an area of approximately 2,383.994 km2 to cover Lagos and its vicinity derived from Land sat thematic mapper (TM) and enhanced thematic mapper (ETM+) data pair of December 18, 1984 and February 6, 2000, acquired from the University of Maryland free Online data services (2005) and combined with the road map to identify the different categories of land use within the metropolis. Biomonitoring of atmospheric pollutants concentration (Pb, Cd, Cu, Cr, Al, Zn, As, Hg, Fe, Mn and Mg) involved weekly collection of leaf samples of the dominant almond

trees (*T. catappa L*) exposed to ambient air and air pollutants at an average height of 1.8 m at 28 randomly selected locations along traffic corridors and at 6 locations 250 m away from traffic corridors as control for 8 months between the short-wet season of September-October and shortdry/ harmattan season of November-December 2005 and 2006.

The leaf samples were collected, bagged and transferred to laboratory where the samples were oven-dried and prepared for titration and quantitative determination of elemental composition of trace metals through chromatographic separations. The variations in the quantity (mass concentration) and quality (chemical composition) of atmospheric pollutants at street level along the traffic corridors was determined with Pearson correlation analysis, ANOVA and difference of mean test. Result of the laboratory analysis shows a significant seasonal variation ($P < 0.05$) in TSP, values varied from 22.36 - 29.07 mg/m3 as against WHO Air Quality Standard (AQS). Concentrations of pollutants were higher than the WHO Air Quality Standards and were also higher along traffic corridor than further away.

Akinyemi and Usikalu. (2013), investigated the carbon monoxide (CO) concentration from anthropogenic sources in eight, different Local Council Development Authority (LCDA) in Lagos State Nigeria. The CO concentration was detected and measured with the aid of a digital carbon monoxide detector (model: DC01001) manufactured by general tools and Instrument, New York. The investigated areas according to the researchers are Ikeja, Festac, Ikoyi, Gbagada, Apapa, Kosofe, Surelere and Isolo which can be grouped into industrial area, commercial and residential areas according to the activities predominant in such vicinity. 5 different measurements were taken for two hours in each location in 1 LCDA and average values were taken.

The CO concentration from cars, trucks, motor cycles, petrol generators, diesel generators and household kitchens and firewood cooking areas were considered in each location the same numbers of point source were considered. The CO concentration obtained as a result of movement of cars, trucks, motorcycles, working of generators, commercial and

residential activities etc, It was found that trucks emitted highest concentration of CO (289.64 ppm) followed by generator operated on diesel (116.23 ppm) while cooking with firewood emitted the lowest concentration of CO (5.75 ppm). Carbon monoxide concentration from residential and commercial areas, are moderate and considered safe for those in the area. The highest CO concentration was obtained in Kosofe (76.7 ppm) which can be traceable to the fact that there is high vehicular movement in this area since this is where Ojota is located. The lowest CO concentration was obtained in Isolo (32.5 ppm) this may be associated with low vehicular movement in the area during this period. According to the US AQI limit, it is only Isolo that has good healthy concern as related to CO concentration while all other locations considered can be said to have moderate healthy concern to CO concentration.

Okelola and Okhimamhe (2013) examined the trend level of vehicular carbon footprints emissions in Minna, Niger State, Nigeria, the study provides an insight into the obtainable emission levels in the selected flashpoints for the study. These flashpoints are spread across the city of Minna's road network. The measurements were achieved using gasman meters for each type of gas investigated in this study namely: carbon dioxide (CO2), carbon monoxide (CO), sulphur dioxide (SO2), ammonia (NH3), nitrogen dioxide (NO2), chlorine (Cl2) and hydrogen sulphide (H2S). The measurements were carried out at the peak and off peak traffic times within the city due to temporal variations.

The average emission values for the peak and off-peak times were calculated and also represented with the Arc-GIS software. The complete data have also been computed and analysed using the SPSS software. The results established that emissions' level of carbon dioxide from vehicular emissions in particular exceeded the internationally accepted safe limits of 350 parts per million in the atmosphere. Upon the completion of the research, necessary measures for climate change mitigation via emissions reduction was documented for effective and efficient urban and regional planning.

CHAPTER THREE: THE STUDY AREA AND METHODOLOGY

3.1 Introduction

This section provides the background to the study area and the methodology employed in order to achieve the set objectives. This study area is Minna Metropolis.

3.2 The Study Area

3.2.1 Location

Minna is the administrative capital of Niger State. It lies within Latitude $9^{o}36^{'}0^{''}$-$9^{o}38^{'}0^{''}$N and longitudes Longitude $6^{o}31^{'}0^{''}$-$6^{o}34^{'}0^{''}$of the Greenwich Meridian; (See) figure 1. It is about 145 kilometers by road from Abuja, the Federal Capital Territory of Nigeria. The study area covers about 76,363km^2 and it's located at the south-eastern axis of the state, in the middle belt region of the country. Politically, Minna town is bordered by Shiroro Local Government Area in the North, Shiroro and Paikoro to the east, pikoro and Katcha Local Government Area in the south and Wushishi and Gbako in the west (Minna was predominantly a Gwari town and its name was derived from a yearly ritual performed by the Gwaris to observe the beginning of the New Year. The word Minna literally means spread fire (Maxlock, 1979).Tribes such as Nupe, Yoruba, Hausa, Igbo and many others settled in different camps within the town as a result of the rail line construction that began in 1914. (Maxlock, 1979).

3.2.2 Population

The population of Minna in 1979 was estimated at 65,000 people and would double every nine (9) years, for instance, by the beginning of 1989 there were 130,000 people in Minna. The growth rate is not far from the 1991 population census that gives a total of 197,996 people. And according to the 2006 national population census, Minna recorded a population of 348,788 people (Gazette, 2009).

3.2.3 Climate

The climate of minna is the result of the general atmospheric circulation of air masses over the earth modified by surface topography and elevation. The principal air masses affecting the weather of the Minna are the Tropical Maritime (M_T) and the Tropical Continental air masses (C_T). The broad rainfall pattern shows a distinct and fairly south-north gradient in which the annual rainfall decreases from the southern fringe (Ati and Sawa, 2008)) The highest mean monthly temperature is recorded in March with at about 30.5°C (87°F) and the lowest in august at about 25.10°C (77°F) (Maxlock, 1979). The annual rainfall ranges from around 1,600mm to 1,230mm. It experiences high temperature all the year round, the mean annual temperature increases northward from about 30°C to 37°C, (Ati and Sawa (2008).

3.2.4 Economic Activities

The predominant economic activities in the study area include commerce, service sector (civil service) and agriculture. Commerce and civil service make up a higher proportion of the population. Agriculture is practiced on a small scale, although the study area is situated in an agricultural belt, agricultural land use has tremendously reduced, while commercial land use is rapidly developing due to the population up surge in the area. The implication of all these to the physical environment is the increase in solid waste generation from these activities.

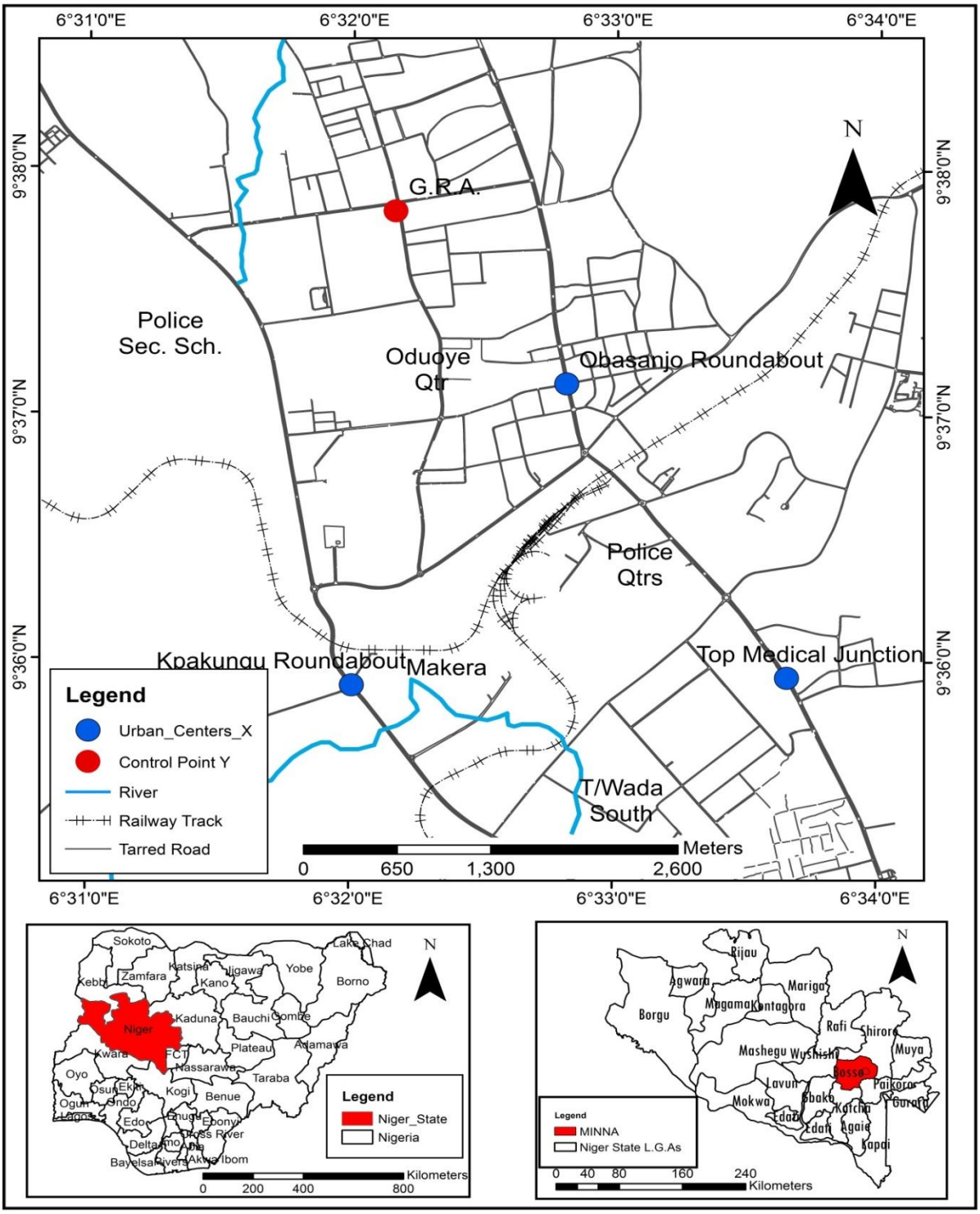


Figure 1: Minna Showing the Study Area
Source**:** Modified from Quickbird Imagery, 2013

3.2.4 Drainage and Geology

The major rivers that make up the drainage of Minna are the bosso, Shango, Chanchaga, Ekpa, Suka and Gora rivers. These rivers mainly have extensive tributaries that cover most part of the areas and serves as major sources of water supply to Minna and its environs. (Maxlock, 1979). The topography of Minna consists of hills and mountains especially towards eastern and western part of the area. Because of these gigantic rocks, development has been restricted towards the eastern and western parts. All developments follow the line of the rock, which was halted by flat rock out crop at the extreme north. The basic geology of the study area is a mixture of rock granites. In most of the areas, the surface is decomposed of laterite, erosion and small stream that cut deep gullies leaving the residual crops generally eaten away by natural forces, such as rain and wind.

3.2.5 Soils and Vegetation

Although no systematic soil survey covering the area, soils in the region represents an interface between intensive weathering of rocks and active surface and subsurface denudational system fueled by intensive rainfall and rapid runoff .The soil type is primarily the result of the interaction between climate, flora and fauna, parent materials and geomorphic factors over varying period of time. Soils are developed from Precambrian basement complex rock comprising granite, schist, genesis, and amphiboles, which occur on an undulating welling dissected plain, developed on undifferential basement complex consisting mainly of granites rock, gneiss and schist. The surface soils are usually loamy sand to sandy loam. Most of these soils are gravely except the soil formed on colloidal material.The vegetation of Minna consists of open savannah. The Fadamas of the larger rivers support savannah with occasional streams covered with dense riparian woodlands or forested area. Minna lies on ecological zone termed by plant geographers the northern guinea savanna, a designation which implies a woodland vegetation type dominated by *isoberlinia doka, I.tomentosa,* and *Uapaca togoensis* tree species, and Andropogoneae herbs (keay,

1959:1960) other common trees of the woodland include *Terminalia avicennioides, Combertum binderianum,piliostigma thonningii, Bridelia ferruginia*. Common shrubs include *Antidesma venosum, Alchornea cordifolia, Aleurite montana*. There is well developed, low cover and mostly perennials grass layer of many *Andropogoneae,* in particular *Hyparrhenia* spp., and *Monocymbium ceresiiforme.* The trees characteristically grow long tap roots and thick bark (Geography of Change and Development in the Middle Niger Basin 2008).

3.3 Methodology

This section captures the methodology adopted for this study. It is organized under the following sub title; types and sources of data used, equipment used for the study, technique of data collection and technique of data analysis

3.3.1 Types of Data

3.3.1.1 Primary data

i. The concentration level of SO_2, CO and NO_2 from the selected sample points for both urban and the control centre measured from vehicular emission in the study area.

ii. Rate of traffic flow at the designated sample points

iii. Photo shots of vehicular movement were taken to boast the visual understanding during the field survey.

3.3.1.2 Secondary Sources

The secondary sources of data for this work consists of published and unpublished works generated from existing materials, internet, journals conference papers research thesis and other documents related to the study as well as related websites.

3.3.2 Sources of Data

i. Vehicular pollutants level for (SO_2, CO and NO_2): This was obtained from field measurement by the use of Crowcon

ii. Rate of traffic flow: manual counting of vehicular movement from each sampling points were recorded.

iii. Photographs of vehicular movement

iv. First hand information gotten through observations

3.3.3 Equipment used for the Study

3.3.3.1 Hardware

i. Computer laptop (ACCEER ASPIRE INTEL ATOM) was used to process the acquired data

ii. Crowcon (Tetra 3) Gas Monitor for field detection of pollutants level (SO_2, CO and NO_2)

iii. Digital Samsung camera for taking photographs

iv. Tricycle for easy movement from one point to the other.

3.3.3.2 Software

i. Moonstat version 1.2 for statistical analysis

ii. IBM Spss statistics (version 20) for further statistical analysis

3.3.4 Method of Data Collection

3.3.4.1 Sampling Procedure

For this research, two points was outlined namely X and Z. The point X represent road intersections where samples were obtained within the metropolis (urban Area namely Obasanjo Complex Roundabout, Top Medical junction , Kpakungu Roundabout and while point Z is the control station which is situated at the Government residential area ideal for less traffic flow. The choice of these locations was based on their potentially high traffic capacity and existing literatures, where the various researchers adopted the various sampling

points because they are the major congested areas in such location. For instance, Okelola and Okhimamhe (2013) conducted a similar research to measure carbon emissions concentration in Minna, the researchers used seven points to obtain the result based on the fact that those points are the flash points. Similarly, Odhiambo, Kinyua and Gatebe 2010 in Kenya in a bid to study motor vehicle air pollution used one (Single) sampling point to make generalization about the entire Kenya metropolis. Also (Ojo and Awolola 2012) in a study to investigate air pollution on from automobiles at intersection in Ogbomosho used four sampling routes. For the purpose of this research, three (3) sampling points was adopted been the most notorious traffic flash points in the study area as well as a control station.

The pollutants were measured using Crowcon (Tetra 3) with model number IECEx BAS 05.0059, air sampler for the detection of the gases (SO_2, CO and NO_2). This device was rented from Kaduna Environmental Protection Authority. (KEPA). The equipment was manufactured by Crowcon OX14 1DY United kingdom, it is a portable multigas detector, designed to be carried or worn by individuals working in hazardous environments. It is suitable for use in Division 1 and 2 hazardous areas; it can monitor up to four different gases and display the readings simultaneously on a display screen. It uses a unique plug and play i-module sensor technology with each sensor unit having its own intelligent processor holding sensor configuration and calibration data. The processes used to design and develop the Tetra 3 software ensure a high degree of reliability and robustness.

The time frame for the collection from the three sampling points was 3 weeks. One week per each sampling point, in three different periods of the day. These periods according to Ndoke and Jimoh (2012) are termed peak and off peak periods. They are the busiest periods of the day. Categorized as follows:

- Morning peak hours which falls between 7:30am to 9:30am
- Off peak hours which falls between 11:00am to 12:00 noon

- Evening peak hours which falls between 4:30pm to 7:00pm

Traffic count of vehicles was performed manually to obtain the rate of flow of vehicles at the sampling points. This was done at the space of 30 minutes to avoid repetition as this is the most acceptable standard for vehicular count in urban areas.

3.3.4.2 Calibration of Crowcon (Tetra 3)

3.3.4.2.1 Calibration

Calibration describes the process of adjusting the output or indication on a measurement instrument to conform to value of the applied standard within a specified accuracy. The calibration of Tetra 3 was performed at the Kaduna Environmental Protection Authority which was where the equipment was rented. It was connected to a PC using single way charger unit and then the wizard was used to select the configuration. Field calibration was also performed where tetra 3 was put to zero for 15 minutes before commencing the gas test instruction.

3.3.5 Technique of Data Analysis

The data obtained was subjected to analysis as follows:

Objective One: **Examine the Concentration of SO_2, CO, NO_2 in the Study Area.** The concentration of the pollutants was measured and presented in a table such that it can be compared with the WHO permissible limit and that of the Federal ministry of Environment Which are CO (10-20ppm), NO_2 (0.0466ppm), and SO_2 (0.01-0.1 ppm). The average measurement for each day was also calculated using the formula below:

$$\mathbf{AVG.E_L = (E_M+E_O+E_E)}$$

Where E_ld = Total daily emission level

E_M= Emission at the morning peak

E_O= Emission off peak

E_E= Emission at the evening peak.

Field counting on the number of vehicles that plies the road at the time when measurements were taken for each point was also recorded; this was done every 30 minutes to avoid repetition. This was presented alongside the pollutants measurement.

Objective Two: compare the difference between the frequency of traffic flow and concentration level of the pollutants

To achieve this, the null hypothesis which states that "there is no significant relationship between traffic volume and the concentration of the pollutants at the various sampling points was tested at 0.05 level of significance, using Pearson correlation.

Objective Three: examine the pollutants concentration level with time for all the variables across the sampling points.

In order to achieve this, data collected was presented in a map such that the points with darker shades indicate high concentration level while the points with lighter shades connotes lower concentration level. Data collected was further subjected to Analysis of variance (ANOVA) to ascertain which of the pollutants has the highest concentration across the points. This was carried out at 0.05 level of significance.

Objective Four: compare the pollutants concentration level at the urban sampling points with that of the control point

This was achieved using Analysis of variance (ANOVA) conducted at 0.05 level of significance which was used to test the hypothesis Ho: 1, predicted based on the assumption that "there is no significance difference in the quality air within the urban center and the control center for all the variables".

Objective Five: examine the pollutants concentration across the periods of the day.

Data collected was subjected to analysis of variance (ANOVA) conducted at 0.05 level of significance to examine what period of the day has the highest concentration of the pollutants ($SO2, CO, NO_2$)

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the result of the vehicular emission recordings in Minna metropolis. First, the mean and total emission levels of the air quality parameter (CO, SO_2, and NO_2) for each period (morning, afternoon and evening) measured at the sampling points, followed by the statistical analysis of the pollutants using Statiscal package for social Science (SPSS) software (version 20) for descriptive and inferential analysis respectively.

4.2 Concentration of So_2, Co and NO_2 in the Study Area

To achieve objective/research question I which sought to examine the concentration of CO, SO_2 and NO_2 in the study area, the pollutants were measured near the road side for the period 45 minutes in the morning, afternoon and evening period. The mean and total concentration of these pollutants were evaluated on weekly basis as well as the corresponding vehicular headcount and presented in table 4.1 below.

Table 4:1 Weekly Concentration of SO_2, NO_2 , CO and Traffic in the Study Area per week

		Air Quality Parameters (ppm)			
		SO_2	NO_2	CO	
Sample Point	**Time of Day**	**Total**	**Total**	**Total**	**Traffic**
Top Medical	Morning	0.119	0.029	30.5	227
	Afternoon	0.093	0.082	38	68
	Evening	0.084	0.076	20	241
Obasanjo Complex	Morning	0.017	0.109	51.5	224
	Afternoon	0.113	0.101	38	69
	Evening	0.089	0.082	23	228
Kpakunguu	Morning	0.114	0.108	50.8	196
	Afternoon	0.481	0.039	13.3	73
	Evening	0.122	0.115	56.8	201
GRA	Morning	0.058	0.045	004	15
	Afternoon	0.045	0.039	003	16
	Evening	0.035	0.039	004	14

Source: Field Survey, 2015.

Table 4.1 shows the average total concentration of CO, SO_2 and NO_2 per week measured within the space of thirty minutes duration in the morning, afternoon and evening period. These measurements were taken at the designated sample points.

Hm67hm The emission level of CO at top medical were 30.5ppm, 38ppm and 20ppm across the periods of the day which are morning, afternoon and evening. They were found to exceed the Nigerian ambient air quality standard which is 10ppm (11.4 Ng/m^3) FEPA (2000) similarly the average weekly emission of CO for Obasanjo roundabout were 51.5pm, 38ppm and 23ppm across the period of the day. This also exceeded the FEPA threshold. The CO weekly concentrations for kpakungu across the periods of the day were also found to be 50.8ppm, 13.3ppm and 56.8ppm. This also exceeded FEPA threshold. Furthermore, the average weekly CO concentration across the day at the control points was found to be lower than the FEPA stipulated limit across the day. Which are 004ppm, 003ppm and 004ppm. This confirms the claim of Akpan and Ndoke, (2006), Ojolo, Oke , Dinrifo, and Eboda, (2007) that Nigerian cities are fast becoming unfriendly especially as regards to air quality.

In the same vein, the average weekly $S0_2$ concentration at top medical junction was found to be 0.119ppm, 0.093 and 0.084ppm across the time of the day. The measurement for the morning rush exceeded the FEPA stipulated limit which is 0.01ppm-0.1ppm FEPA (2000). The $S0_2$ reading for Obasanjo roundabout was also found to be 0.0890ppm, 017ppm and 0.109ppm.both the recordings for the morning and afternoon periods were found to be slightly higher than the threshold. Furthermore, $S0_2$ recording for kpakungu was found to be 0.481ppm, 0.114ppm and 0122ppm across the period. These values are higher than the FEPA standard. In a likely manner, $S0_2$ reading for the control point (GRA) was found to be 0.058ppm, 0.045ppm and 0.035ppm across the periods of the day which is below the threshold by FEPA. The variation in the measurement of SO_2 is attributed to leaded fuel in Vehicles (Gorham, 2002).

4.3 Relationship between the Rate of Traffic Flow and Concentration Level of the Pollutants

To achieve objective/research question II, which sought to address the relationship between the rate of traffic flow and concentration level of the pollutants, the collected data was subjected to test of association using correlation; the result obtained is presented in table 4.2 below:

Table 4.2: **Pearson Correlation Showing the Rate of Traffic Flow and Concentration Level of the Pollutants**

Variable	N	Mean	Std.Dev.	Df	r	P
Emission Measurement	266	2.765	.2417	484	0.266	0.01
Traffic	266	95.576	98.652			

Significant at the $P \leq 0.05$
Source: Authors Analysis, 2015

Table 4.2 above shows the test of association between the volume of traffic counted and the corresponding vehicular emission recorded for the sampling points. The total number of cases used for the analysis is 266 for both the vehicular head count as well as the recorded vehicular emission. The mean value of vehicular emission for all the cases is 2.765, while the mean value of vehicular head count is 95.576. Their standard deviations are 0.2416, 8.651 for emission measurement and traffic head count respectively.

Statistics from the test of association reveals low significant relationship, However, r (0.266=P <0.05) is significant. (Appendix II) Hence relationship between vehicular head count and emission measurement was established, reason being that the p value of 0.01 is less than the 0.05 alpha level of significance. Also, the calculated coefficient of correlation (r) 0.266 was found to be higher than the critical r value of 0.088 (Appendix IV). The type of relationship between the two variables is directly proportional thus the null hypothesis which states that "there is no relationship between traffic volume and the concentration of the pollutants at the various sampling points is hereby rejected and the alternate hypothesis which

states that "there is relationship between traffic volume and the concentration of the pollutants at the various sampling points" is hereby accepted

4.4 Pollutants Concentration across the Sampling Points

To achieve objective/research question III, which sought to examine the pollutants concentration level with time for all the variables across the sampling points, the result obtained is presented in figures 4.1, 4.2 and 4.3 below:

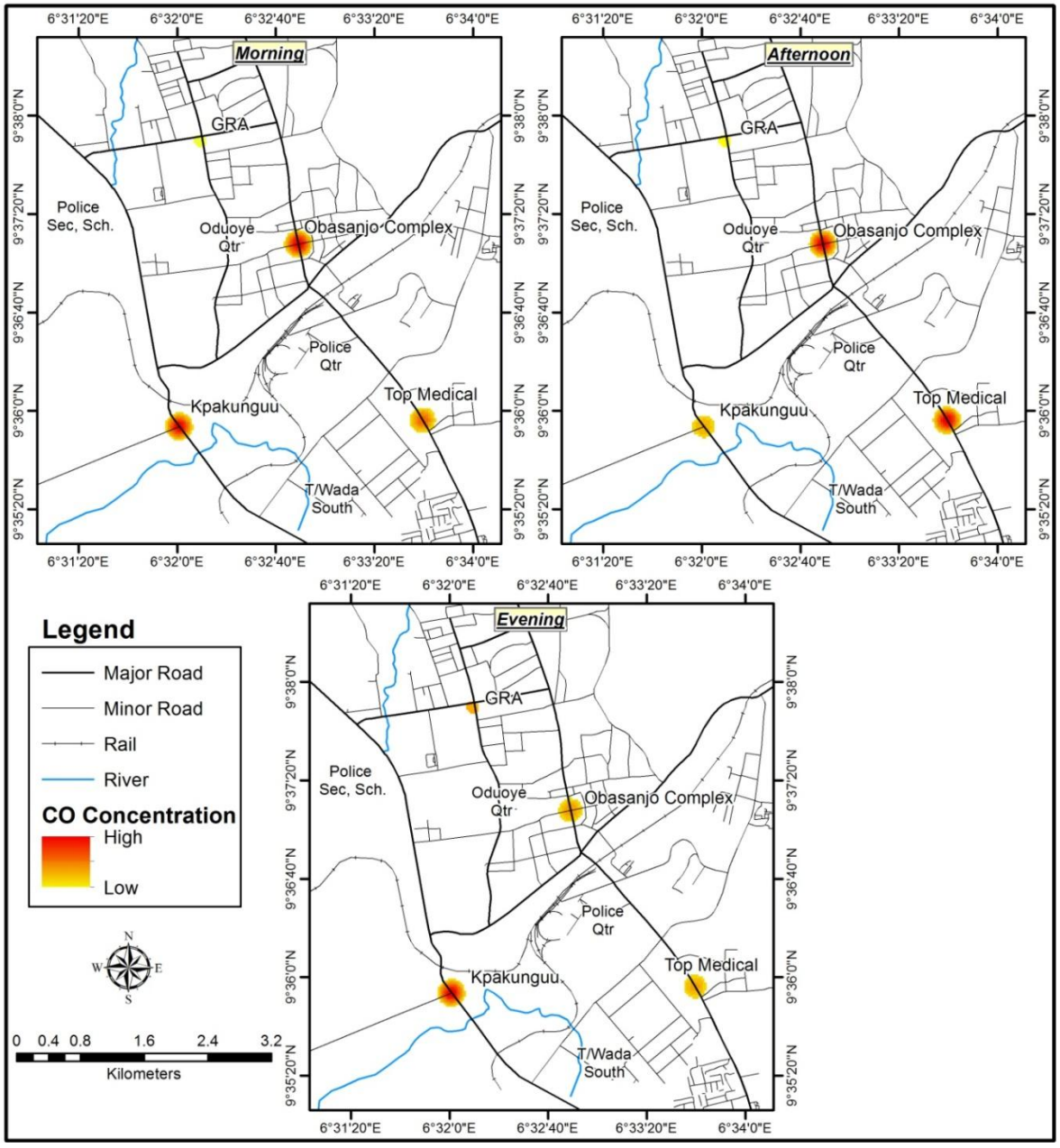


Figure 2: Minna showing CO Concentration across the sample points
Source: Quikbird imagery + Authors compilation

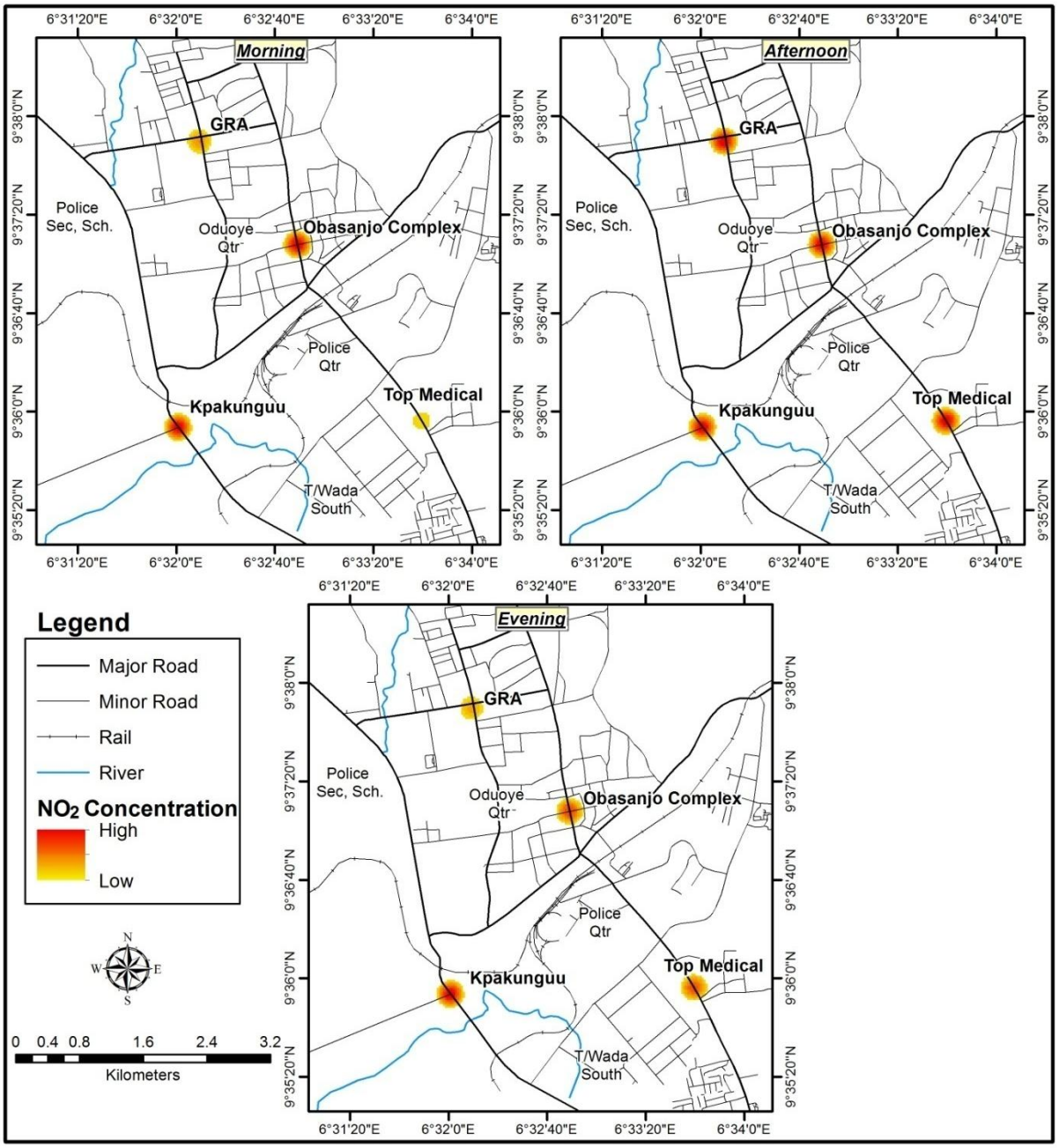


Figure 3: Minna showing NO_2 Concentration across the sample points
Source: Quikbird imagery + Authors compilation

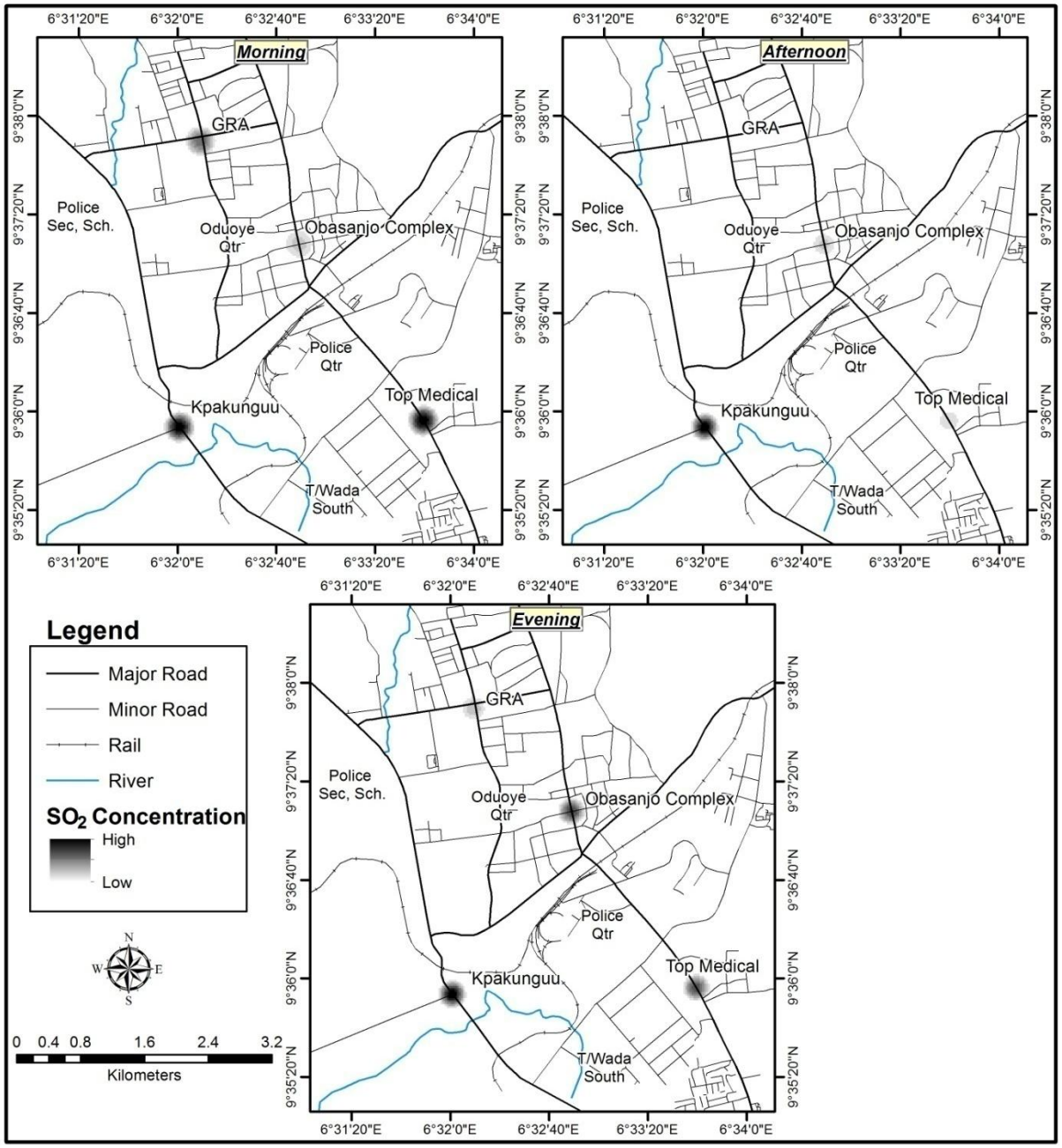


Figure 4: Minna showing SO_2 Concentration across the sample points
Source: Quikbird imagery + Authors compilation

Figures 4.1, 4.2 and 4.3 above revealed the pollutants spread across the periods of the day which are morning, afternoon and evening. The darker shades indicate higher level of concentration while the lighter shade connotes lower concentration level of the pollutants.

4.4.1 Test of Hypothesis 2

In order to ascertain which pollutant has the highest concentration level, the data collected was further subjected to analysis of variance and the result is presented in table 4.3 below:

Table 4.3: Analysis of Variance of Concentrations of Variables across the Sampling Points

Pollutants	Number	Mean	Standard deviation	Lower Bound	Upper bound	Min	Max	F	Sig
SO_2	162	0.984	0.321	0.487	0.148	0.000	2.000	103.711	001
NO_2	162	0.608	3.306	0.950	1.121	0.000	34.000		
CO	162	7.590	8.430	6.282	8.898	0.000	27.000		
Total	486	2.765	6.242	2.209	3.321	0.000	34.000		

** Significant difference exit at P≤ 0.05 level
Source: Authors Analysis, 2015

The result from table 4.3 shows that the total number of the pollutants measurement recorded was 486 with each pollutants measurement across the periods of the day having 162 measurement. The mean value of SO_2 is 0.984 that of NO_2 is 0.608 and that of CO is 7.590. This shows that significant difference exist in the concentration of the pollutants when their mean values are compared. Furthermore, the comparison of the pollutants from scheffe (Appendix I) and post hoc (lsd) shows that significant difference exist in the level of CO recorded across the points to other pollutants. Thus, CO has the highest concentration in the study area this is because the calculated P value was found to be 0.01 which is lower than the 0.05 alpha level of significance

4.5 Difference in Pollutants Concentration At The urban Centre and the Control Point

Research question IV sought to address the differences in the level of pollutants measured in the urban centre and control point. The result is presented in Table 4.4 below.

Table 4.4: Analysis of Variance for Level of Significant Difference between the Urban Center and the Control Station Air Quality

Pollutants	Number	Mean	Standard deviation	Lower Bound	Upper bound	Min	Max	F	Sig
SO_2	81	0.357	0.006	0.342	0.342	0.004	0.043	392.64	.000
NO_2	81	0.452	3.774	0.348	0.382	0.024	34.000		
CO	81	14.50	6.756	13.01	15.99	3.000	27.000		
Control	243	0.533	6.242	0.318	0.748	0.000	18.00		

Source: Authors Analysis, 2015

Table 4.4 shows that there exists a significant difference in the readings on the basis of the groups. (SO_2, CO and NO_2 and the control point). This is because calculated P value of 0.00 was found to be lower than the 0.05 alpha level of significance. Their calculated mean readings are 0.0356, 0.4523, 14.504 and 0.534 for SO_2, CO and NO_2 and the control point respectively. The post hoc (Lsd) (Appendix III) also shows that significant difference exists in the pair mean readings comparism. Consequently, the null hypothesis which states that "there is no significant difference in the concentration of the pollutants (SO_2, CO and NO_2) within urban center and the control point" is hereby rejected and the alternate hypothesis which states that "there is significant difference in the concentration of the pollutant at the urban center and the control point is hereby accepted. This shows that vehicular emissions significantly pollute the air and confirms what was obtained in other related studies reviewed in this study: Akpan and Ndoke, (2006), Ojolo, Oke , Dinrifo, and Eboda, (2007) , Abam and Unachukwu (2009), Ojo and Awokola (2012), Akanni, (2010)

CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This study is aimed at educating the general public that emphasis has shifted from the pollution problems caused by industries to the ones associated with motor vehicle emissions and to educate the public on the dangers of the presence of pollutants in the air we breathe especially near the road sides. This chapter captures the summary, conclusion and recommendations of this study.

5.2 Summary

This study focused on measuring the level of air pollutant gases (CO, SO_2, and NO_2) generated by vehicles in Minna Township and was limited to major motor ways within the town which include Top Medical Junction, Kpakungu Roundabout, and Obasanjo Roundabout. A point (GRA) less ideal for traffic was also selected to serve as the control point. The aim of the study is to make an assessment of the spatio - temporal variations of vehicular emission and air quality in minna metropolis. With the following specific objectives, which are to:

i. examine the concentration of SO_2, CO, NO_2 in the study area
ii. compare the relationship between the rate of traffic flow and concentration level of the pollutants
iii. compare the pollutants concentration for all the variables across the sampling points.
iv. compare the pollutants concentration at the urban sampling points with that of the control point.

The concentration of the pollutants was measured using Crowcon (Tetra 3) kit with model number IECEx BAS 05.0059 , at each sampling points three days a week for which are Mondays, Tuesday and Wednesday for the period of 45 minutes during

morning peak hours (7:30am.-8:15am.), 45 minutes during afternoon off peak hours (12:30pm.-1:15pm.) and 45 minutes during evening peak hours (4:30pm.-5:15pm.) for 4weeks. The analytical tools used were: mean, and standard deviation, analysis of variance, as well as correlation coefficient. The end result of this study showed that relationship exists between the volume of traffic and vehicular emission where the calculated coefficient of correlation (r) 0.266 was found to be higher than the critical r value of 0.088. Furthermore, significant difference was also found in the concentration of the pollutants measured between the urban area and the control point. The comparison of the pollutants across the points also showed that CO has the highest concentration in the study area with mean emission value 14.50ppm as compared to other pollutants ($S0_2$ = 0.357ppm and $N0_2$ = 0.452ppm.) Majority of the emission measured also exceeded the National regulatory limits. Which are CO (10-20ppm), NO_2 (0.04.66ppm), and SO_2 (0.01-0.1 ppm)

5.3 Conclusion

This study has shown that vehicles contribute greatly to air pollution and that urban environment characterized by high vehicular volume pose a serious threat to road users and passersby, especially when vehicles are used excessively, knowing full well that older vehicles are associated with higher emissions of both global and local pollution than newer vehicles. (Gorham, 2002). When vehicles are poorly maintained, the resultant effect is deterioration of emissions and this characteristic has been linked to maintenance practices of owners. (Gorham, 2002)

The outcome of this study was found to conform with literatures from several studies of air pollution which were reviewed in this work: Ndoke, Akpan, and Kato (2006), Ojolo, Oke , Dinrifo and Eboda (2007) Abam and Unachukwu (2009) Akanni, (2010) Ojo and Awokola (2012), Akinyemi and Usikalu. (2013). This calls for urgent measures, so as to

protect the teeming population in the study area especially road users against the adverse impacts of these pollutants.

5.4 Recommendation

To make less severe the consequences of air pollution on people's health, pollution awareness should be of high priority to both government and individuals. One possible approach is to establish channels of communication to enlighten the general public on the dangers associated with vehicular emission. This will help protect individuals particularly road users from possible harm. Furthermore, tree planting scheme in a city have been established to be effective in achieving the objective of improving the air quality. (Naomi 2014).

Based on the findings of this study the following recommendation is put forward:

i. Baseline data for the development of vehicle emissions control standards and regulations by Niger state Environmental Protection Agency

ii. Vehicle emission tests should be carried at various speeds and weights to simulate real driving conditions of vehicles in the study area

iii. Restriction on age limit of vehicles imported into the country at large by relevant agencies (i.e Federal Road Safety Corp, FRSC)

iv. Continue air quality monitoring along major routes.

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Appendix I

ANOVA

EMISSION MEASUREMENT

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	5676.559	2	2838.279	103.711	.000
Within Groups	13218.417	483	27.367		
Total	18894.975	485			

Multiple Comparisons

Dependent Variable: EMISSION MEASUREMENT

	(I) GASSES	(J) GASSES	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Scheffe	so2	NO2	-.509438	.581264	.681	-1.93665	.91777
		CO	-7.491160*	.581264	.000	-8.91837	-6.06395
	NO2	so2	.509438	.581264	.681	-.91777	1.93665
		CO	-6.981722*	.581264	.000	-8.40893	-5.55451
	CO	so2	7.491160*	.581264	.000	6.06395	8.91837
		NO2	6.981722*	.581264	.000	5.55451	8.40893
LSD	so2	NO2	-.509438	.581264	.381	-1.65156	.63268
		CO	-7.491160*	.581264	.000	-8.63328	-6.34904
	NO2	so2	.509438	.581264	.381	-.63268	1.65156
		CO	-6.981722*	.581264	.000	-8.12384	-5.83960
	CO	so2	7.491160*	.581264	.000	6.34904	8.63328
		NO2	6.981722*	.581264	.000	5.83960	8.12384

*. The mean difference is significant at the 0.05 level.

Appendix II

Correlations

		EMISSION MEASUREMENT	TRAFFIC
EMISSION MEASUREMENT	Pearson Correlation	1	.266**
	Sig. (2-tailed)		.000
	N	486	486
TRAFFIC	Pearson Correlation	.266**	1
	Sig. (2-tailed)	.000	
	N	486	486

**. Correlation is significant at the 0.01 level (2-tailed).

Appendix III

Dependent Variable: EMISSION MEASUREMENT

LSD

(I) groups	(J) groups	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
	NO2	-.416716	.530152	.432	-1.45841	.62498
SO2	CO	-14.468136*	.530152	.000	-15.50983	-13.42644
	control	-.497844	.432867	.251	-1.34838	.35270
	SO2	.416716	.530152	.432	-.62498	1.45841
NO2	CO	-14.051420*	.530152	.000	-15.09311	-13.00973
	control	-.081128	.432867	.851	-.93167	.76941
	SO2	14.468136*	.530152	.000	13.42644	15.50983
CO	NO2	14.051420*	.530152	.000	13.00973	15.09311
	control	13.970292*	.432867	.000	13.11975	14.82083
	SO2	.497844	.432867	.251	-.35270	1.34838
control	NO2	.081128	.432867	.851	-.76941	.93167
	CO	-13.970292*	.432867	.000	-14.82083	-13.11975

*. The mean difference is significant at the 0.05 level.

Appendix IV

20	0.378	**0.444**	0.561	0.679
21	0.369	**0.433**	0.549	0.665
22	0.360	**0.423**	0.537	0.652
23	0.352	**0.413**	0.526	0.640
24	0.344	**0.404**	0.515	0.629
25	0.337	**0.396**	0.505	0.618
26	0.330	**0.388**	0.496	0.607
27	0.323	**0.381**	0.487	0.597
28	0.317	**0.374**	0.479	0.588
29	0.311	**0.367**	0.471	0.579
30	0.306	**0.361**	0.463	0.570
35	0.283	**0.334**	0.430	0.532
40	0.264	**0.312**	0.403	0.501
45	0.248	**0.294**	0.380	0.474
50	0.235	**0.279**	0.361	0.451
60	0.214	**0.254**	0.330	0.414
70	0.198	**0.235**	0.306	0.385
80	0.185	**0.220**	0.286	0.361
90	0.174	**0.207**	0.270	0.341
100	0.165	**0.197**	0.256	0.324
200	0.117	**0.139**	0.182	0.231
300	0.095	**0.113**	0.149	0.189
400	0.082	**0.098**	0.129	0.164
500	0.074	**0.088**	0.115	0.147