ASSESSMENT OF VEHICULAR EMISSIONS ON AIR QUALITY AND PROXIMATE COMPOSITION OF *AMARANTHUS HYBRIDUS* AND *MANGIFERA INDICA* IN ZARIA, NIGERIA

By

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DECLARATION

I declare that the work in thisDissertation entitled **Assessment of Vehicular Emissions on the Air Quality and Proximate Composition of*Amaranthus hybridus* and*Mangifera indica* in Zaria, Nigeria** has been carried out by me in the Department of Chemistry, Ahmadu Bello University, Zaria. 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.

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CERTIFICATION

This Dissertationentitled ASSESSEMENT OF VEHICULAR EMISSIONS ON AIR QUALITY AND PROXIMATE COMPOSITION OF *AMARANTHUS HYBRIDUS AND MANGIFERA INDICA* IN ZARIA, NIGERIA by **IDONGESIT EDEM OKON**, meets the regulations governing the award of the degree of Masters in Analytical Chemistry of the Ahmadu Bello University, Zaria, and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This Dissertation is dedicated to Mrs Affiong Okon Mbat for her love towards me and assistance during the period of this study.

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ABSTRACT

Pollutants from vehicular emissions can cause negative impact on air quality and the nutrients content of vegetables planted by the road side. This work assessed the impact of vehicular emissions on the proximate composition of roadside *Amaranthushybridus* and roadside *Mangifera indica* and the air quality of Zaria. The air pollutants analysed were particulate matter (PM), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), carbon monoxide (CO), carbon dioxide (CO_2) and hydrocarbons (HCs). These pollutants were measured during morning peak, evening peak and off-peak traffic periods. Traffic count was carried out to determine the traffic density at all experimental sites (Rex Junction, PZ Junction, MTD Junction and Kwangila Fly-Over). All the experimental sites were at traffic hot-sports in Zaria. The proximate composition determined were moisture content, fat content, ash content, crude protein content, crude fibre content and carbohydrate content. All the pollutants from vehicular emissions except particulate matter showed high correlation with traffic density at all the experimental sites. The concentrations of all the pollutants at all the experimental sites were higher than the concentrations at the control site. There were also higher concentrations during traffic peak periods than during off-peak. At traffic peak periods, the highest average concentrations of PM (213.00 µg/m^2) and CO_2 (348.00 ppm) in the air of Zaria were below the Nigerian Ambient Air Quality Standard (NAAQS) limit of 250 µg/m^2 and 600 ppm for PM and CO_2 respectively. NO_2, SO_2 and CO average concentrations at traffic peak periods were within the NAAQS limit range of 0.04 – 0.06 ppm, 0.01 – 0.1 and 10 – 20 ppm for NO_2, SO_2 and CO respectively. The average concentration range of hydrocarbons (0.057 – 0.070 ppm) at traffic peak periods were higher than the NAAQS limit of 0.05 ppm but was below the 0.05 ppm standard limit at traffic off-peak period. This shows that all the air pollutants from vehicular emissions at the

experimental sites in Zaria were either below or within the NAAQS limit except for HCs. The mean proximate composition determined for *Amarathushybridus* cultivated at each of the experimental sites was compared to the mean proximate composition of *Amarathushybridus* cultivated at the control site and there was no significant difference (P = 0.05) between the two, showing that vehicular emission did not have negative impact on the proximate composition of the roadside *Amarathushybridus*. The proximate compositions of the roadside *Mangifera indica* were higher than the ones obtained at the Control except for the ash content that was significantly higher (P = 0.05). For the *Amarathushybridus*, moisture content, fat content, and crude protein content showed high negative correlation with age, crude fibre content and carbohydrate content showed high positive correlation with age while ash content did not correlate with age.

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ABBREVIATIONS

AOAC	Association of Official Analytical Chemists
AQI	Air Quality Index
BRT	Bus Rapid Transport
CNG	Compressed Natural Gas
ED – XRF	Energy Dispersive X – Ray Fluorescent
GPS	Global Positioning System
HCs	Hydrocarbons
ICP – MS	Inductive Couple Plasma Mass Spectrophotometer
IQ	Intelligent Quotient
KEPA	Kaduna State Environmental Protection Authority
LPG	Liquefied Petroleum Gas
m	Metres
NAAQS	Nigerian Ambient Air Quality Standards
NMT	Non – Motorized Transport
NOx	Nitrogen oxides
PAN	Peroxyacetyl nitrate
PCF	Plant Concentration Factor
PGEs	Platinum Group Elements
PM	Particulate Matter
ppm	Parts Per Million
SL	Significance Level
SOx	Sulphur oxides
TEL	Tetra-ethyl Lead
TSN	Taxonomy Serial Number

v/h Vehicle per hour

VOCs Volatile Organic Compounds

WHO World Health Organization

CHAPTER ONE

1.0 INTRODUCTION

The emission of pollutants by vehicles into the atmosphere as a result of traffic density emanating from high fleet growth, increased population, increased urbanization and economic improvement have caused serious damage to the environment. These pollutants affect plants, animals and man and by extension crops cultivated on places exposed to this emissions especially those areas close to road sides. The negative effects of vehicular emission on roadside crops have been illustrated by Naveed *et al*., (2010). The main products of the combustion of motor fuels are carbon dioxide and water but inefficiencies and high temperature inherent in engine operation encourages the production of many other pollutants of varying effect.

1.1 Concept of Vehicular Emission and Systemic Effect

Vehicular emission leads to the accumulation of both primary and secondary pollutants in the atmosphere. The primary pollutants from vehicular emission includes carbon monoxide (CO), carbon dioxide (CO_2), nitrogen oxides (NOx), sulphur oxides (SOx), hydrocarbons (HCs), heavy metals and particulate matter (PM). These primary pollutants usher in secondary pollutants such as smog, fog, ground level ozone (O_3) and peroxyacetylnitrate (PAN) which arise from the chemical reaction of primary pollutants possibly involving the natural component of the atmosphere especially water and oxygen. Road vehicle emission comes from both light duty vehicle (gasoline powered vehicles) and heavy duty vehicles (diesel powered), the light duty vehicles emit more of hydrocarbons otherwise known as volatile organic compounds (VOC_S), CO and NOx whereas the heavy-duty vehicles emit more of NOx and particulate matter PM (Sawyer, 2010).

Health effect of vehicular emission pollutants can cause serious health problem to people living in such environments. High level of carbon monoxide can cause harmful health effect by reducing oxygen delivery to the body organs and tissues. When CO enters the blood system, it binds with the haemoglobin since haemoglobin has more affinity for CO than O_2; hence oxygen delivery to the body will be hindered thus depriving the body of an essential for life. The health threat from ambient CO is most serious for those having cardiovascular disease; high level of CO can lead to impairment of vision, headache and nausea (Sabo, 2009).

Ground level ozone (O_3) can reduce lung function and scarring of lung tissue, it can aggravate asthma and other respiratory diseases. SO_2 causes a wide variety of health problems especially in people with lung disease, at high concentration in the ambient air; SO_2 can cause breathing difficulty for people with asthma who are active outdoors. Nitrogen dioxide (NO_2) can irritate the lung and lower the resistance to respiratory infections. Particulate matter can cause lung infection when inhaled in large amount leading to pre-mature death (Sabo, 2009).

Lead as a pollutant from vehicular emission can affect learning ability (Sabo, 2009). This negative effect in learning is caused by the fact that lead can affect many organs including the brain causing neurodevelopment problems. Evidence from Cross-sectional and prospective studies of populations with lead levels generally below 25ug/decilitre in blood relates to decrement in intelligence quotient (Lon, 2003).

Other heavy metals also cause health problems, for instance cadmium can damage the kidney, liver and brain,m chromium is toxic to body tissues with high tendency of causing ulceration of the skin, nickel creates respiratory problem while zinc fume have corrosive effect on skin and can cause irritation and damage mucous membrane (Dara, 2008).

1.2 Effect of Vehicular Emission on the Environment

Pollutants from vehicular emission bring adverse effect to the environment. Pollutants like NO_2 play a major role in the atmospheric reactions that produce ground level ozone. It also contributes to the formation of acid rain. SO_2 reacts with other chemicals in the atmosphere to form secondary pollutants such as sulphuric acid and sulphates. These sulphate particles reduce visibility, SO_2 also form acid rain, fog, snow or dry particles, it also accelerates the decay of building materials, and it reduces aesthetic value of monuments, Statues and Sculptures which are part of the environment. This acid rain from SO_2 and NO_2 changes the Composition of our soil and also make our water acidic and unsuitable for aquatic life (Dara, 2008).

Particulate matter creates visibility impairment as a result that fine particles scatter and absorb light creating a haze that limit the distance we can see and that degrade the colour, clarity and contrast of view. Carbon monoxide emitted by vehicles contributes to global warming after being oxidized to CO_2 which is a greenhouse gas. Vehicles also release CO_2 directly into the atmosphere during complete combustion (Dara, 2008).

1.3 Composition and Volume of Emission by Individual Vehicle

The volume and composition of emission from individual vehicle is determined by many factors. These factors are:

1.3.1 Fuel composition

The amount of sulphur, metals, benzene, toluene and other components in fuel used by vehicles has a significant influence on the composition and concentration of those pollutants in the emissions (Faiz*et al.*, 1996).

1.3.2 Level of engine maintenance

Inadequate maintenance, poorly adjusted timing, dirty air cleaners, dirty and contaminated oil, blocked air filter, malfunctioning fuel supply system and wrong tempering with pollution control devices can increase emission, primarily through incomplete combustion (Tsunokowa and Hoban, 1997).

1.3.3 Age of vehicle

Old vehicles lack the modern emission control technology mounted on vehicles today, and since there is close relationship between the age of automobile engine and exhaust technology which determines the quality of exhaust emission, those vehicles with old engines produce higher level of emissions than do newer fleets of the same size. As illustrated by Ndoke*et al.,* (2006), vehicular emission pollutant like CO_2 was more in the atmosphere of some part of Kaduna than in Abuja even when more number of vehicle were being used in Abuja, this could be as a result of the quality of vehicles used in Abuja. In the future,the Abuja situation mentioned here could also be obtainable in Zaria if newer and good quality vehicles are used on its roads through proper regulation and enforcement.

1.3.4 Engine temperature

The fuel burning efficiency of cold engines are very low and the catalytic converters on gasoline engines do not function at all until normal operating temperature is attained hence this will lead to high volume of more toxic emission since at low engine temperature, the catalytic converters will not be able to convert vehicular emissions to more environmentally friendly forms, for instance, the conversion of CO to CO_2 which is less toxic in the environment (Tsunokawa and Hoban, 1997).

1.3.5 Nature of road geometry

Automobile engines produce greater emissions while decelerating, accelerating and going up high levels. Roads that are full of up, and down profile will surely encourage high vehicular emissions (Tsunokowa and Hoban, 1997). This is because as the vehicle clutch and brake are applied during deceleration and acceleration more fuel goes into the engine combustion chamber which will burn more giving rise to higher emissions.

1.3.6 Types and size of vehicle

Vehicles with large engines emit more pollutants than vehicles with small engines. For instance big diesel engines produce large amount of NOx and particulate matter while the gasoline engines which are smaller and less powerful produce more of CO and HCs (Black, 2010).

1.3.7 Speed stability

Most Vehicles display fuel burning efficiency at a speed between 80-100km/h steady speed (Tsonokawa and Hoban, 1997). Unstable Speed less than this will definitely lead to engine inefficiency thereby releasing more emission.

Vehicle kilometres travelled is also a factor affecting vehicle emission, as kilometres travelled increases, so the increase in emission (Abbaspour and Soltaninejad, 2004).

1.3.8 Engine operation cycle

Apart from the type of engine as per the type of fuel used (gasoline, alcohol or gas fuel engines), the numbers of cycle of operation of the engine have a direct influence on the quality and quantity of pollutants released into the atmosphere. The 4-Stroke Cycle engines are more efficient in burning than the 2-Stroke engines making the 4- Stroke engines more environmentally friendly than the 2-Stroke engines (Aminnurul, 2009)

1.4 Vehicular Emission Pollutants

The vehicular emission pollutants that have constituted nuisance to man and the environment include CO_2, SO_X, NO_X, CO, PM, HCs and heavy metals among others.

1.4.1 Carbon dioxide (CO_2)

This is one of the greenhouse gases. One of the most important human impacts on our environment is the sharp increase in atmospheric CO_2 caused by the use of fossil fuel. CO_2 is a colourless gas. Its density at 25^oC is 1.98 kgm^{-3} about 1.5 times that of air. It is a linear shape molecule (O=C=O) containing two double bonds having no electrical dipole as it is fully oxidized and it is a non-flammable gas.

The basic process that brings about the emission of CO_2 by automobiles is through the combustion of fossil fuel which involves the reaction of alkanes with oxygen to form $CO_{2,}$ water and heat. When there is more complete combustion in the combustion chambers of automobile engine much CO_2 is produced and released as emission into the atmosphere. The amount of CO_2 produced is directly related to the quantity of fuel consumed (Tzirakis *et al*., 2006)

1.4.2 Sulphur oxides (SO_X)

These are produced during combustion process of fuel which usually contains sulphur as impurities. Sulphur (IV) oxide and Sulphur (VI) oxide are the two prominent sulphur oxides associated with vehicular emission. Sulphur (VI) oxide is a colourless toxic gas with characteristic irritating odour. Oxidation of SO_2 in the atmosphere produces SO_3 which is the precursor of sulphuric acid formation in the presence of $NO_{x,}$ O_3 and HCs as catalyst(Dara, 2008). This is responsible for the sulphate particulate matter emission. Since sulphur present in fuel is either released as a Sulphate particle which is an important component of particulate matter or as gaseous Pollutant (Mishra, 2008).

1.4.3 Nitrogen oxides (NOx)

Most of the NOx in vehicle emissions are in the form of NO, which is a by-product of fuel combustion under conditions of extreme heat and pressure which is typical of combustion chambers. Once released from the tailpipe (exhaust), it is oxidized to NO_2 which in conjunction with SO_2 plays a major role in the formation of acids in the atmosphere. NOx also react with hydrocarbons (HCs) to produce photochemical smog in the atmosphere. Apart from NO other forms of Nitrogen Oxides could also be produced in the combustion chamber of automobile engines. Those other forms include N_2O and $NO_{2.}$ NO is extremely reactive. It destroys resistance to respiratory infection. NOx products are increased when an engine runs at it most efficient (i.e. hottest) part of the cycle (Mishra, 2008).

1.4.4 Carbon monoxide (CO)

This is a colourless, odourless, non-irritating but very poisonous gas. It is a by-product of incomplete combustion of fuel. Vehicular exhaust emission is a major source of carbon monoxide especially from substandard vehicles. In the United State of America, CO is emitted by engines more than any other pollutants from vehicular emissions because according to Ronni (2012), CO has 77% of the total emissions from automobile emission used for land transport in USA, other pollutants stood at: NOx 58.37%, VOCs 35.5%, NH_3 8.1%, PM_{10} 2.67%, $PM_{2.5}$ 9% and SO_2 4.5%. This data shows that incomplete combustion that leads to CO emission is the major player in vehicular emission.

1.4.5 Particulate matter (PM)

Particulate matter (PM) represent a broad class of chemically and physically diverse substances that exist as discrete particles (liquid droplet or solids) over a wide range of sizes. Particle matter may be emitted directly into the atmosphere or may be formed by transformation of gaseous emissions such as sulphur dioxide, nitrogen oxides and volatile organic compounds (VOCs). Some particulate matter occurs naturally originating from volcanoes, dust storm, forest and grass land fires, and sea spray. Particulate matter is a core emission by automobile especially diesel engine vehicles. Vehicular emission is connected to two types of particulate matter, the fine particulate matter ($PM_{2.5}$) and the coarse particular (PM_{10}). $PM_{2.5}$ consist of particles less than one-tenth the diameter of human hair and possess the most serious threat to human health (Ronni, 2012). The size of particle is directly linked to their potential for causing health problems.

Particles that are ten micrometre (PM_{10}) in diameter generally pass through the nose into the lungs. Once inhaled these particles can affect the health and lungs and cause serious health effect. Particles less than 2.5 micrometres in diameter are termed "fine particle or

$PM_{2.5}$ as mentioned before, they are so small that they can be inhaled deeper into the lungs than the PM_{10}, hence it causes more health problem than PM_{10} (Walsh, 2001).

1.4.6 Ground level ozone (O_3)

Ozone is an extremely reactive gas unlike other gaseous pollutants associated with vehicular emissions; O_3 is not directly emitted into the atmosphere. Instead, ground level ozone is formed when vehicular emission like NOx chemically reacts with volatile organic compounds (VOCs) through series of complicated chemical reactions in the presence of strong sunshine (Ultra violet light) as reported by (Tsunokawa and Hoban, 1997; Sabo, 2009).

1.4.7 Hydrocarbons (HCs)

Hydrocarbons also known as volatile organic compounds (VOCs) are made up of unburned or partially burned fuel and are the major contributors to urban smog. Hydrocarbons are volatile organic compounds which includes benzene, toluene, naphthalene etc, we should bear in mind that vehicular emission is divided into two categories; exhaust (tailpipe) emission and evaporative (vapour) emissions (Agyemang – Bonsu*et al*., 2010). It is the evaporative that gives rise to VOCs. This evaporative emission includes running losses which occurs when the vehicle is operating in a hot stabilized mode; hot soak emission resulting from fuel evaporation from still hot engine at the end of the trip; diurnal emissions; which result from evaporation of fuel from gasoline tank whether the vehicle is driven or in steady state (Agyemang- Bonsu*et al.*, 2010). All these emissions from evaporation of fuel especially gasoline contribute to the concentration of volatile organic compounds in our atmosphere.

1.4.8 Heavy metals

Heavy metal pollutants are also associated with vehicular emissions. These metals range from cadmium, zinc, lead, chromium, nickel, and many others. There has been evidence of heavy metal pollution on roadside as a result of vehicular emission (okunola*et al*., 2011).

The most abundant heavy metal associated with vehicular emission before now was lead metal. Because it was used as additive to prevent engine knock in automobile fuel which the lead compound known as tetra-ethyl lead (TEL) was used. But with oxygenated blending technology of fuel today, lead additive is no more used, hence reducing the amount of lead emission to almost zero. There has been some evidence of lead and other metal pollution from automobile emission in Nigeria many years ago (Ndiokwere, 1984). But a recent study has also showed that lead pollution still relates to vehicular emission (Naveed*et al*., 2010). This might arise from the use of adulterated or fuel that is not well refined common among underdeveloped nations.

1.5 Effect of Vehicular Emissions on Plants

Vehicular emissions have some effect on plants especially those plants on the road side which are exposed to it. Some pollutants like the photochemical oxidants (ozone and peroxyacetyl nitrate) which are formed by sunlight acting on products of fuel combustion particularly the nitrogen dioxide and hydrocarbons that come from vehicle exhausts are very dangerous to plants since plant leaves are sensitive to them (Rejini and Janardhanan, 1989). Ozone causes many irregular lesions called fleck or stipple on the upper surface of broad – leaves plants (Mishra, 2008). Yellowing of leaves also occurs (chlorosis). Peroxyacetyl nitrate (PAN) as well as ozone cause collapse of tissues, silvering, glazing or bronzing occurring usually on the lower leaf surface with more effect on younger leaves (Butz, 2012). Excessive NO_2 in the atmosphere damages leaves of plants, reduce photosynthetic activity and also causes chlorosis (Durrani*et al*., 2004). SO_2 can inhibit or promote stomata closure depending on its concentration coupled with other pollutants in the environment (Viskarri*et al*., 2000).These stomata response create variation in the uptake of pollutants by plants. SO_2 as well as other pollutants changes the morphology, physiology and biochemistry of sensitive plants. It can also cause bleaching of leave pigments due to conversion of chlorophyll to phacophytin and this reduces plant productivity. NOx, VOCs and particulate matter released by vehicles enter the plant through the stomata in the leaves and damage them. These pollutants may abrade theepicuticular wax and thereby reducingcuticular resistance to air and to gas diffusion and also affectingstomatal response (Babu, 1993). NO_2 suppresses plants growth without marking the leaves when concentration is low (Butz, 2012). These pollutants interfere with plants normal respiration leading to the destruction of chlorophyll and the reduction inphotosynthetic activity. Other damages to plants by vehicular emission range from reduction in growth rate, pale look, reduction in yield to complete death (Uchegbu, 1998).

1.6 Systematic Approaches to Reducing Emissions from Vehicle

The development of a strategy involves the selection of a logical and rational set of measures which, when implemented, will help to reduce vehicular emissions. These measures can be technology-oriented, aimed at the vehicles and fuels used and maintenance practices within transport system, or they can be behavioural, seeking to reduce (or prevent increases in) the amount of activity of the most polluting vehicles. They may also focus on systemic aspects of the transport system which is the ways in which the transport network influences either the number of vehicle used or the emission intensity of individual vehicles. It should be borne in mind that emission control strategies should be determined in the wider context of improving outdoor air quality in traffic environment. This involves important economic technical analysis in the context of an air quality management programme. These programmes, such as the World Bank's Air Quality Management System, are useful in identifying the most efficient use of scarce resources to address an air quality problem. However, the process of carrying out such an assessment tends to be difficult (Gorham, 2002).

1.6.1 Technical strategies

Technical approaches aims at reducing the emissions produced by road vehicles by intervening with the quality of vehicles being used and the fuels they are burning. By definition, these approaches address per unit emissions rather than the amount of activity causing the emissions. An exclusively technological approach may be insufficient to address the growth in emissions, for a number of reasons. First, growth in activity continuously puts pressure on technology gains. Secondly, technological improvements can intensify the growth in activity; thirdly an exclusively technological approach to addressing the problem of emissions may result in significant over-investment in technology compared with a socially optimum solution like introduction and implementation of tax (Gorham, 2002).

1.6.2 Vehicle technology

These strategies may involve improvements in conventional technologies already in the system, and acceptable for use, such as improvements in engine and fuel systems, changes and improvements to transmission systems (to increase efficiency and reduce CO_2 emissions), treatment for fuel supply and crankcase systems (to reduce evaporative emissions), or improvements to overall vehicle or tyre design to reduce friction. Technological improvements might also involve the adoption and use of alternative fuel or alternative propulsion vehicles. In developing countries like Nigeria, the most commonly discussed alternative vehicle fuel strategies include compressed natural gas (CNG), liquefied petroleum gas (LPG), alcohol-based fuels and biodiesel, but Nigeria lacks technical know-how for actual implementation. Other alternative fuels showing potential long-term promise in the reduction of vehicular emission in the transport sector include hydrogen fuel and various synthetic fuels for use in compression-ignition engines (Aminurul, 2009).

1.6.3 Rate of change of technology in the vehicle fleet

In the under developed world such as our country Nigeria, the adoption or response to new technology is far too slow if not impossible. There has been an extensive review of appropriate technologies in the emissions-reduction literature and at conferences but no adequate implementation. The rate of change is more important than the technology itself for reducing transport emissions, particularly for fleets where baseline emission control mechanisms are minimal or non-existent. In assessing any technology, therefore, the analysis of technological options needs to move beyond a narrow assessment of the relative emissions and energy consumption capabilities of each technology; rather, the analysis should focus on how rapidly the different technologies can be deployed and widely used in the fleet. Policy on rate of change of technology should contain strategies which allows older vehicles to benefit from more recent technology, like in the case of marine vehicles, where dedicated ballast tank is assigned on board to old tankers that did not have clean ballast tank when built in effort to fight marine pollution from ships.

1.6.4 Vehicle maintenance

Vehicle maintenance is a very important aspect of any technical strategy to reduce per kilometre emissions of pollutants from each vehicle because we have more number of old vehicles than new in any system, hence thorough maintenance of these vehicles should be carried out. Effective strategies focusing on vehicle maintenance have three key elements: (i) emissions testing, which provides a mechanism to identify vehicles that are not performing according to regulations standard, (ii) driver and fleet manager education and training, which help to facilitate the acceptance of emissions testing components, (iii) a programme of on-going product liability, for either manufacturers or importers, which also helps to ensure better maintenance by creating a market incentive for suppliers to follow up on their products.

1.6.5 Fuel technology

Research and improvement to the specifications of fuels or composition of fuel are as important as improvements to vehicles. Fuel improvements can affect emissions in three ways. First, changes to fuel content can directly bring about a reduction in emissions of certain pollutants, such as lead, sulphates, oxides of sulphur (SOx), or volatile organic compounds (VOCs). Unlike changes to vehicle technology, the effects of these types of fuel content changes are immediate. Secondly, changes in fuel content can facilitate the use of certain exhaust after-treatment technologies–particularly those using platinum -based catalysts–which would not have been usable before. Thirdly, the costs of these improvements are passed on to the consumer but, unlike the costs for technical improvements to vehicles, these costs are passed on as variable rather than fixed costs which makes it acceptable without people feeling much impact (Gorham, 2002).

1.6.6 Systemic strategies

Systemic approaches to air quality improvement in connection to vehicular emission is also very important in emission reduction, this strategy tries to adjust driving conditions so as to enable vehicles to operate in the least emissions-intensive manner possible. Such a goal can involve increasing average speeds to an optimal level (ordinarily between 65 and 90 kilometres per hour for most pollutants, including CO_2), as this favours engine efficiency (Abbaspour and Soltanninejad, 2004). To achieve this speed, systematic approach such as building good roads and modern round-about should be on ground. Systematic approach could also include good traffic management strategies such as proper road marking and creation of dedicated lane for mass transit vehicles to reduce hold- up on the road, as is obtainable in Lagos bus rapid transport (BRT) in Nigeria.

1.6.7 Behavioural strategy

Behavioural approaches seek to reduce the amount of vehicular travel undertaken, either by substituting alternative modes, changing the structure of accessibility for large segments of society, so as to reduce the need to travel, for instance spreading social amenities and industries to provide employment to the rural people instead of every one coming to look for employment in the urban centres. Behavioural strategies are most effective when focused on the future adaptive behaviour of travellers rather than on current patterns. Strategies involving mode shifts usually focus on displacing or reducing car, taxi, or micro-bus trips with either conventional public transport or non-motorised modes. The - none motorised mode could be the encouragement for the use of bicycles.

Several conditions affect how successful this strategy can be. The travel on the alternative mode must be a shift (substitution), and not a new trip (addition). Policy must support the separation of vehicle ownership growth rates from vehicle use growth rates. The link between car ownership and use is not unbreakable, and careful attention to pricing can reinforce this. This could be achieved by imposing higher tax on private vehicle usage within the town to discourage private car owners, this changes their behaviour and ideologies. The synergies created by combinations of measures are significantly more effective than any of the measures on their own. The behaviour of travellers should be fine-tuned towards public transport system as emission control strategy, because one bus under mass transit scheme could transport the number of people ten cars could, thereby reducing the number of vehicles on our roads drastically and in turn checks vehicular emission possibly because common sense will let one know that this one mass transit bus cannot burn or consume the quantity of fuel as the ten cars in question; suggesting a decrease in emission bearing in mind that the quantity of emissions is proportional to the amount of fuel burned (Enemari, 2001) and fuel consumption is also a function of vehicle density (Odhiambo*et al*., 2010). A primary goal of a public transport intervention involves the targeting of service improvements and enhancements in corridors and for socio-economic groups that would otherwise be expected to adopt widespread car use. Since these groups tend to be more priced than time-sensitive, service enhancements are more effective than fare restraint or fare subsidies. For many jurisdictions, this strategy may conflict with another fundamental goal of public transport policy: providing low-cost transport services to the poor. Secondary air quality goals would involve reducing the number of vehicles required to service a given market for a given level of service reliability, and improving the cash flow of vehicle operators to enable them invest in better equipment. These goals all point to the need to commercialise public transport service delivery and establish functioning regulatory frameworks. An effective non-motorised transport (NMT) strategy for developing countries needs to be oriented towards the gradual substitution of non-motorized transport system (Gorham, 2002).

1.6.8 Accessibility planning

Transport is a demand derived from the need for access. By better addressing directly the accessibility needs of populations, the need for transportation might be reduced. This could involve better attention to land-use planning and urban development, or better application of telecommunications technology as a strategic substitute for particular trips. A number of best-practice principles in land-use/urban planning to improve accessibility can be identified as follows:(i)recognising that the designation of primary rights of way and movement corridors will have an impact on location, land-use and building-pattern decisions for decades, and take this impact into account in the early planning stages· (ii) recognising the cumulative impact of land-use and transport decisions. (iii) Correcting pricing distortions in the transportation system before they are "capitalised" into land through particular urban forms or densities. (iv) Ensuring the inclusion of full infrastructural costs in land prices through the development process. Increase the liquidity and transparency of real estate to allow markets to respond adequately and fairly to public policy signals and accelerate demand-driven changes in land use. (v) Avoiding inappropriate regulations and excessive reliance on regulatory measures to influence land use without commensurate, compatible and supportive infrastructural investments and transportation policy, but enforce appropriately scaled and applied regulations with heartiness. (vi) Fostering amenity and access in urban design as counterweights to the demand for space as incomes grow. (Vii) Experimenting on a small scale with new or innovative ideas shifting the costs associated with travel. Innovations in a number of transport delivery options in developed countries–including car-sharing, road or congestion pricing, variable-priced insurance, cash-out of free parking are coalescing around an increasingly recognized element of transport pricing: shifting the overall lifetime cost burden associated with auto mobility from fixed to variable costs (Gorham, 2002).

A policy goal of varying costs associated with motorisation can help better to align the costs and the benefits of individual trips, leading to a more efficient allocation of trip-making, chaining (combining or sequencing trips throughout the day), and mode choice (Gorham, 2002)

1.7 Research Problem

There is uncertainty arising from whether the quality of road side vegetables could be as good as those cultivated far away in terms of nutritional values. This has created doubt in the minds of concerned people making them to be curious about knowing which level of air pollutant could course a change in the nutritional value of road side vegetable crops and whether the concentration of these pollutants from vehicular emission in Zaria metropolis have reached that level.

1.8 Research Aim/Objectives

This research aimed at determining the impact of vehicular emissions on the proximate composition of roadside *Amaranthus hybridus* (African spinach or green amaranth), roadside *Mangifera indica*(Mango) and air quality in Zaria. It also aimed at: -establishing whether vehicular emission could affect the proximate composition of *Amaranthus* *hybridus* and *Mangifera indica*, determining whether the air quality in Zaria has been reduced by vehicular emissions below the recommended standard and to make recommendations on how any possible negative effect on the crops and air quality could be handled.

1.8.1 Objectives

The aim of this research was achieved through the following objectives:-

1 Determination of the pollutants loads [Carbon monoxide (CO), Carbon dioxide (CO_2), Nitrogen dioxide (NO_2), Sulphur dioxide (SO_2), Hydrocarbons (HCs) and Particulate matter (PM)] in Zaria atmosphere at strategic points with high traffic density.

2 Determination of these pollutants at peak and off-peak periods.

3 Carrying out traffic count in order to determine the traffic density at chosen sampling sites.

4 Correlating the amount of pollutants with traffic density.

5 Determination of proximate composition of the *Amaranthus hybridus.*

6 Determination of the impact of these pollutants on the proximate composition of road side *Amaranthus hybridus.*

7 Determination of the impact of these pollutants on the growth rate of the roadside *Amaranthus hybridus.*

8 Comparing the impact of vehicular emission on air quality and the roadside crops at experimental sites with control site.

9 Comparing the proximate composition of *Amaranthus hybridus* to that of a perennial crop (*Mangifera indica*).

10 Comparing the concentration of these pollutants with the Nigerian Ambient Air Quality Standard (NAAQS) limit.

1.9 Justification

The daily increase in number of vehicles in Zaria metropolis has certainly increased the volume of vehicular emissions in Zaria environment and research to determine the amount of these pollutants in the atmosphere and their impact on roadside *Amaranthus hybridus* have not been adequate since it is not readily available in literature. Based on this, there is need for a research work such as this in order to determine the impact of these emissions on the atmosphere and roadside *Amaranthushybridus* within Zaria metropolis to compliment the few existing data bearing in mind that any negative impact on crops may have direct influence on the nutritional need of man who depends on these crops.

Available evidence shows that vehicular emissions have adverse effect on crops and air quality and this have been illustrated by some researchers, for instance, Lowry *et al*.,(1951) showed that pollutants from vehicular emission can reduce plant protein content. A reduction in the amount of plant proteins, chlorophyll pigments and adverse effect on morphology were also shown by Andrew *et al*., (2007) while the negative impact of vehicular emissions on air quality was shown by Utang and Peterside (2011). Based on these, there is a need to further determine the impact of vehicular emission in Zaria atmosphere to ascertain the level of pollutants coming out from the tailpipe and its impact on a major vegetable the *Amaranthus hybridus* widely consumed in Zaria metropolis.

1.10 Scope and Limitation

Four traffic hotspots were used as experimental points and another point 250 metres away from the nearest major road was used as control point. Only one kind of vegetable crop, the *Amaranthus hybridus* was cultivated at all sampling sites. The impact of vehicular emissions was determined considering only the effect on air quality and proximate composition (moisture content, ash content, fat content, crude fibre content, crude protein content and carbohydrate content) of the crop. Air quality was measured considering only the gaseous pollutants [carbon monoxide (CO), carbon dioxide (CO_2), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), hydrocarbon (HC_S)and particulate matter (PM)] and they were all determined at each sampling points.

1.11 Significance of the Research

Research carried out on vehicular emissions shows that vehicular emissions can cause adverse health effect on plants, reduce crop quality, affect plant morphology and also have negative impact on air quality as reported by Andrew *et al*., 2007 and Dara, 2008. Based on this, it becomes appropriate that a work of this nature is needed to establish whether there could be negative impact from vehicular emissions on air quality and the crops under study so as to help regulatory bodies to reduce the volume of emissions in Zaria on time by enforcing the laws which help to check traffic emissions. Result obtained from this research will contribute to knowledge and help other researchers that will be interested in this area of research.

1.12 The Study Area

The study area, Zaria is in Kaduna State of the Federal Republic of Nigeria. It is the second largest city in kaduna state, it is located between longitude 7^{o} 36' to 7^{o} 42'E and latitude 11^{o} 00' to 11^{o} 10' N of the equator and found on the high plains of northern Nigeria, in sub-Saharan Africa (Ubogu*et al*., 2011). Zaria metropolis contains two local government areas, Zaria and Sabon-Gari. The major drainage systems in Zaria metropolis are the River Galma which is a major tributary of River Kaduna having a drainage basin of about 6902 km^2 area, the River Kubani, the River saye among others (Mortimore, 1970). It has two major soil types, the red laterite soil of northern Zaria and the heavier and more fertile blackish soil which occurs further south of the region (klinkenbera, 1970). The space economy of Zaria comprises of commercial, residential, educational, transportation, agricultural and industrial land use with the industrial activities presently dominated by small-scale informal sector (Ubogu*et al*., 2011).

1.13 *Amaranthus hybridus*

Amaranthus hydridus according to Integrated Taxonomic Information System of North America is commonly known as green amaranth, smooth pigweed and smooth amaranth having the taxonomy serial number TSN20735. It is a member of the Amaranthaceae family. In Nigeria, it is generally and commonly called spinach although not of the same species with the real spinach plant (*Spinacia oleracea*). It is also known as green in southern part of Nigeria, alefo in northern part and effo in the west. An annual herbaceous plant of 1 - 6 feet (0.3 – 1.83 meters) high with petiole alternate light green leaves Akubugwo*et al*., (2007). *Amaranthus hydridus* is a leafy vegetable widely consumed in Nigeria especially in the north. It is probably the most widely occurring leafy vegetable in Africa (Mordi, 2007). Apart from being used as vegetable, it is also used as herbal medicine since it has medicinal values for the treatment of intestinal bleeding, diarrhea and excessive menstruation (Foster and Duke, 1990).

Classification of *Amaranthus hydridus*
Kingdom ------- Plantae
Phylum --------- tracheophyta
Class ----------- magnoliopsida
Order ----------- Caryophyllates
Family ---------- Amaranthaceae
Genius ---------- Amaranthus
Species --------- *Amaranthus hybridus*
Source: Integrated taxonomic information system of North America (2013)

1.14 *Mangifera indica*

Mangifera indica according to Integrated Taxonomic Information System of North America is commonly known as mango having the taxonomy serial number TSN 28803. It is a member of the Anacardiaceae family. It originated from southern Asia, more precisely from India where it has been cultivated for more than 4,000 years from the Malay Islands (Sauer, 1993). *Mangifera indica* fruit is widely consumed in Nigeria and other part of the world. The fruit is a berry whose pulp is low in acid, rich in sugars and considerable quantities of Vitamins and Minerals (Alves*et al*., 2002).

Classification of *Mangifera indica*
Kingdom ------- Plantae
Phylum --------- Magnoliophita
Class ----------- Magnoliatae
Order ----------- Sapindales
Family ---------- Anacardiaceae
Genius ---------- Mangifera
Species --------- *Mangifera indica*
Source: Integrated taxonomic information system of North America (2013)

Plate I: *Amaranthus hybridus* plant showing seeds

Plate II: *Amaranthus hybridus* plant

Plate III: *Mangifera indica* plant

Plate IV: *Mangifera indica* fruit

CHAPTER TWO

2.0 LITERATURE REVIEW

Research to know the impact of vehicular emission on our environment gained popularity and recognition many years ago, for instance, Ndiokwere, (1984) carried out a study on the effect of automotive emissions of heavy metals on soil, vegetation and crops along a major federal highway. Vehicular emissions have been a major contributor to environmental pollution causing negative effect on our natural environment through the addition of toxic pollutants with some being non-biodegradable (Luilo and Othman, 2006). Generally, air pollutants effect on plants have been a long time research before now, for instance, plant protein reduction was shown by Lowry *et al*., (1951), reduction in chlorophyll and cell size was shown by LeBlanc and Rao, (1975) and effect on plant growth characteristics such as leaf area was shown by Khanam*et al*., (1990). All these are recorded work to show the negative impact of pollutants from vehicular emissions on plants.

2.1 Impact of Vehicular Emissions on the Level of Heavy Metals in Roadside Environment

Ndiokwere (1984) looked at the effect of these vehicular emissions on the environmental media (roadside soil, vegetation and crops) in Nigeria. In his study, it was discovered that the accumulation of heavy metal pollutants in soil, vegetation and crops varies or decreased in concentration with distance from the traffic. It was also concluded that high accumulation of these metals in road side soil and vegetation was attributed mainly to aerial deposition of the metal particulates from motor vehicles.

The washed leaves of petunia grown in the urban area where there is heavy traffic emission were found to contain more trace metal (Mn, Fe, Cu, Ni and Pb) than those leaves from suburban region where traffic density is less. It was concluded that this is due to intense traffic in the urban region (Caselles*et al*., 2001).

Kylander, (2002) affirms the accumulation of Platinum Group Elements (PGEs) namely platinum, palladium and rhodium in the environment due to vehicle exhaust emission. In Accra, Ghana, it was shown that PGEs used as catalytic converters in automobile exhaust is the major source of PGEs pollutants near roadsides. Road soils and grass samples were taken from five sites that differed in traffic density; these samples were put into solution by microwave digestion and then analysed using inductive coupled plasma – mass spectrophotometer (ICP – MS). The study indicated that the concentration of platinum (a typical PGE) in soil increased with increase in traffic density and that the concentration in grasses at high traffic density areas was higher too, indicating that platinum concentration in the sample is associated with traffic density. It was reported that the concentration of platinum in Accra environment is higher than that in Europe; attributed to the large number of old fleet.

Pollution from Platinum Group Elements (PGEs) fixed on the exhaust pipes of vehicles to help convert exhaust pollutants to a more environmental friendly form was further shown to contribute to the accumulation of heavy metal in the environment by Whitely (2004). The study aimed at elucidating the post depositional and geochemical behaviour of auto- catalyst of derived Platinum Group Elements [platinum, Palladium and Rhodium] in selected roadside environment in Perth Western Australia - a cold temperate climate zone. It was revealed that spatial distribution of PGE exhibited greater vertical mobility in the soil. Cation exchange technique was found to be the most accurate for determination of PGE in the road dust and soils.

Lone *et al*., (2006) conducted a field study to evaluate the lead content in soil and wheat as affected by vehicle exhaust in Rawalpindi district in Pakistan. They selected three different roads with various traffic densities. On each road, five different fields at a distance 20, 220, 420, 620 and 820 metres across the road were selected. The five different fields were cultivated by farmers of the area between September and October in 2003. Plant and soil sample were collected at flag leave stage. The plant sample was digested in nitroperchloric acid mixture and soil samples were extracted with ammonium bicarbonate- diethylenetriaminepentacetic acid (AB – DTPA) and lead content was determined by atomic absorption spectrophotometry. By the use of regressional model of statistical analysis, they discovered that lead content of both soil and plants samples were positively correlated with the traffic density and negatively correlated with distance from the road, the lead content in soil and plant at PirVadhaiRaod (the busiest road) were found to be highest, the lead content found in the soil and plant samples along Ratehjang road (Medium traffic) was the least, along karma road having the lowest traffic load), maximum values of lead content at 620 and 820m distance in soil and plant samples were attributed to the use of sewage water.

Luilo and Othman (2006) determined the lead pollution level in urban roadside environment of Dar Es Salaam city. Soil and vegetation samples were collected at various distance from the road edges of the new Bagamoyo, Sam Nujoma and Mandelaroadsin in Dar Es Salaam city and analysed for lead using Atomic absorption spectrophotometry. The higher lead content (152.5ppm in soil and 35.7ppm in couch grass) were found in soil and vegetation within 1 to 5 metres from the road edge. The backgrounds lead level of 1.2ppm was determined by measuring lead accumulation at a point 150 metres from the road in both soil and vegetation. The lead levels along these roads exhibited strong correlation with the average traffic density (r = 0.912) for soil and r = 0.88 for grass. It was also concluded that the major source of lead pollution of these areas was emissions from automobile traffic on these highways and that high level of lead at a distance between 0 – 10m from the edge of these highway in soils and vegetation were potential health hazard to both humans and animals.

Lead and other heavy metals can contaminate the environment through auto repair workshops. Ipeaiyeda*et al*., (2007) assessed the dispersion of some, heavy metals notably Zn, Ni, Cr, Hg, and Pb within the soil profile of reclaimed auto – repair workshops in Iwo, Nigeria. All the metals recorded were at significantly higher levels than the background concentrations in the control sites. Pb was the highest contaminant followed by Ni. The average factors of accumulation within the soil profile were Zn 3.37, Ni 3.38, Cr 6.22, Hg 14.5 and Pb 2.1. The average (± S.D) level of the heavy metal in the topsoil (10cm) of the auto – repair workshops were; Zn 0.90 ± 0.5 mg kg^{-1} , Ni 11. 5 ± 3.3 $mgKg^{-1}$, Cr 5.3± 2.3 $mgkg^{-1}$ Hg 9.4 ± 4 6 $mgkg^{-1}$ and Pb 133 ± 66mg kg^{-1} The general trends of the concentration for these metal is Pb> Ni> Hg > Cr > Zn.

Samples of soil and plant (*Amarathusviridis*) were collected from three sites; two sites located on major highways in Lagos, Nigeria and another in a rural area which served as control site. The samples were collected 5, 10, 15 and 20metres from the road side and analysed for Pb and (Cd). The two metals level in soil were found in the range 47 to 151 mg kg^{-1} and 0.3 to 1.33 $mgkg^{-1}$ (dry weight) respectively. Lead and cadmium concentration level in leaves of the *Amaranthus* ranged from 68 to 152 mg kg^{-1} and 0.5 to 4.9 mg kg ((dry weight) respectively. The pattern of concentration of these metals in the plant showed a decreasing concentration with increase distance away from the road edge. This evidenced the impact of vehicular emission on roadside crops (Atayese*et al*., 2009).

Kabir*et al*., (2009) studied the effect of lead on seedling growth of *Thespesiapopulanea*L.This study investigated the effect of lead on the root, shoot / seedling length, leaf area, number of leaves, plant circumference, seedling dry weight, root /shoot and leaf ratio of *Thespesiapopulnea*L in a greenhouse under natural environment conditions with and without phytotoxic metal ions at 5, 10, 15 20 and 25 µmol/l. It was observed that lead treatment have strong impact on the growth and development of T. *Populnea* by reducing significantly ($P< 0.05$) effect in shoot length, number of leaves and leaf areas when compared to control. A significant ($P< 0.05$) reduction in plant circumference and seedling dry weight of *T.Populnea* was seen with increasing concentrations of lead from 5 – 25 µmol/l as compared to control. At 25 µmol/l of lead treatment, tolerance in *T. Populnea*seedling was lowest as compared to all other treatments. This evidenced the possible negative effect of lead could create on roadside crops if leaded fuel is used.

Abechi*et al*., (2010) analysed the level of lead, zinc, Manganese, copper, Nickel, cadmium, cobalt and iron in soils exposed to vehicular emission in Jos metropolis, Nigeria using atomic absorption spectrophotometry. Cobalt and nickel were not detected in the soil samples. Levels of the detected heavy metals correlate positively with traffic volume, indicating that the metallic pollution in the soil most likely originates from vehicular emissions.

Naveed*et al*., (2010) reported the leaves of roadside plants as bio-indicator of traffic related lead pollution during different seasons in Sargodha, Pakistan.
Three road side plants (*Dalbergiasissooroxb*, *Prosopisjuliflora L.* and *Eucalyptus*Spp) were used as study specimens. The study area was divided into five on the basis of traffic density and industrial pollution. These were urban, suburban, industrial, road side and rural. In this study, it was found that lead concentration was highest in the plants that were collected from industrial site in Delbergia during winter and summer at a concentration of 421.43±19.30 and 429±14.49 μgg^{-1} respectively and lowest at the control site (rural site) 69.57± 36.80 $\mu g\ g^{-1}$ in *Prosopisjuliflora L* during summer. This indicated that .all the three plants were good bio - indicator of lead pollution and their leaves can be used as a bio- indicator intensively, since they are common in different parts of the world. This work also revealed that heavy industrialization could emit more lead into the environment than from vehicular emissions.

Uboh*et al*., (2011) carried out study on the distribution of heavy metals in fluted pumpkin *(Telfeiriaocidentalis)* leaves cultivated at different distance away from the traffic congested highways in AkwaIbom State and cross River state, Nigeria. Fluted pumpkin cultivated at close proximity to the road has higher concentration of heavy metals than those cultivated far away from the highways, with difference in concentration being statistically significant ($P < 0.05$).

Soil lead accumulation from vehicular emissions can cause serious negative effect on plants, the work on spinach plant in Parkistan carried out by Zinada*et al*., (2011) lead to the findings that growth characters such as root length, shoot height, total leaves area, fresh and dry weight of root, shoot and whole plant decreased with increasing lead accumulation on Soil. Plant pigment such as chlorophyll and total carotenoid also decreased with increasing Pb concentration in the soil. It was found that the toxicity of Pb on growth characters and its effect on elemental transport and accumulation were reduced when it was combined with foliar iron

2.2 Impact of Vehicular Emissions on Air Quality

Vliet and Kinney (2007) carried out study on the impact of roadway emissions on urban particulate matter concentrations in Sub-Saharan African: a case study of Nairobi, Kenya. The research was driven by the fact that there was no enough ambient monitoring data, particularly urban road side concentration for particulate matter which hindered the ability to describe temporal and spatial pattern of concentrations for policy making toward health, air standard and transportation planning. The work collected pilot data, on air concentration of $PM_{2.5}$ and black carbon encountered while driving in metropolitan of Nairobi and to compare the data gotten to background concentration level. Portable air sampling system was used. At the end of the study, it was established that the road way concentration of $PM_{2.5}$ were approximately 20-fold higher than those from the urban background site and black carbon concentration differed by 10-fold.

The test of the pollutants CO, NO_2 SO_2 and particulate matter (PM_{10}) including weather elements like ambient temperature, wind direction and wind speed were carried out in Calabar town, Nigeria. It was discovered that at traffic intersections and points of high traffic count, NO_2, PM_{10} and noise level were higher (Abam and Unachukwu, 2009).

Akanni, (2010) carried out an assessment study on traffic related pollution of the air in Lagos metropolis, Nigeria. Almond (*Terminaliacatappa L*) leaves used as sample were collected along traffic corridors and six stations located 250 m away (as control) during dry and wet seasons for two years. Concentration of trace element pollutants (Pb, Cd, Cu, Cr, Al Zn, As, Hg, Fe, Mn and Mg) were measured by laboratory analysis on the leaf samples.

Multivariate statistical analysis was used to test for the significance of variations in air pollutant. The study reports that suspended particulate matter varied from 22.36-29.07 mg/m^3 as against 0.05-0.15 mg/m^3 which is WHO standard, SO_2 and O_3 varied from 1.1-173 mg/m^3 and 0.01-0.18 mg/mrespectively as against 0.00125and 0.0015 mg/m^3 WHO air quality standard (AQS). Using step-wise regressional analyses. The study showed that density, air temperature and land use contributed significantly to air pollution at ($P< 0.05$). Concluding that all pollutants tested were higher in the environment than the recommended level by WHO air quality standards and were also higher along traffic corridors than farther ways.

Another report given on the state of air in Nairobi by Odhiambo*et al*., (2010) was on the concentration level of NO_x O_3, PM_{10} and trace elements. Sampling was done once a week from February to April 2003. Chemilumiscent technique was used to measure hourly average concentrations of NOx and O_3. Energy dispersive X – ray fluorescent (ED- XRF) technique was used to analyse for trace element. An automatic vehicle counter was used to determine the traffic density of sampling points. It was concluded that particulate matter (66.66 – 444.45 μgm^{-3}) was above the WHO standard and that coarse particulate matter accounted for 70% of total particles, and that there was a strong correlation (r =

0.966) between fine (0.4µm) particulates, NOx and motor vehicle density indicating that traffic density is a common source for both fine particle matter and $NO_{x.}$

Utang and Peterside (2011) estimated the air pollutants CO, NOx, SO_x and hydrocarbons from four sampling points within parts of the city of Portharcourt. The level of variation in concentration of emissions between peak and off peak periods of traffic and between locations was determined. The concentration of CO detected was higher than the federal environment protection agency limit and the recommended municipal (local) standard. The level of hydrocarbon detected in the atmosphere varied in space and time while NO_x was found to be above the local and international standard limit. It was concluded that the city is under the threat of traffic related pollution and could be more dangerous considering the increasing vehicle population and traffic in the city. It was also recommended that the construction of modern roundabouts could help to reduce peak period traffic in the nearest future thereby reducing vehicular emission.

2.3 Impact of Vehicular Emissions on Plants

The amount of sulphur in leaves of *C. procera*, *P. Juliflora* and *Sennaholosericea*collected from three different distances around the super highway nearKarachi were determined. The amount of sulphur was highest in all the samples collected at a distance 4.5 metres away from the highway as compared to longer distances from the highway. It was also found that the leaves of *S. holosericea* had an insignificant sulphur concentration at all distance, indicating that the absorption of pollutant by plant from the atmosphere depends on the plant concentration factor (PCF). Soil analysis for available sulphur demonstrated a highly significant difference ($P < 0.05$) in the level of sulphur in the soil samples collected distance away compared to the ones at the edge of the highway. A correlation was seen between the total concentration in foliage of the plants and the level of available sulphur in the soil; showing that high level of sulphur in plants and soil nearer to the highway is due to the emission from vehicle activities (Iqbal and Mahmood, 1992)**.**

The phenology of the plants *Alstoniascholaris* and *Pongamiapinnata* was significantly affected by vehicular emissions when compared to the control and the level of the impact on the individual plants was not the same. Because it was observed that the leaf length, area and width of *Pongamiapinnata* was reduced significantly at $p < 0.05$ when compared to the leaves of *Alstoniascholaris* (Shafiq and Igbal, 2003). This result may be due to the plant concentration factor (PCF) of the individual plants (Igbal and Mahmood, 1992).

Durrani*et al*., (2004) showed how vehicular emission can impact negatively on plant photosynthetic processes. In his work, he reported a decrease in chlorophyll and carotene pigments in plants grown closer to the point of high traffic emissions.

Wagh*et al*., (2006) investigated into the impact of vehicular emission on vegetation along the road using sample from Neem *(Azadirachta indica),* Peepal *(Fiscusreligiosa) and* Bangan*(Fiscusbenghalensis*) since these plants were the major component of the plantation along the area. Total chlorophyll and plant protein were analysed to study the impact of vehicular emission. At the end of the work it was observed that plants that were very close to roadside with heavy traffic were affected more by the emission. Significant decrease in total chlorophyll and protein content were also observed.

Andrew *et al*., (2007) studied the growth rate of red pine (*Pinusresinosa*) and observed that the red pine growing along the road side exposed to vehicular emissions had a reduced growth rate compared to other pines growing on the other side where vehicular emission was absent.

Seygednejad*et al*., (2009) drew attention to the fact that gaseous pollutants (NO, NO_2 $SO_{2,}$ CO, and CO_2) from industrial zones can have negative effect on the physiology and morphology factors of plants, especially under high temperature condition of the tropic. It was shown that these gaseous pollutants can reduce chlorophyll A and B, carotenoid, proline and total soluble sugars in plants as well as morphological characteristics. Although, industrial source of these pollutants was considered in this work, it is also believed that since these pollutants are also associated with vehicular emissions, they could also cause same effect on the environment in a high traffic density zones at equivalent concentration with those released to industries.

Chauhan (2010) researched into the use of plants as bio-monitor for automobile pollution in Defraud city. Four plants *Ficusreligionsa*, *Mangifera indica*,*Polyalthialongifolia* and *Delonixregia* were used. It was observed that reduction in chlorophyll A, chlorophyll B, ascorbic acid (vitamin C), carotenoid and relative water content was displayed in all the leaves sample collected from polluted site when compared to sample from control. The reduction of chlorophyll A in theleaves was highest in*Ficusreligiosa* and lowest in the leaves of *Mangifera indica.* Maximum reduction of carotenoid was found in the leaves of *Polyalthialongifolia*and minimum reduction in *Mangifera indica*. The maximum reduction was observed in the leaves of *Polyalthialongifolia.* This suggests that some plants are not very good bio-indicator for a particular pollutant when certain parameter is required.

2.4 Effect of Fuel Type on Quality and Volume of Vehicular Emissions

Kammerbauer*et al*., (1999) illustrated on the different effects of alcohol used as fuel compared to gasoline asserting that vehicular emission from alcohol engines were less toxic than emissions from gasoline engines.

Tsai *et al*., (2006) showed that vehicle fuels (gasoline, diesel and liquefied petroleum gas LPG) contribute variously to volatile organic compounds (VOCs) and NOx emission on roadside environment. They found that LPG having C_3 – C_4 hydrocarbons mostly propane and butane has the highest contribution to VOCs emission followed by gasoline fuel having C_4- C_6 hydrocarbons mostly toluene and pentane, then diesel fuel having C_8 – C_{10} hydrocarbons and having the least and insignificant VOCs emission, but had the highest NOx emission.

Biofuel has better emission characteristic when compared to fossil fuel like gasoline and diesel. Biofuel show decrease emission of greenhouse gas, substantial reduction in emission of unburned hydrocarbons and particulate matter. The blending ratio of biofuel with fossil fuel also has influence on the quality of emissions when used as automobile fuel (Vidosh*et al*., 2011).

2.5 Effect of Time and Seasons on the Quality and Volume of Vehicular Emissions

Variations in concentration of vehicular pollutants can be influenced by time and seasons as reported by Emerhi*et al*., (2002). Hand held air monitors comprising of industrial scientific corporation ITX multigas monitor and aerosol mass monitor were used to monitor volatile organic compounds and particulate matter at different time of the seasons at traffic high density areas of some metropolis in Niger Delta, Nigeria. Emissions were higher than those measured at low density traffic points, apart from traffic density and distance away from the road, it was found that the concentration of these pollutants were higher in dry season than in rainy season and the difference was significant at $p \geq 0.05$ confidence level.

Audu and Lawal, (2006) in their work on the variation in metal contents of plants in vegetable garden sites in Kano metropolis also confirm this fact about seasonal variation of pollutant concentration in the environment where reductions of metal level ranging from 8.25% Fe in onions to 45.19% Ni in okra were observed in rainy season. This accumulation of pollutants in crops arising from vehicular emission in the environment can lead to some negative effect on the crops and human health.

2.6 Effect of Vehicular Emissions on Health

Enemari (2001) alerted people of the danger of vehicular lead emission which causes physiological disorders in man such as interference with intelligent quotient (IQ) of children of school age, gastrointestinal collapse, fatigue, blindness, central nervous system disorder, anaemia and many more health problems.

Ojolo *et al*., (2007) carried out a research work on the effect of vehicular emissions on human health in Nigeria. The investigation employed questionnaires and laboratory experiment. Health problems like sleeplessness, running nose, heavy eyes, asthmatic attack and headache were observed in the test locations and the percentage of these health implications was higher in people leaving in the three locations of high traffic congestion (Oshodi, Mushim and Apapa) compared to people living in the control location (FolaAgoro). So conscious efforts must be intensified by private, co- operate and governmental bodies towards alleviating the menace of vehicular emissions to the environment.

Table 2.1: Nigerian Ambient Air Quality Standard (NAAQS) Limits

Pollutants	**Averaging time**	**Limits**
Particulates	Daily averages of daily values 1 h	250 µg/m3 600 µg/m3
Sulphur dioxide (SO_2)	Daily mean of hourly values. 1 h	0.01 ppm (26 µg/m3) 0.1 ppm (260 µg/m3)
Carbon monoxide (CO)	Daily mean of hourly values. 8 hourly mean	10 ppm (11.4 µg/m3) 20 ppm (22.8 µg/m3)
Carbon dioxide (CO_2)		600 ppm
Nitrogen dioxide (NO_2)	Daily mean of hourly values 1h	0.04 – 0.06 ppm (75.0 - 113 µg/m3)
Hydrocarbons (HCs)		0.05 ppm

Source: Ajayi and Dosunmu, (2002); Gobo et al., (2012); Nwachukwu*et al*., (2013) and Akande*et al*., (2013)

CHAPTER THREE

3.0 EXPERIMENTAL METHODS

3.1 Reagents

All reagents used for this work were of analytical grade or as otherwise stated. The reagents include sulphuric acid (0.023 M), sodium hydroxide (0.312 M), hydrochloric acid (0.10 M), petroleum ether, 4% boric acid, 40% sodium hydroxide, potassium sulphate, copper sulphate and distilled water.

3.2 Preparation of Solutions

3.2.1 Sulphuric acid (0.023 M)

Concentratedsulphuric acid(1.25 cm^3) having specific gravity of 1.84 and percentage purity of 98 was measured out into volumetric flask and diluted with distilled water and the volume was made up to 1000 cm^3 to have a 0.023 M sulphuric acid solution

3.2.2 Hydrochloric acid (0.10 M)

Concentrated hydrochloric acid (9.40 cm^3) having specific gravity of 1.05 with percentage purity of 37 was measured into volumetric flask and diluted with distilled water and the volume was made up to 1000 cm^3 to have 0.1 M of hydrochloric acid solution

3.2.3 Sodium hydroxide 0.312 M

Sodium hydroxide (12.50 g) was dissolved in distilled water in a volumetric flask; the solution was made up to 1000 cm^3 with distilled water to give 0.312 M sodium hydroxide solution.

3.2.4 Sodium hydroxide (40.00 % w/v)

Sodium hydroxide (100.00 g) was added to distilled water in a 250.00 cm^3 volumetric flask; the solution was made up to mark with distilled water to give 4.00 % w/v solution of sodium hydroxide.

3.2.5 Boric acid (4.00 % w/v)

Boric acid (10.00 g) was added to distilled water in a 250.00 cm^3 volumetric flask. The solution was made up to mark with distilled water to give 40.00 % w/v solution of boric acid.

3.3 Sampling Sites

Five (5) points otherwise known as sites were considered as sampling points, these are REX junction, PZ junction, MTD junction and Kwangila Fly-Over which are all located athigh traffic areas of Zaria, Nigeria.These served as experimental sites. The fifth site which is 250 metres away from the road was used as the control site; this is the farm area of Palladan in Zaria metropolis. The exact positions of the points (experimental and control sampling sites) are $11^{o}6^{1}25^{11}$ N, $7^{o}43^{1}26^{11}$ E**;** $11^{o}6^{1}17^{11}$ N, $7^{o}43^{1}13^{11}$ E**;** $11^{o}7^{1}26^{11}$ N, $7^{o}42^{1}48^{11}$ E**;** $11^{o}813511$ N, $7^{o}42^{1}73^{11}$ E**;** and $11^{o}8^{1}51^{11}$ N, $7^{o}41^{1}29^{11}$ Erespectively as were located with the help of GP 220X model global positioning system (GPS) instrument obtained from Transport Technology Centre, Nigerian Institute of Transport Technology, Zaria. The sites were chosen based on volume of traffic and the possibility of having crops cultivated very close to the road with special consideration to the safety and security of the crops under study.

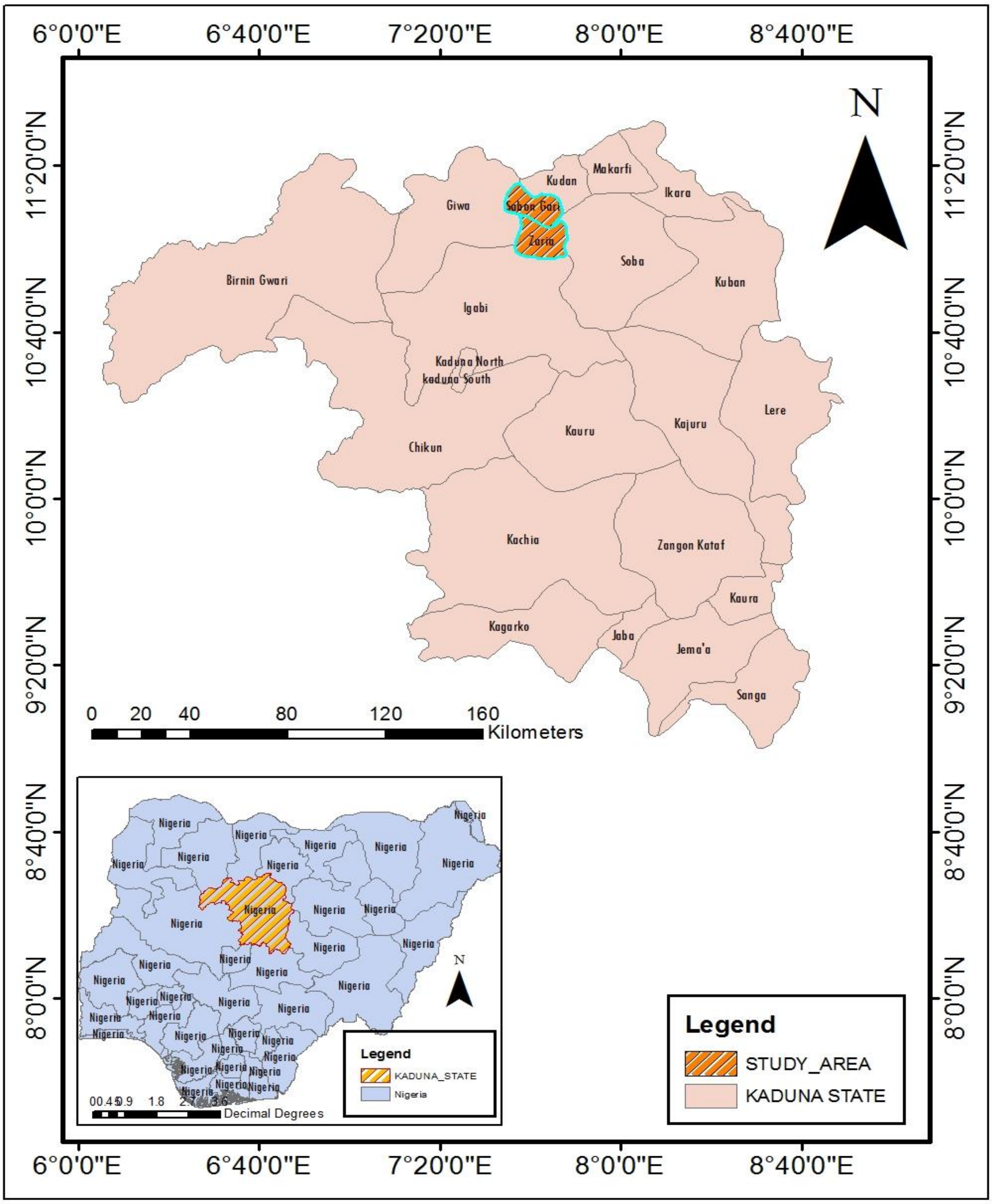

Figure 3.1: Map of Kaduna showing Zaria (the study area)

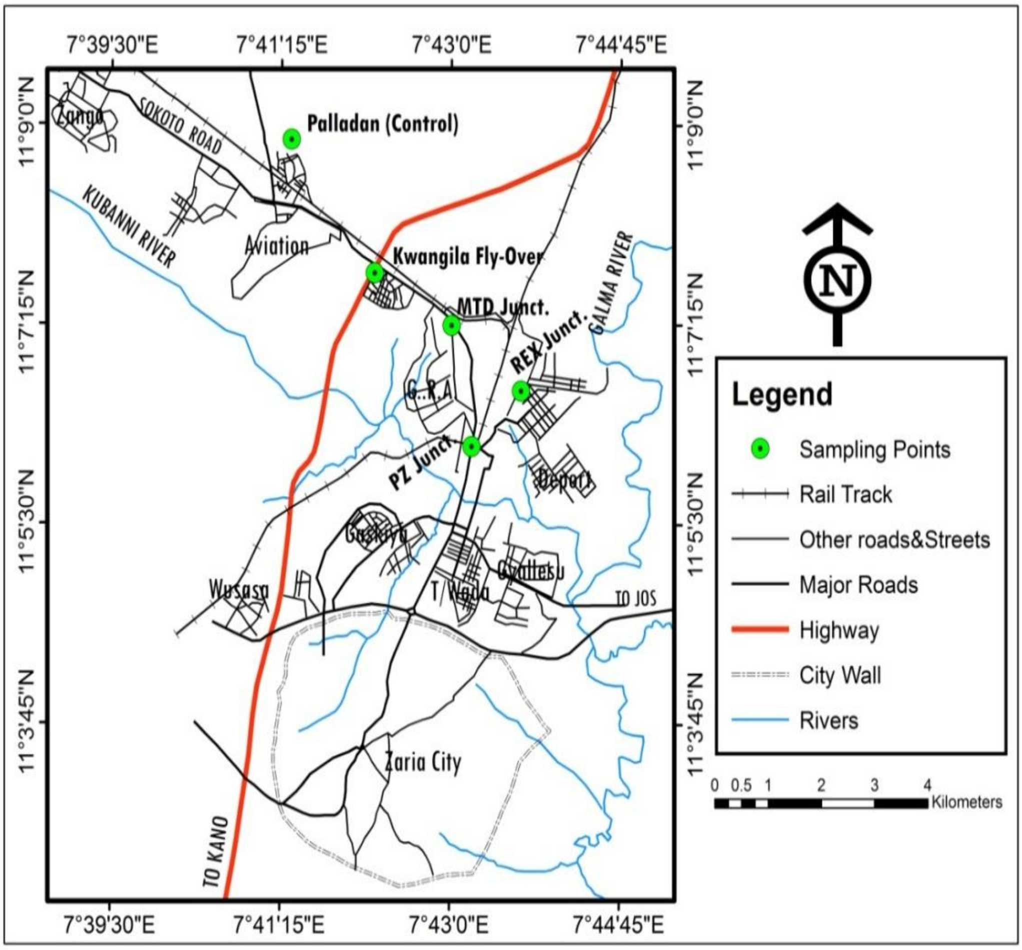

Figure 3.2: Map of Study area showing sampling points

3.4 Cultivation of *Amaranthus Hybridus*

Viable seeds of *Amaranthus hybridus* collected from the Institute of Agricultural Research, Ahmadu Bello University (ABU) Zaria, were cultivated in pots using good soil of uniform composition collected from Soil Science Department of ABU. The pots were kept at five (5) meters away from road edge at traffic hot spots. Three (3) planting pots containing at least eight (8) plant stands each were kept at each of the five (5) sampling points bringing the total planting pots to fifteen (15). The control were cultivated on the same soil and at a distance of 250 metres away from the road where there was no traffic to make sure it is not exposed to vehicular emissions as the experimental set.

3.5 Traffic Count

Traffic count was carried out using the tally sheet method. The inflow and outflow traffic was considered during the counting at every experimental point (Rex Junction, PZ Junction, MTD Junction and Kwangila Fly-Over). The counting was conducted thrice for each point and the average was taken as the traffic density for each of the points expressed in number of vehicles per hour (v/h).

3.6 Measurement of Growth Rate of the Amaranthus hybridus

The growth rate of the cultivated *Amaranthus hybridus* was determined by the use of a transparent meter rule. The measurement of the *Amaranthus hybridus* was done from the base to the stem tip to determine the average height and was expressed in centimetre.

3.7 Measurement of Air Pollutants from Vehicular Emission

The air quality measurement for vehicular emitted pollutants [carbon monoxide (CO), carbon dioxide (CO_2), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), hydrocarbons (HC_S)and particulate matter (PM)] was conducted in thepeaktrffic periods and off-peak trafficperiods of traffic using portable gas analysers. Hours between 7:00 –10:00 am served as morning peak period, 10:00 am – 1:00pm served as off-peak while 4:00 – 7:00 pm served as evening peak. This measurement was carried out thrice, once in every two weeks at the experimental and control site. Measurements were done in triplicate, environmental factors including temperature, windspeed and relative humidity (RH) was also determined during the measurement of pollutants. CO, NO_2, SO_2 and HCs were measured with the use of Growncon Gasman single gas monitoring analysers for CO, NO_2, SO_2 and HCs respectively.Particulate matter (PM) was measured using the Hazdust HD 1000 model emission analyser while CO_2 was measured using the GE 2028 model gas analyser. Temperature and humidity were measured using the TES 360 model humidity/temperature meter while Kestrel 400 weather tracker was used to measure the wind speed. All the gas analysers and the temperature/humidity meter were obtained from Kaduna Environmental Protection Agency (KEPA), Kaduna State.

3.8 Sample Collection

3.8.1 *Amaranthus hybridus* sample collection

Three (3) crop stands, one from each of the planting pots were collected from each of the sites during each sampling making the sample collected to be fifteen (15) and the sample collection was carried out four times bringing the total sampling size to sixty (60) at the end of six weeks (42 days) of planting the seeds. Sampling was carried out on weekly basis starting from the third week of growth through the sixth week making sampling time to be four.

3.8.2 *Mangifera indica* sample collection

Leaves and bark of*Mangifera indica* cultivated on the roadside at five metres from road edge were collected as composite sample at each of the five sampling points at the same time with the *Amaranthus hybridus* for four times bringing the total *Mangifera indica* sample to twenty.

3.9 Preparation of Sample

The fresh vegetable samples of *Amaranthus hybridus* and *Mangifera indica* leaves were washed with tap water once and then rinsed with distilled water several times. The samples after being washed were air dried to remove residual moisture at room temperature before sun drying for three days at 32 – 34 ^{o}C and relative humidity (RH), 30 – 35 % on a clean paper spread on concrete floor with regular turning to avert microbial growth. The sun dried samples were ground into fine powder using pestle and mortar and sieved through 2.0 mm sieve to obtain a dried powdered sample that was used throughout the analysis. The *Mangifera indica* bark was given the same treatment but was sun dried for 5 days (Mepba*et al*., 2007).

3.10 Determination of Proximate Composition

The following proximate composition of the study crops *Amaranthus hybridus* and *Mangifera indica* were determined and these are moisture content, ash content, fat content, crude fibre content, crude protein content and carbohydrate content. The A.O.A.C 1980standard method was used to determine these.

3.10.1 Determination of moisture content

This was obtained based on the difference between the net weight and the weight after oven drying the crop. A clean aluminium plate was dried to a constant weight in an oven at a temperature of 105^{o}C, cooled in a desiccator and weighed (W_1). 2.00 g of the ground sample was weighed into the aluminium plate (W_2) and dried in the oven at 105^{o}C for 8 h. The aluminium plate and its content were cooled in a desiccator and weighed (W_3) (A.O.A.C 1980).The % of the moisture content was calculated as presented in equation 1

$$\frac{\boldsymbol{W_2 - W_3}}{\boldsymbol{W_2 - W_1}} \times \mathbf{100} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad \mathbf{1}$$

3.10.2 Determination of ash content

A 2.00 g of the finely ground sample was weighed (W_2) together with a previously weighed clean and dried crucible (W_1), the crucible and its content was ignited in a muffle furnace with temperature gradually increased to 550^{o}C for 8 h. After this 8 h, the crucible and its residue was allowed to cool to 200^{o}C. This was removed and cooled in a desiccator and the procedure continued until constant weight was obtained (W_3) (A.O.A.C 1980).The % of the ash content was calculated as presented in equation 2

$$\frac{\boldsymbol{W_3 - W_1}}{\boldsymbol{W_2 - W_1}} \times \mathbf{100} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad \mathbf{2}$$

3.10.3 Determination of fat content

A200.00 cm^3 of petroleum ether at 40^{O}C - 60^{O}C in a 250.00 cm^3 round bottom flask was fitted with soxhlet extraction unit. Some anti-bumping granules were added. Fat free extraction thimbles weighed (W_1) and 20.00 g of the ground sample was added and weighed (W_2).The thimble was fixed into the soxhlet extraction unit with forceps and cold water circulation was put on. The heating mantle was switched on and heating temperature was adjusted to 40^0 -60^0C until the solvent refluxed at steady rate. This extraction was carried out for 8 h, after which the heating mantle was switched off and the thimble removed and dried to a constant weight in an oven at 70^oC and reweighed (W_3).The % extractible lipid of the sample was calculated as presented in equation 3

$$\frac{\boldsymbol{weigth\ of\ fat\ extracted}}{\boldsymbol{weigth\ of\ direct\ sample}} \times \mathbf{100} \ \ldots\ldots\ldots\ldots \quad \mathbf{3}$$

Where the weight of lipid extracted (crude fat) is given by the loss in weight (W_2-W_3) of the thimble content after extraction (A.O.A.C, 1980)

3.10.4 Determination of crude fibre

A 2.00 g of the ground sample was put into a round bottom flask, 100 cm^3 of 0.023M H_2SO_4 was added and the mixture boiled under reflux for 30 minute, it was then filtered under suction. The insoluble matter was washed several times with hot water until it was free of acid. This insoluble matter was transferred into another flat bottom flask and 100.00 cm^3 of 0.312 M of NaOH was added and the mixture boiled again under reflux for 30 min and filtered under suction, it was washed again until it was free of NaOH. This final residue was dried to a constant weight in an oven at 100^oC cooled in a desiccator and weighed (W_2). The weighed residue was incinerated in a muffle furnace at 550^oC for 2 h, cooled in a desiccator again and weighed (W_3).The % crude fibre content was calculated as presented in equation 4

$$\frac{\boldsymbol{W_{2-W_3}}}{\boldsymbol{W}} \times \mathbf{100} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \mathbf{4}$$

Where (**W2-W_3**) is the loss in weight on ashing (incineration) and W is weight of original sample (A.O.A.C 1980).

3.10.5 Determination of crude protein (Kjeldahl Method, A.O.A.C, 1980)

A 2.00 g amount of the sample was weighed into 100 cm^3Kjeldahl digestion flask and about 1.00 g of the catalyst mixture (K_2SO_4 + anhydrous $CuSO_4$) was added to speed up the reaction. 25.00 cm^3 of concentrated sulphuric acid was added into the flask. The flask content was heated slowly at first until frothingsubsided and then more vigorously with occasional rotation of the flask to ensure even digestion and to avoid over heating of the content. The heating continued until a clear solution was obtained. After cooling, the solution was transferred into 100 cm^3 volumetric flask and diluted to mark with distilled water. 10.00 cm^3 aliquot of the diluted or digest was pipetted into Markham semi macro flask and 10.00 cm^3 of 40% sodium hydroxide solution was added. The solution distilled and the liberated ammonia trapped in a 100 cm^3 conical flask containing 10.00 cm^3 of 4% boric acid and two drops of methyl red indicator. Distillation continued until the pink colour of the indicator turned greenish, the content of the conical flask was titrated with 0.10 M HCl. The end point was indicated by a change from greenish to pink colour. The volume of the acid used for each distillate as well as the blank was then noted. Triplicate samples of the crops were determined.

Calculation for crude protein

Total amount of N per sample was calculated as presented in equation 5

$$\boldsymbol{N} = \frac{\boldsymbol{v_{1\times v_{0\times M\times 14\times 100_{c\times 100_d}}}}}{\boldsymbol{2\times 1000\times 1_0}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad 5$$

Where,
V_0 = vol. of HCl required for the blank

V_1 = vol. of HCl required for 10 cm^3 sample solution

M = concentration of HCl

14 = atomic weight of nitrogen

100_d = total volume of digest

100_c = % conversion

1_0 = volume of distillate

2 = weight of sample taken in gram

1000 = conversion to dm^3

N = nitrogen

From here, the crude protein = % N × 6.25,Where 6.25 is the protein conversion factor

3.10.6 Determination of carbohydrate (nitrogen free extract NFE)

The Pearson method (1976) was used to determine the carbohydrate content of the vegetables. The carbohydrate was obtained by subtraction. (Estimation by difference)

% carbohydrate = 100 - (crude protein + crude fat + ash content + moisture content)

CHAPTER FOUR

4.0 RESULTS

4.1 Concentration of Air Pollutants from Vehicular Emissions

The concentrations of air pollutants [particulate matter (PM), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), carbon monoxide (CO), carbon dioxide (CO_2) and hydrocarbon (HCs)] from vehicular emissions in the air of Zaria metropolis are presented in Figures 4.1 – 4.6

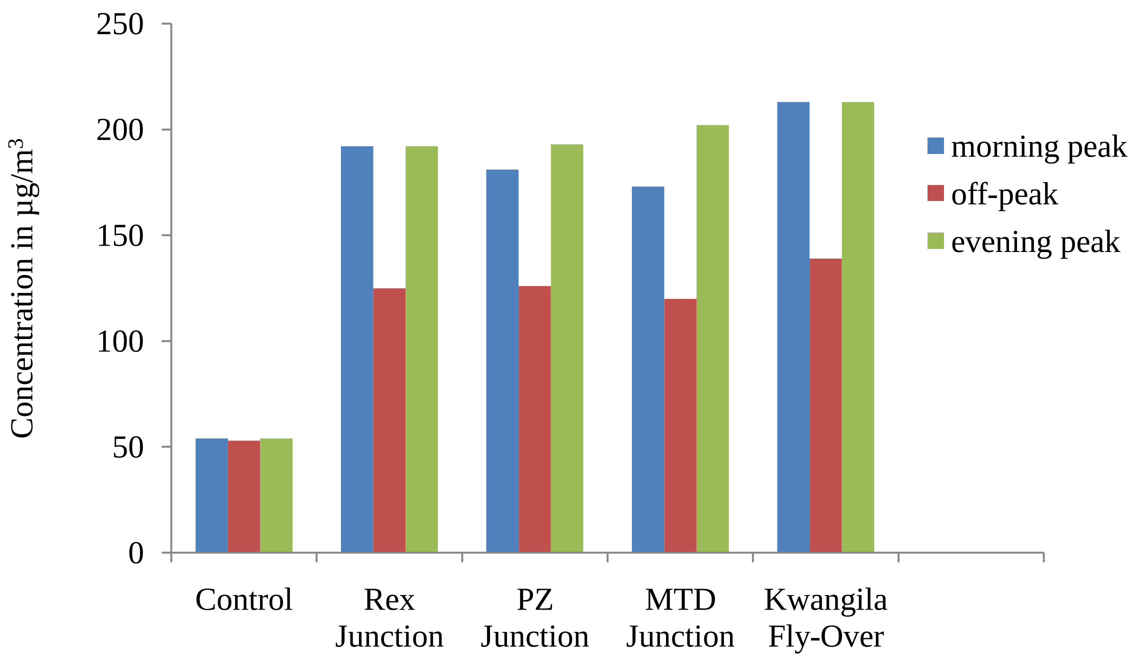

Figure 4.1: Concentration of PM in the Air at all the sites

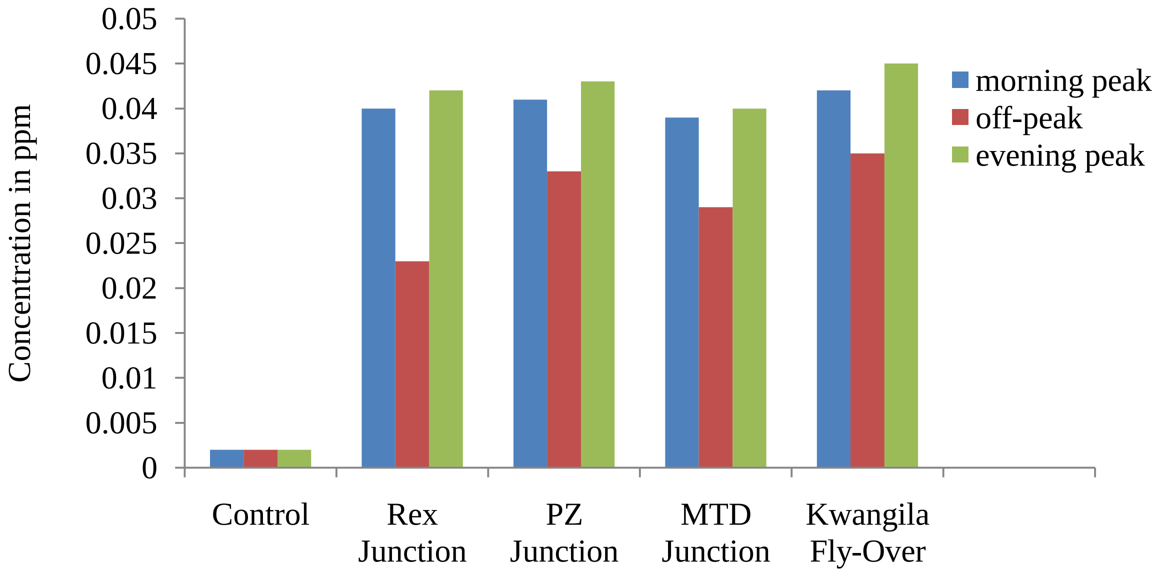

Figure 4.2: Concentration of NO_2 in the Air at all the sites

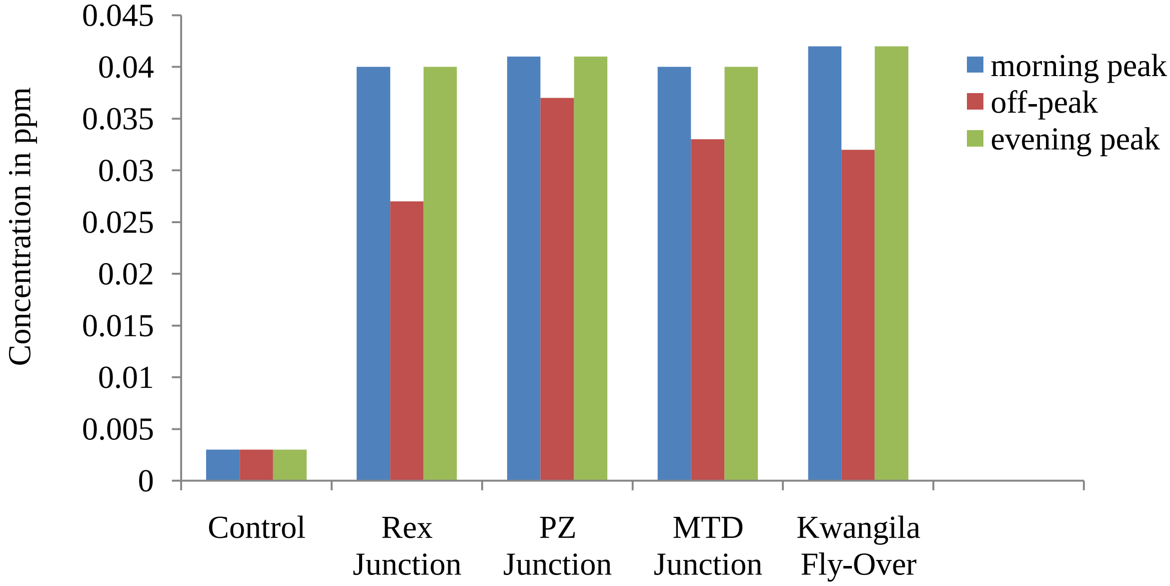

Figure 4.3: Concentration of SO_2 in the Air at all the sites

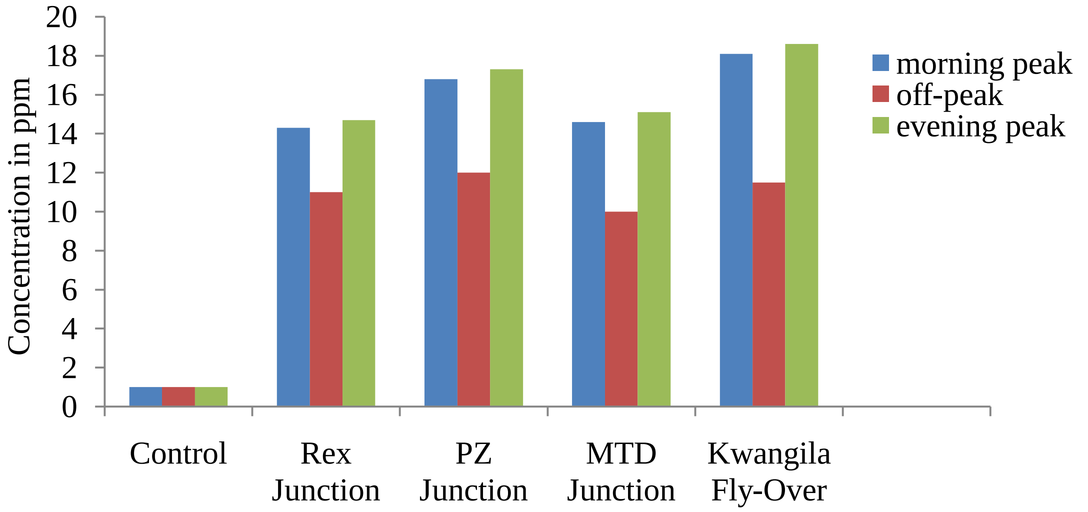

Figure 4.4: Concentration of CO in the Air at all the sites

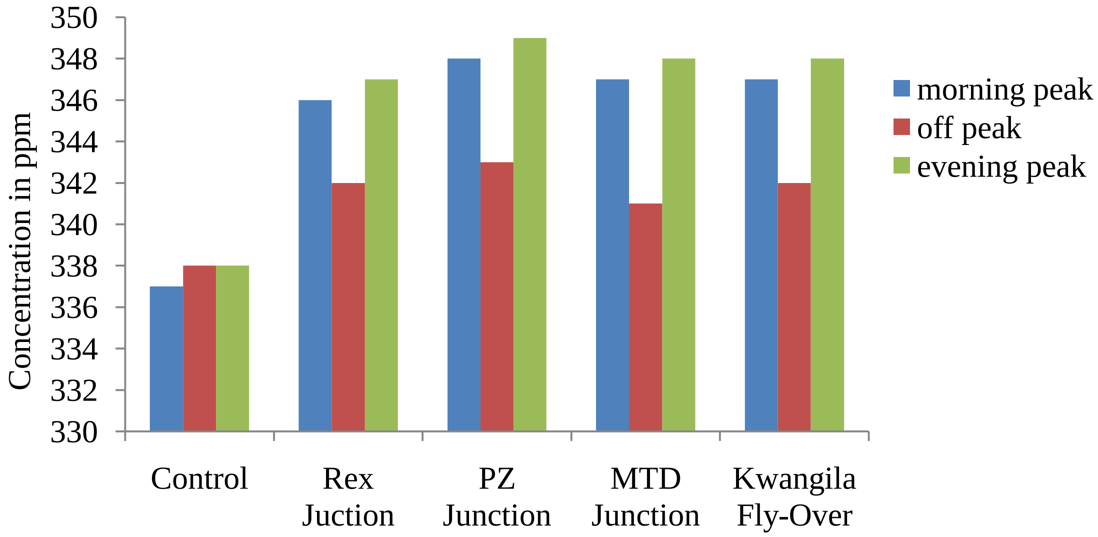

Figure 4.5: Concentration of CO_2 in the Air at all the Sites

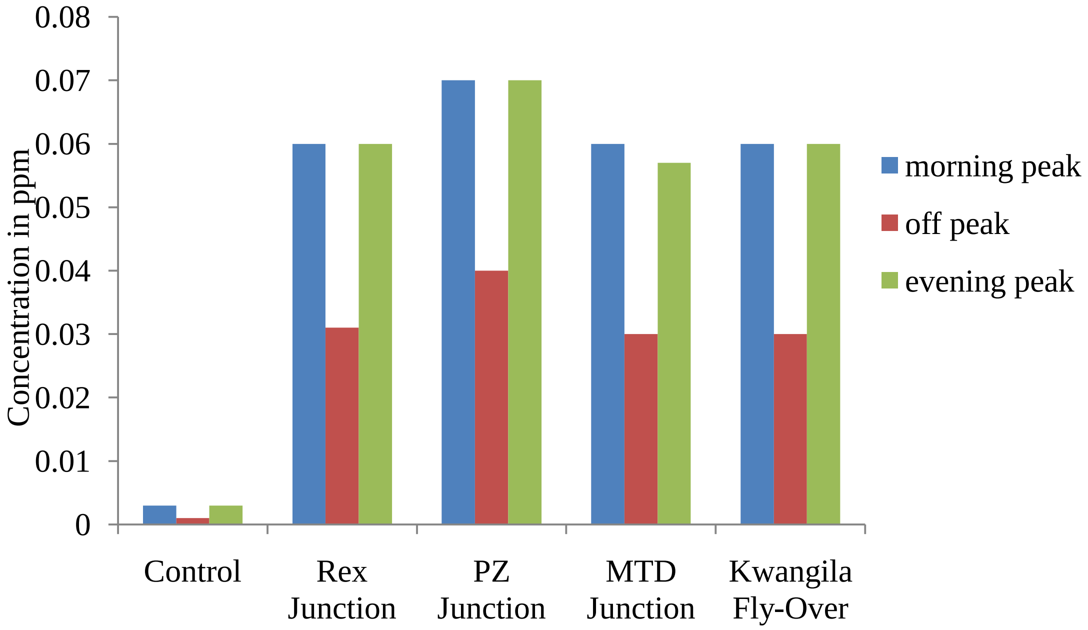

Figure 4.6: Concentration of HCs in the Air at all the Sites

4.2 Traffic Density

The traffic density at every site is expressed in number of vehicle per hour (v/h). It was determined from the traffic count carried out at all the sites as presented in Figure 4.7 – 4.10

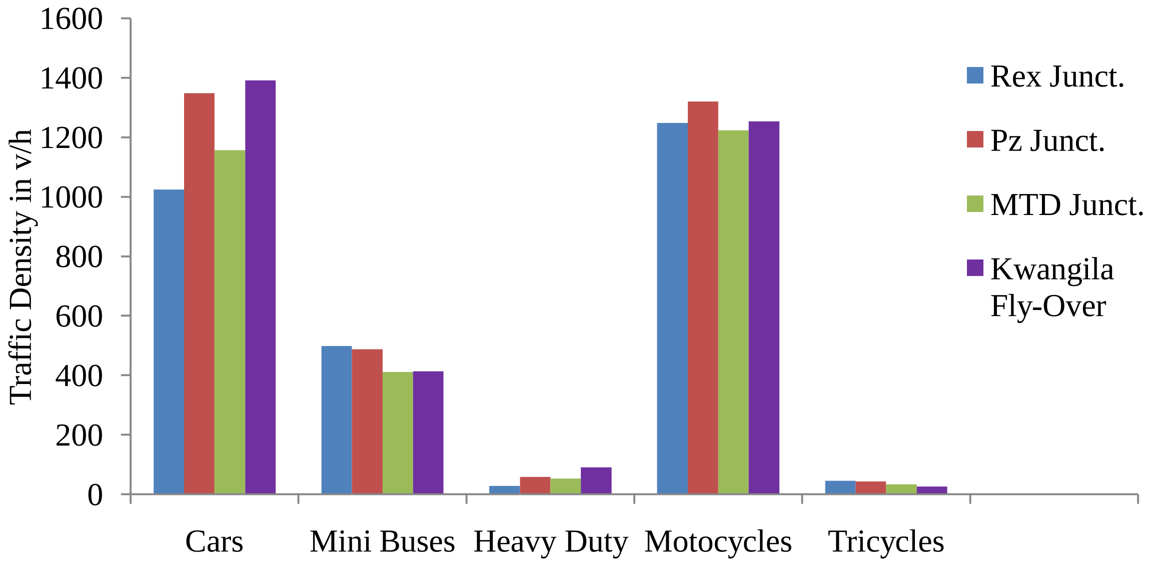

Figure 4.7: Morning Peak Traffic Density in Zaria for each Vehicle

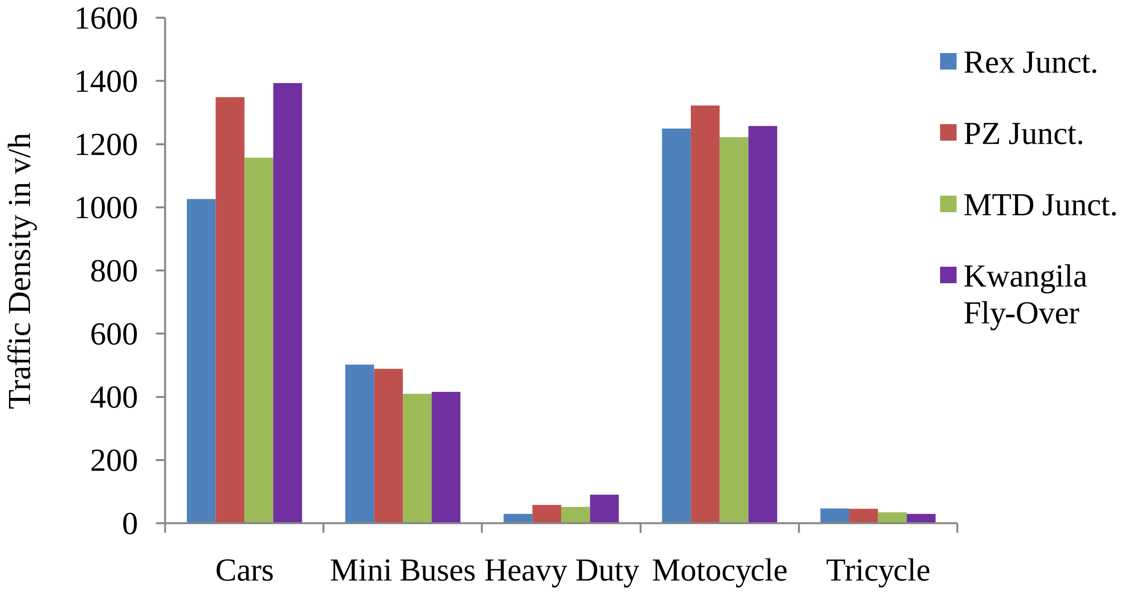

Figure 4.8: Evening Peak Traffic Density in Zaria for each Vehicle

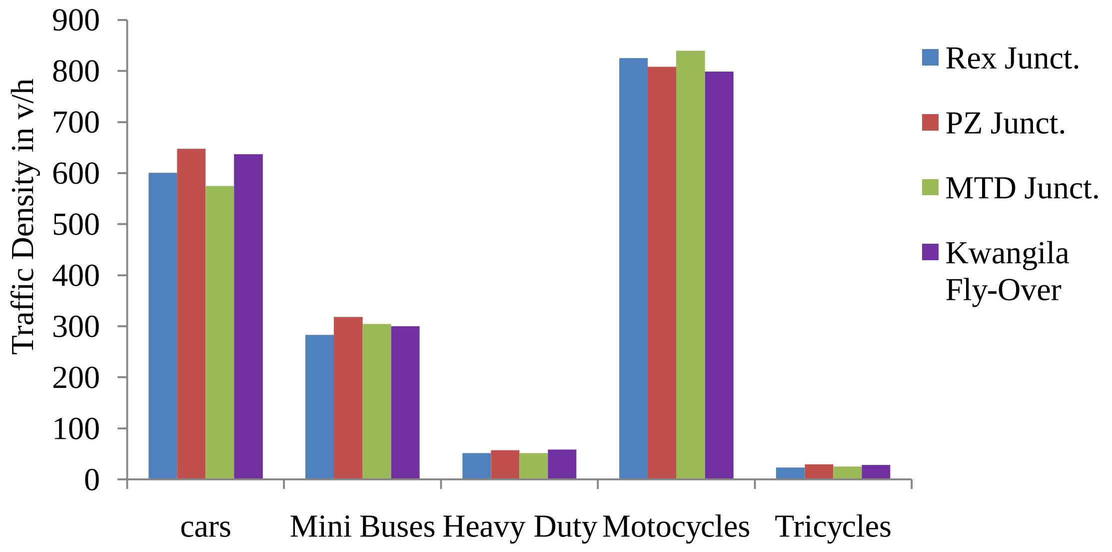

Figure 4.9: Off-Peak Traffic Density in Zaria for each Vehicle

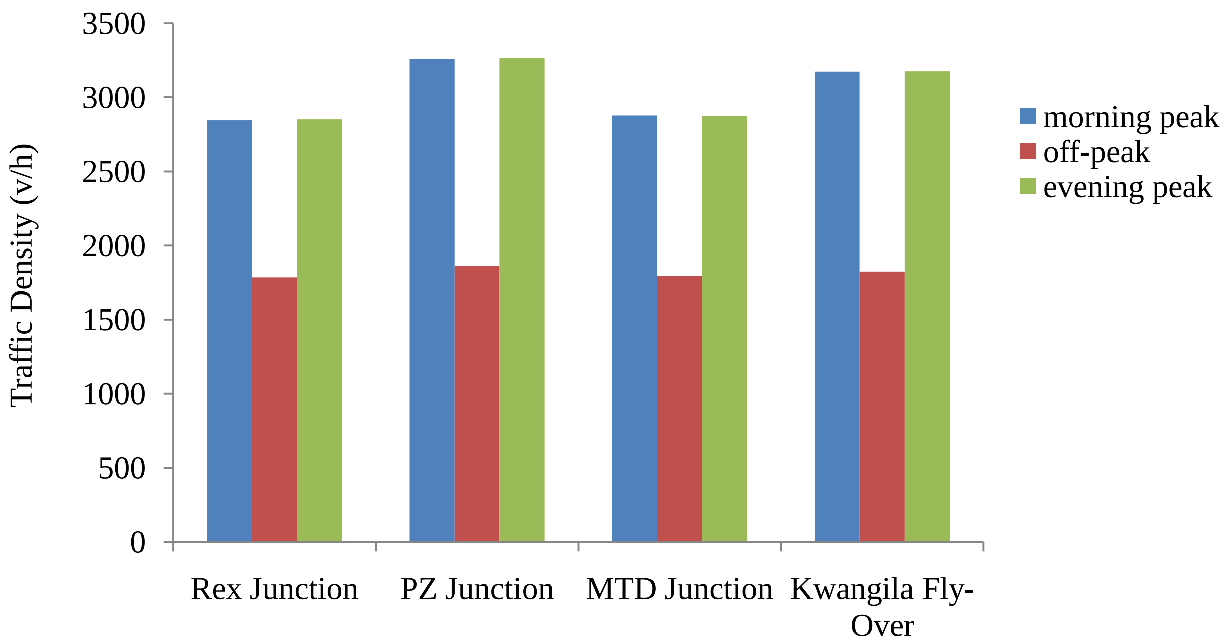

Figure 4.10: Total Average Traffic Density in Zaria at each Experimental Site

4.3 Correlation analysis for Traffic Density with Air Pollutants

The Pearson product momentcorrelation analysis for a relationship between traffic density and air pollutants from vehicular emissions is given in Table 4.1 – 4.3

Table 4.1: Correlation Analysis of Traffic Density with Air Pollutants during Morning Peak Traffic Period

	Traffic Density	PM	NO_2	SO_2	CO	CO_2	HCs
Traffic Density	1						
PM	0.30086	1					
NO_2	0.796165	0.8112	1				
SO_2	0.803946	0.757647	0.94388	1			
CO	0.882205	0.650339	0.924337	0.987513	1		
CO_2	0.818924	-0.25888	0.316228	0.426401	0.562117	1	
HCs	0.722552	-0.33627	0.258199	0.174078	0.312097	0.816497	1

Table 4.2: Correlation Analysis of Traffic Density with Air Pollutants during Off-Peak Traffic Period

	Traffic Density	pm	NO_2	SO_2	CO	CO_2	HCs
Traffic Density	1						
PM	0.302202003	1					
NO_2	0.768523546	0.606348	1				
SO_2	0.864031178	-0.025	0.750479	1			
CO	0.785686352	0.566019	0.479512	0.367773	1		
CO_2	0.776821501	0.302276	0.308607	0.397033	0.956183	1	
HCs	0.835521471	-0.14823	0.298349	0.705091	0.693301	0.840663	1

Table 4.3: Correlation Analysis of Traffic Density with Air Pollutants during Evening Peak Traffic Period

	Traffic Density	PM	NO_2	SO_2	CO	CO_2	HCs
Traffic Density	1						
PM	0.222876	1					
NO_2	0.732509	0.459202	1				
SO_2	0.815781	0.677492	0.919866	1			
CO	0.892324	0.61571	0.871585	0.985225	1		
CO_2	0.805265	0.041812	0.196116	0.426401	0.574875	1	
HCs	0.76509	-0.45688	0.352462	0.291207	0.404527	0.718885	1

4.4 Average Proximate Composition

The average proximate composition for *Amaranthus hybridus* and *Mangifera indica* cultivatedat experimental and control sites is presented in Table 4.4 – 4.5

Table 4.4: Average Proximate Composition of *Amaranthus hybridus*

Site	Proximate Composition (%)					
	Moisture Content	Fat Content	Ash Content	Crude Protein	Crude Fibre	Carbohy-drate
Rex Junction	29.86 ±3.09	3.19 ±0.11	4.10 ±0.37	6.82 ±0.63	4.26 ±1.00	56.09 ±3.81
PZ Junction	30.04 ±3.06	3.20 ±0.11	4.38 ±0.18	6.75 ±0.67	4.14 ±1.00	55.74 ±3.92
MTDJunction	29.41 ±2.50	2.94 ±0.08	4.54 ±0.45	6.75 ±0.54	4.14 ±0.93	56.27±3.46
Kwangila Fly-Over	29.88 ±3.10	3.11 ±0.05	4.68 ±0.35	6.80 ±0.06	4.04 ±1.03	55.47 ± 3.96
Control	30.15 ±3.30	3.14 ±0.20	4.09 ±0.17	6.77 ±0.65	4.44 ±0.80	55.78 ±4.08

Table 4.5: Average Proximate Composition of *Mangifera indica*

Site	Proximate Composition (%)					
	Moisture Content	Fat Content	Ash Content	Crude Protein	Crude Fibre	Carbohy-drate
REX Junction	28.39 ±0.89	2.03 ±0.06	2.41 ±0.04	3.48 ±0.11	5.16 ±0.16	63.70 ±0.95
PZ Junction	27.80 ±0.84	2.16 ±0.15	2.32 ±0.05	3.51 ±0.11	4.89 ±0.18	64.23 ±1.16
MTD Junction	29.31 ±0.17	2.12 ±0.08	2.01 ±0.02	3.51 ±0.18	5.27 ±0.21	63.01 ±0.59
Kwangila Fly-Over	28.66 ±0.06	2.15 ±0.23	2.57 ±0.53	3.50 ±0.14	5.12 ±0.21	63.46 ±0.17
Control	28.14 ±0.89	1.96 ±0.05	2.70 ±0.04	3.42 ±0.13	4.13 ±0.53	63.79 ±0.10

4.5 Comparing the Proximate Composition of *Amaranthus hybridus* to that of *Mangifera indica*

The t- test values for comparism between the proximate compositions of *Amaranthus hybridus* to that of *Mangifera indica* is presented in Table 4.6

Table 4.6:Student's T-Test for Comparing the Proximate Composition of *Amaranthus hybridus* to that of *Mangifera indica* (p = 0.05) for Two – Tail Analysis

Proximate Compositions	T Calculated	T Critical
Moisture Content	3.75	2.78
Fat Content	11.72	,,
Ash Content	10.07	,,
Crude Protein Content	7.25	,,
Crude Fibre Content	- 2.80	,,
Carbohydrate Content	- 26.56	,,

Note: The negative sign indicates that the Mean (X_2) for the Proximate Composition of *Mangifera indica* was numerically higher than that of the *Amaranthus hybridus* (X_1) but the difference may not be statistically Significance.

4.6 Comparing the Mean Proximate Composition at Control to those at Experimental Sites

The t- test values for the comparism between the mean proximate compositionat the control and those at the experimental sites for both*Amaranthus hybridus* and *Mangifera indica* is presented in Table 4.7.

Table 4.7: Student's T-Test for Comparing Proximate Compositions at Experiment Sites to that at Control(p = 0.05) for two – tail analysis

Sites	t-calculated for Proximate Composition of *Amaranthus hybridus*						T Critical
	Moisture	Fat	Ash	Protein	Fibre	Carbohydrate	
Rex Junct.	0.54	- 0.59	- 0.06	- 2.03	0.92	- 0.44	3.18
PZ Junct.	0.23	1.08	- 1.86	0.09	2.25	0.05	,,
MtdJunct.	1.58	1.78	- 1.48	0.29	1.13	- 0.84	,,
Kwangila Flyover	2.67	0.29	- 2.81	- 1.29	1.5	1.79	,,
	t-calculated for Proximate Composition of *Mangifera indica*						T Critical
	Moisture	Fat	Ash	Protein	Fibre	Carbohydrate	
Rex Junct.	- 0.28	- 5.70	7.26	- 1.78	- 4.28	0.10	3.18
PZ Junct.	0.50	- 2.67	10.20	-2.05	- 2.88	- 0.65	,,
MtdJunct.	- 2.90	- 13.85	18.04	- 3.95	- 3.55	1.76	,,
Kwangila Flyover	- 1.09	- 2.27	0.45	- 2.15	- 5.39	0.63	,,

Note: The negative sign indicates that the Mean (X_2) of a particular parameter from study site was numerically higher than that of the control (X_1) but the difference may not be statistically Significance

4.7 Proximate Composition as Age Increases in Weeks

The proximate composition of *Amaranthus hybridus* measured in percentage (%) as age of growth increases in weeks during the six weeks of study for both at experimental and control sites is presented in Figure 4.11.

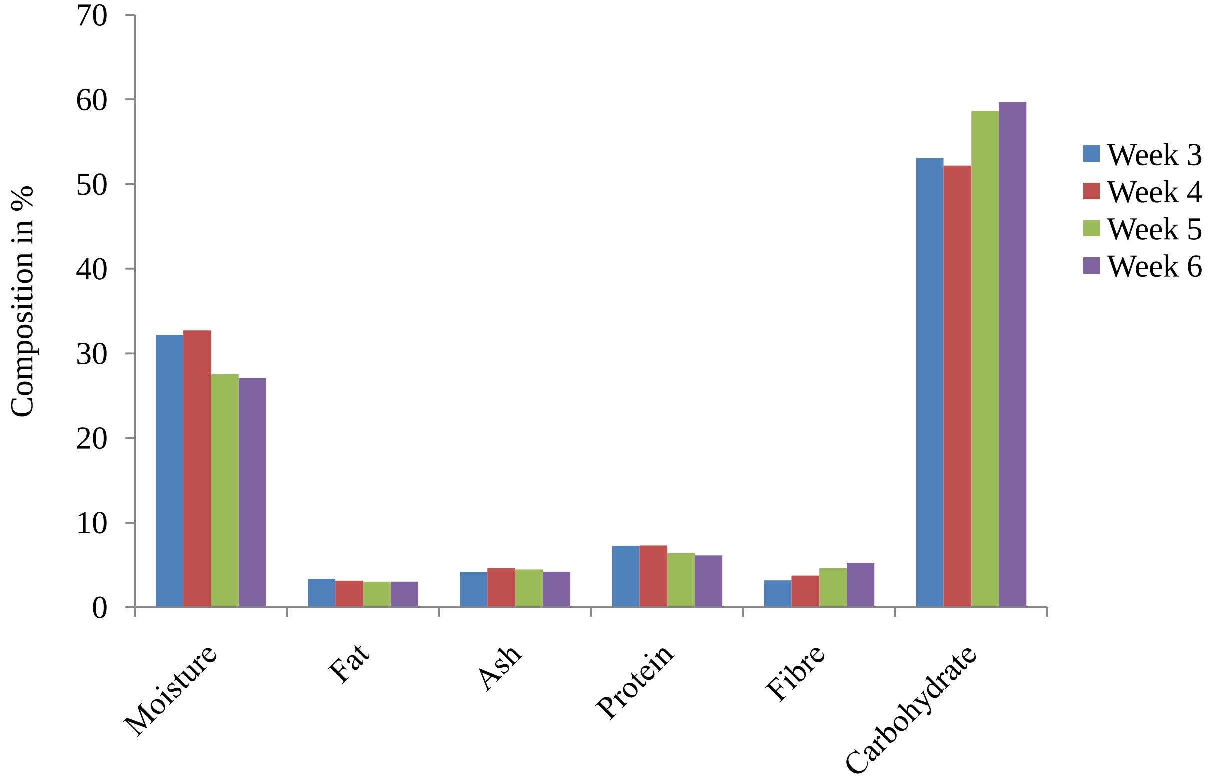

Figure 4.11: Proximate Composition of *Amaranthus hybridus* with Age

4.8: Relationship between Age and Proximate Composition

The Pearson product moment correlation analysis for determining the relationship between proximate composition and age of the Amaranthus hybridus is presented in Table 4.8

Table 4.8: Correlation Analysis of Proximate Composition with Age for *Amaranthus hybridus*

	Age in Weeks	Moisture	Fat	Ash	Protein	Fibre	Carbo-hydrate
Age in Weeks	1						
Moisture	-0.88604224	1					
Fat	-0.92270627	0.758105	1				
Ash	0.006199949	0.217352	-0.38615	1			
Protein	-0.92508579	0.992185	0.778323	0.239561	1		
Fibre	0.9966621	-0.92053	-0.90498	-0.043	-0.95295	1	
Carbohydrate	0.892405743	-0.9984	-0.74635	-0.25715	-0.99635	0.926253	1

4.9 Growth Rate of the *Amaranthus hybridus*

The growth rate of the *Amaranthus hybridus* cultivated at experimental and control sites is presented in Figure 4.12

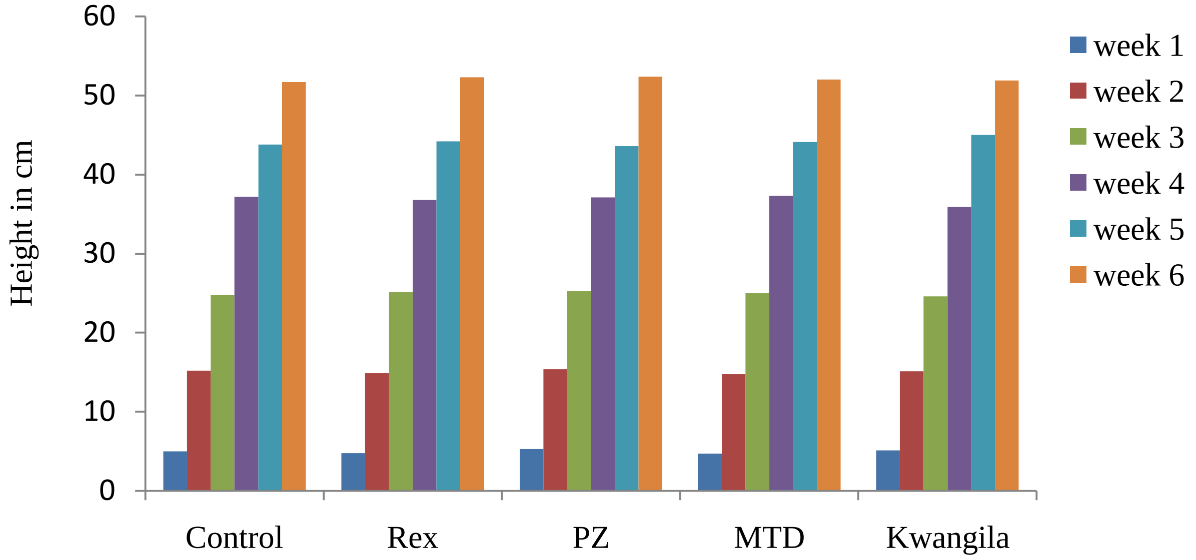

Figure 4. 12: Growth Rate of *Amaranthus hybridus*

4.10: Comparing the Growth Rate at Control with that at Experimental sites for*Amaranthus hybridus*

The t- test values for the comparism between the mean growth rate at the control and those at the experimental sites for *Amaranthus hybridus* is presented in Table 4.9.

Table 4.9: Student' T-Test for Comparing Growth Rate at Control to those at Experimental sites ($p = 0.05$) for two – tail analysis

Sites	t-calculated for Growth Rate of *Amaranthus hybridus*	t- critical
Rex Junct.	- 0.39	2.57
PZ Junct.	- 1.66	,,
MtdJunct.	- 0.27	,,
Kwangila Flyover	0.05	,,

Note: The negative sign indicates that the Mean (X_2) from an experimental site was numerically higher than that of the control (X_1) but the difference may not be statistically Significance.

CHAPTER FIVE

5.0 DISCUSSION

5.1 Impact of Vehicular emission on Air Quality

The air quality parameters measured were particulate matter (PM), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), carbon monoxide (CO), carbon dioxide (CO_2) and hydrocarbons (HCs). They were compared to Nigerian Ambient Air Quality Standard (NAAQS) limit. The relationship between traffic density and the concentration of these pollutants was determined and the impact of these pollutants on proximate composition and growth rate of *Amaranthushybridus* was also determined.

5.1.1 Particulate matter (PM)

As presented in Figure 4.1.The concentrations of PM for morning peak traffic period were 192.000 ± 3.000 $\mu g/m^3$, 181.000 ± 2.000 $\mu g/m^3$, 173.00 ± 2.000 $\mu g/m^3$, 213.000 ± 2.000$\mu g/m^3$ and 54 ± 0.010 $\mu g/m^3$ at Rex Junction, PZ Junction, MTD Junction, Kwangila Fly-Over and Control respectively. The concentrations for evening peak traffic period were 192.000 ± 2.000 $\mu g/m^3$, 193.000 ± 2.000 $\mu g/m^3$, 202.000 ± 2.000 $\mu g/m^3$, 213.000 ± 1.000 $\mu g/m^3$ and 54 ± 0.030 $\mu g/m^3$ for Rex Junction, PZ Junction, MTD Junction , Kwangila Fly-Over and Control respectively. During the off-peak, the concentrations were 125 ± 2.000 $\mu g/m^3$, 126 ± 1.000 $\mu g/m^3$, 120 ± 1.00 $\mu g/m^3$, 139 ± 1.000 $\mu g/m^3$ and 53 ± 0.000 $\mu g/m^3$ for Rex Junction, PZ Junction, MTD Junction Kwangila Fly-Over and control respectively. From the concentrations of PM during peak traffic periods, evening peak concentrations were higher than those of morning peak except at Kwangila Fly-over and Rex Junction where the morning peak and the evening peak had the same concentration value of 213.00 $\mu g/m^3$ and 192 $\mu g/m^3$ respectively as presented in Figure 4.1. This could be attributed to residual accumulation of PM from morning and afternoon. The concentrations at the control site were the same for both morning and evening peak period and the value was 54.000$\mu g/m^3$

It was also discovered that the concentrations of PM were higher during peak traffics than during off-peak as the value of 139.000 ± 1.000 $\mu g/m^3$ at Kwangila Fly-Over was the highest concentration during the off-peak. This is further evidence that high traffic density can lead to high level of PM in the air. The high level of PM at Kwangila Fly-Over compared to every other experimental site could be as a result of the high traffic density of 90.33 vehicles per hour (v/h) for heavy duty vehicles at this point during morning and evening peak periods as presented in Figure 4.7 – 4.9. This is in agreement with Sawyer (2010).

These concentration values for PM were all lower than the 250 $\mu g/m^3$ minimum Daily Average Standard Limit established by NAAQS. The concentrations were higher at all the experimental sites which were exposed to vehicular emissions than at the control site showing that vehicular emission have contributed to the high concentration of PM in the air of Zaria.

5.1.2 Nitrogen dioxide (NO_2)

As presented in Figure 4.2. The concentrations of NO_2 during morning peak traffic period were 0.040 ± 0.010 ppm, 0.041 ± 0.001ppm, 0.039 ± 0.003 ppm, 0.042 ± 0.004ppm and 0.002 ± 0.000 ppm at Rex Junction, PZ Junction, MTD Junction, Kwangila Fly-Over and Control respectively. The concentrations for evening peak traffic period were 00.420 ±0.002 ppm, 0.043 ± 0.000 ppm, 0.040 ± 0.001 ppm, 0.045 ± 0.002 ppm and 0.002 ± 0.000 ppm at Rex Junction, PZ Junction, MTD Junction, Kwangila Fly-Over and Control respectively. During the off-peak, the concentrations were 0.023 ± 0.001ppm, 0.033 ± 0.001ppm, 0.029 ± 0.001 ppm, 0.035 ± 0.001ppm, and 0.002 ± 0.001 ppm at Rex Junction, PZ Junction, MTD Junction Kwangila Fly-Over and Control respectively. These results showed that vehicular emission had contributed to higher values of NO_2 concentration in the air at all the experimental sites when compared to the concentrations at the control where there were no vehicles. All concentrations of NO_2 as presented in Figure 4.2 were all within the standard limit range of 0.04 - 0.06 ppm by NAAQS.

These concentrations were higher during evening peak than morning peak as presented in Figure 4.2; this could be as a result of residual accumulation from morning and afternoon. The highest concentration of 0.045 ± 0.002 ppm for NO_2 was found at Kwangila Fly-Over during evening peak period. This could also be attributed to the higher number of heavy duty vehicles at Kwangila Fly-Over which naturally will emit more NO_2 than light vehicles (Tsai *et al*., 2006; Sawyer, 2010).

5.1.3 Sulphur dioxide (SO_2)

As presented in Figure 4.3. The concentrations of SO_2 during morning peak traffic period were 0.040 ± 0.010 ppm, 0.041 ± 0.000ppm, 0.040 ± 0.000 ppm, 0.042 ± 0.001 and 0.003 ± 0.001 ppm at Rex Junction, PZ Junction, MTD Junction, Kwangila Fly-Over and Control respectively. The concentrations for evening peak traffic period were 0.040 ±0.001 ppm, 0.041 ± 0.000 ppm, 0.040 ± 0.002 ppm, 0.042 ± 0.002 ppm and 0.003 ± 0.001 ppm at Rex Junction, PZ Junction, MTD Junction, Kwangila Fly-Over and Control respectively. During the off-peak, the concentrations were 0.027 ± 0.001ppm, 0.037 ± 0.001ppm, 0.033 ± 0.000 ppm, 0.032 ± 0.002ppm, and 0.003 ± 0.002 ppm at Rex Junction, PZ Junction, MTD Junction Kwangila Fly-Over and Control respectively. Unlike other pollutants, the concentrations of SO_2 during evening peak traffic period were not higher than the concentrations obtained during morning peak traffic.

SO_2 concentrations during peak traffic periods at all experimental sites were all within the 0.01 – 0.1 ppm standard range limit by NAAQS while the concentrations at the control were below this standard range. The average concentration range of 0.040 – 0.042 ppm measured at experimental sites during peak traffic periods is better compared to the 0.04 – 0.15 ppm range reported by Abam and Unachukwu (2009) and since this range of 0.040 – 0.042 ppm is within the NAAQS limit range of 0.01 – 0.1 ppm, it is safe to the environment.

From the above results, the concentrations of SO_2 in the air of Zaria metropolis at all experimental sites were higher than those at the control where there were no vehicles showing that vehicular emissions can increase the concentration of SO_2 in the air of Zaria. The peak traffic periods concentrations during morning and evening peaks at all the experimental sites were higher than the concentrations at off-peak period and also higher than the concentration of 0.003ppm at the control showing that the concentration of SO_2 in Zaria can increase with increase in number of vehicles.

5.1.4 Carbon monoxide (CO)

As presented in Figure 4.4. The concentrations of CO during morning peak traffic period were 14.300 ± 0.300 ppm, 16.800 ± 0.100 ppm, 14.600 ± 0.400 ppm 18.100 ± 0.200 ppm and 1.000 ± 0.001 ppm at Rex Junction, PZ Junction, MTD Junction, Kwangila Fly-Over and Control respectively. During the evening peak traffic period, the concentrations were 14.700 ± 0.200 ppm, 17.300 ± 0.300 ppm, 15.100 ± 0.100 ppm, 18.600 ± 0.100 ppm and 1.000 ± 0.500 ppm at Rex Junction, PZ Junction, MTD Junction, Kwangila Fly-Over

Control respectively. For the off-peak period, the concentrations were 11.000 ± 0.500 ppm, 12.000 ± 0.500 ppm, 10.000 ± 0.500 ppm, 11.500 ± 0.500 ppm and 1.000 ± 0.010 ppm at Rex Junction, PZ Junction, MTD Junction, Kwangila Fly-Over and Control respectively. From these results, the concentrations of CO during evening peak were higher than those obtained during morning peak at all the experimental sites, this could also be as a result of residual accumulation from morning and afternoon. The peak period concentrations of CO at all experimental sites were higher than those obtained during off-peak and the concentrations at all experimental site were higher than those at the control where there were no vehicles, this showed that vehicular emission could increase the concentrations of these pollutants in the air of Zaria.

All the concentrations of CO at all experimental sites were within the NAAQS limit range of 10 – 20 ppm although higher than the 1.25 – 4.00 ppm range reported for Tse-Kucha community of Benue State of Nigeria by Abdulkarim*et al*., (2007). The concentrations of 1.000 ppm for CO at the control were far lower than the NAAQS limit range of 10 – 20 ppm.

5.1.5 Carbon dioxide (CO_2)

As presented in Figure 4.5.The concentrations of CO_2 during morning peak traffic period were 346.000 ± 2.100 ppm, 348.000 ± 2.000 ppm, 347.000 ± 2.00 ppm, 347.000 ± 0.200 ppm and 337.000 ± 2.000 ppm at Rex Junction, PZ Junction, MTD Junction, Kwangila Fly-Over and Control respectively. During the evening peak traffic period, the concentrations were 347.000 ± 2.000 ppm, 349.000 ± 1.000 ppm, 348.000 ± 0.000 ppm, 348.000 ± 2.650 ppm and 338.000 ± 1.000 ppm at Rex Junction, PZ Junction, MTD

Junction, Kwangila Fly-Over and Control respectively. For the off-peak period, the concentrations were 342 ± 0.000 ppm, 343.000 ± 1.000 ppm, 341.000 ± 1.000 ppm, 342.000 ± 1.000 ppm and 338.000 ± 2.000 at Rex Junction, PZ Junction, MTD Junction, Kwangila Fly-Over and Control respectively.These concentration values for CO_2 are very high compared to that of CO, this could be as a result of the fact that CO is rapidly oxidised to CO_2 as it is emitted by vehicles into the atmosphere (Abdulkarim*et al*., 2007; Wallington *et al*., 2008).

The concentrations of CO_2 at all the experimental sites and the control site were all below the NAAQS limit of 600 ppm. The evening peak concentration values of 347.00 ± 2.000 ppm, 349.000 ± 1.000 ppm, 348.000 ± 0.000 ppm, 348.000 ± 2.6500 ppm and 338.000 ± 1.000 at Rex Junction, PZ Junction, MTD Junction, Kwangila Fly-Over and Control respectively were slightly higher than the morning peak concentrations of 346.000 ± 2.100 ppm, 348.000 ± 2.000 ppm, 347.00 ± 2.000 ppm and 347.000 ± 2.000 ppm and 337.000 ± 2.000 at Rex Junction, PZ Junction, MTD Junction, Kwangila Fly-Over and Control respectively and this again could be attributed to residual accumulation.

From the result above, the concentrations of CO_2 during peak period were all higher than during the off-peak period as presented in Figure 4.5, also the concentrations at all the experimental sites were higher than those at the control site which had the highest concentration of 338 ppm showing that vehicle emissions can increase CO_2 concentration in the air of Zaria.

5.1.6 Hydrocarbons (HCs)

As presented in Figure 4.6. The concentrations of HCs during morning peak traffic period were 0.060 ± 0.010 ppm, 0.070 ± 0.005 ppm, 0.060 ± 0.003 ppm, 0.060 ± 0.000 and 0.003 ± 0.001 ppm at Rex Junction, PZ Junction, MTD Junction, Kwangila Fly-Over and Control respectively. The concentrations for evening peak traffic period were 0.060 ±0.020 ppm, 0.070 ± 0.010 ppm, 0.057 ± 0.001 ppm, 0.060 ± 0.001 ppm and 0.003 ± 0.000 ppm for Rex Junction, PZ Junction, MTD Junction, Kwangila Fly-Over and Control respectively. During the off-peak, the concentrations were 0.031 ± 0.000 ppm, 0.040 ± 0.001ppm, 0.030 ± 0.000 ppm, 0.001 ± 0.000 ppm, and 0.003 ± 0.002 ppm for Rex Junction, PZ Junction, MTD Junction Kwangila Fly-Over and Control respectively. The concentrations of HCs during evening peak traffic were not higher than those obtained during morning peak traffic period as in the case of SO_2.

The concentrations of HCs during peak traffic periods at all experimental sites were higher than the NAAQS limit of 0.05 ppm while the concentrations during off-peak period at all experimental sites were below the 0.05 ppm NAAQS limit.

5.2 Traffic Density

Traffic density at each of the experimental sites was determined by traffic count and it is expressed in number of vehicles per hour (v/h). The class of vehicles considered were cars, mini-buses, heavy-duty vehicles (big buses, lorries and trailers), motorcycles and tricycles.

5.2.1 Traffic count for individual class of vehicles

During morning peak traffic period as presented in Figure 4.7, the traffic count for individual class of vehicles at Rex Junction were 1024.67 ± 4.73 v/h, 498.33 ± 8.50 v/h, 28.33 ± 2.52 v/h, 1248.67 ± 9.29 v/h and 45.33 ± 3.06 v/h for cars, minibuses, heavy-duty vehicles, motorcycles and tricycles respectively; At PZ Junction, the traffic count were 1348.00 ± 3.61 v/h, 487.67 ± 1.53 v/h, 57.67 ± 2.08 v/h 1320.67 ± 1.53 v/h and 43.33 ± 1.53 v/h for cars, minibuses, heavy-duty vehicles, motorcycles and tricycles respectively; At MTD Junction, the traffic count were 1156.67 ± 12.90 v/h, 411.00 ± 6.93 v/h, 52.67 ± 3.66 v/h, 1223.00 ± 4.36 v/h and 33.67 ± 153 v/h for cars, minibuses, heavy-duty vehicles, motorcycles and tricycles respectively; At Kwangila Fly-Over, the traffic count were 1391.33 ± 7.31 v/h, 413.00 ± 6.08 v/h, 90.33 ± 3.79 v/h, 1254.00 ± 1.00 v/h and 25.67 ± 0.58 v/h for cars, minibuses, heavy-duty vehicles, motorcycles and tricycles respectively.

During the evening peak traffic period as presented in Figure 4.8, the traffic count for individual class of vehicles at Rex Junction were 1025.67 ± 4.73 v/h, 502.00 ± 6.08 v/h, 29.00 ± 2.00 h/v, 1249.00 ± 9.29 v/h and 46.67 ± 2.52 v/h for cars, minibuses, heavy-duty vehicles, motorcycles and tricycles respectively; At PZ Junction, the traffic count were 1349.00 ± 3.79 v/h, 488.67 ± 3.21 v/h, 57.33 ± 4.16 v/h, 1322.67 ± 1.53 v/h and 46.00 ± 3.6 v/h for cars, minibuses, heavy-duty vehicles, motorcycles and tricycles respectively; At MTD Junction, the traffic count were 1157.00 ± 12.49 v/h, 410.33 ± 6.03 v/h, 51.67 ± 3.06 v/h, 1222.00 ± 7.00 v/h and 34.67 ± 1.53 v/h for cars, minibuses, heavy-duty vehicles, motorcycles and tricycles respectively; At Kwangila Fly-Over, the traffic count were 1393.00 ± 7.21 v/h, 415.67 ± 6.66 v/h, 90.33 ± 5.69 v/h, 1257.33 ±

1.15 v/h and 29.00 ± 2.00 v/h for cars, minibuses, heavy-duty vehicles, motorcycles and tricycles respectively.

During the off-peak as presented in Figure 4.9, the traffic count for individual class of vehicles at Rex Junction were 600.67 ± 5.03 v/h, 283.33 ± 2.08 v/h, 51.33 ± 1.53 v/h, 825.33 ± 6.11 v/h and 23.00 ± 1.00 v/h for cars, minibuses, heavy-duty vehicles, motorcycles and tricycles respectively; At PZ Junction, the traffic count were, 648.00 ± 5.57 v/h, 318 ± 7.02 v/h, 57 ± 2.00 v/h, 808.67 ± 7.57 v/h and 29.33 ± 2.08 v/h for cars, minibuses, heavy-duty vehicles, motorcycles and tricycles respectively; At MTD Junction, the traffic count were 574.00 ± 11.5 v/h, 304.67 ± 4.7 v/h, 51.33 ± 3.05 v/h, 839.67 ± 2.25 v/h and 25.33 ± 1.53 v/h for cars, minibuses, heavy-duty vehicles, motorcycles and tricycles respectively; At Kwangila Fly-Over, the traffic count were 637 ± 9.85 v/h, 300.00 ± 6.08 v/h, 58.66 ± 1.53 v/h, 799.00 ± 10.82 v/h and 28.33 ± 2.08 v/h for cars, minibuses, heavy-duty vehicles, motorcycles and tricycles respectively.

5.2.2Total Average traffic density at each experimental site

The average traffic density at each of the experimental sites during morning peak traffic period were 2845.33 ± 4.16 v/h, 3257.33 ± 0.58 v/h, 2877 ± 19.29 v/h and 3174.33 ± 15.89 v/h at Rex Junction, PZ Junction, MTD Junction and Kwangila Fly-Over respectively as presented in Figure 4.10. During the off-peak traffic period, the average traffic density were 1783.67 ± 7.05 v/h, 1861.33 ± 61.5 v/h, 1795.67 ± 10.26 v/h and 1823.67 ± 17.24 v/h at Rex Junction, PZ Junction, MTD Junction and Kwangila Fly-Over respectively as presented in Figure 4.10 while during the evening peak traffic period, the average traffic density were 2852.34 ± 4.58 v/h, 3264.00 ± 1.73 v/h, 2875.67

± 20.2 v/h and 3175.22 ± 26.08 v/h at Rex Junction, PZ Junction, MTD Junction and Kwangila Fly-Over respectively as presented in Figure 4.10. From these results, PZ Junction had the highest traffic density of 3257.33 ± 0.58 v/h, 3264.00 ± 1.73 v/h and 1861.33 ± 16 v/h at morning peak, off-peak and evening peak periods respectively. This could be as a result that PZ Junction is centrally located and with much commercial activities like small and medium scale businesses, banks, government establishments and many others.

5.3 Impact of Traffic Density on Air Pollutants Concentration

The impact of traffic density on the concentration of pollutants from vehicular emissions was determined using the Pearson Product Moment correlation Statistical tool to find out the strength of relationship between traffic density and the concentration of each of the pollutants in the air of Zaria. To achieve this, the coefficient of correlation (r) for the relation between traffic density and concentration of each of the pollutants from vehicular emissions was determined. Particulate matter showed a low correlation that was not significant at $r = 0.30$ during morning peak traffic period as presented in Table 4.1. Other pollutants correlated strongly with traffic density at $r = 0.80$, 0.80, 0.88, 0.82 and 0.72 for NO_2, SO_2, CO, CO_2 and hydrocarbon respectively during morning peak period. During the traffic off-peak period, Particulate matter again showed a low correlation with traffic density at $r = 0.3$ as presented in Table 4.2, other pollutants exhibited high positive correlation with traffic density at $r = 0.77$, 0.86, 0.79, 0.78 and 0.84 for NO_2, SO_2, CO, CO_2 and hydrocarbon respectively. During the evening peak traffic period, particulate matter also showed a low positive correlation with traffic density at $r = 0.22$ as presented in Table 4.3 while other pollutants showed high positive correlation at r = 0.73, 0.82, 0.89, 0.81 and 0.77 for NO_2, SO_2, CO, CO_2 and hydrocarbon respectively.

The positive correlation agrees with Wallington *et al*., (2008) that increase in traffic density can increase the air pollutants load resulting from vehicular emissions. The low correlation of particulate matter with traffic density at all peak traffic periods could be attributed to the fact that apart from traffic density, other factors like speed, engine condition, age of vehicle, vehicle technology among others could influence the concentration of pollutants coming out from the tail pipe (Tsunokowa and Hobban, 1997; Abbaspour and Soltaninejad, 2004)

5.4 Proximate composition

The proximate composition determined were moisture content, fat content, ash content, crude protein content, crude fibre content and carbohydrate content. These were determined for *Amaranthus hybridus* and *Mangifera indica* as presented in Table 4.4 and 4.5 respectively.

5.4.1 Proximate composition of *Amaranthus hybridus*

The values of moisture content for *Amaranthus hybridus* aspresented in Table 4.4 were29.86 ± 3.09 %, 30.04 ± 3.06 %, 29.14 ± 2.50 % , 29.88 ± 3.10 % and 30.15 ± 3.30 % at Rex Junction, PZ Junction, MTD Junction, Kwangila Fly-Over and the control respectively. For the fat content, the values were 3.19 ± 0.11 %, 3.20 ± 0.11 %, 2.94 ± 0.08 %, 3.11 ± 0.05 % and 3.14 ± 0.20 % at Rex Junction, PZ Junction, MTD Junction, Kwangila Fly-Over and the control respectively. For the ash content, the values were

4.10 ± 0.37 %, 4.38 ± 0.18 %, 4.54 ± 0.45 %, 4.68 ± 0.35 % and 4.09 ± 0.17 %, at Rex Junction, PZ Junction, MTD Junction, Kwangila Fly-Over and the Control respectively. For the crude protein content, the values were 6.82 ± 0.63 %, 6.75 ± 0.67 %, 6.75 ± 0.54 %, 6.80 ± 0.06 % and 6.77 ± 0.65 %, at Rex Junction, PZ Junction, MTD Junction, Kwangila Fly-Over and the Control respectively. For crude fibre content, the values were 4.26 ± 1.00 %, 4.14 ± 1.00 %, 4.14 ± 0.93 %, 4.04 ± 1.03 % and 4.44 ± 0.80 %, at Rex Junction, PZ Junction, MTD Junction Kwangila Fly-Over and the Control respectively while for the carbohydrate content, the values were 56.09 ± 3.81 %, 55.74 ± 3.92 %, 56.27 ± 3.46, 55.47 ± 3.96 % and 55.78 ± 4.08 %, at Rex Junction, PZ Junction, MTD Junction, Kwangila Fly-Over and the Control respectively.

From the results, the values of proximate composition of some nutrients in the *Amaranthus hybridus* were higher at the experimental sites exposed to vehicular emissions than at the Control site. for instance, the values of 3.19 ± 0.11 % and 3.20 ± 0.11 % at Rex Junction and PZ Junction respectively were higher than the 3.14 ±0.20 % at the Control for fat content; the values of 4.10 ± 0.37 %, 4.38 ± 0.18 %, 4.54 ± 0.45 %, 4.68 ± 0.35 % at Rex Junction, PZ Junction, MTD Junction and Kwangila Fly-Over respectively were higher than the 4.09 ± 0.17 % at the Control for ash content; the values of 6.82 ± 0.63 % and 6.80 ± 0.06 % at Rex Junction and Kwangila Fly-Over respectively were higher than the 6.77 ± 0.65 % at the Control for crude protein content while the values of 56.09 ± 3.81 % and 56.27 ± 3.46 % a at Rex Junction and MTD Junction respectively were higher than the 55.78 ± 4.08 % at the Control for carbohydrate content. This suggested that vehicular emissions in Zaria did not reach the level that could cause a remarkable negative impact on the proximate composition of *Amaranthus hybridus* cultivated on the road side although the air pollutants at all the experimental sites were really higher than at the Control site.

The values for crude fibre content, fat content, ash content and crude protein content at all the sites for *Amaranthus hybridus* were respectively lower than the 30.55 %, 9.45 %, 7.78 % and 32.38 % reported for *Mucunapoggei* by Oko*et al*., (2012) but the values for carbohydrate content and moisture content for *Amaranthus hybridus* were respectively lower than the 11.55 % and 8.25 % as also reported for *Mucunapoggei* by Oko*et al*., (2012).

The values for ash content, fat content, crude fibre and crude protein content at all the sites for *Amaranthus hybridus* were respectively lower than the 13.80 %, 4.65 %, 8.61 % and 17.92 % reported by Akubugwo*et al*., (2007). This lower nutrient content of roadside *Amaranthus hybridus* in Zaria could be attributed to other environmental factors like soil type since the vehicular missions did not have a significant impact on the roadside *Amaranthus hybridus* proximate composition when compared to the proximate composition of the ones cultivated at the Control during the study. The values for carbohydrate content at all the sites were higher than the 52.18 % as also reported by Akubugwo*et al*. (2007) for *Amaranthus hybridus.* The value range of 4.09 – 4.68 %, 2.94 – 3.20 %, 4.04 – 4.44 % and 6.75 – 6.82 % for ash content, fat content, crude fibre and crude protein were respectively lower than the 15.55 %, 14.02 %, 8.05 % and 49.09 % reported by Asaolu*et al*., (2012). The value range of 29.41 – 30.15 % and 55.47 – 55.76 % for moisture content and carbohydrate were respectively higher than the 10 % and 3.36 % as also reported by Asaolu*et al*., (2012).

5.4.2 Proximate composition of *Mangifera indica*

The values of moisture content for *Mangiferaindica*as presented in Table 4.5were 28.39 ± 0.89 %, 27.80 ± 0.84 %, 29.31 ± 0.17 %, 28.66 ± 0.06 % and 28.14 ± 0.89 %, at Rex Junction, PZ Junction, MTD Junction, Kwangila Fly-Over and Control respectively. For the fat content, the values were 2.03 ± 0.06 %, 2.16 ± 0.15 %, 2.12 ± 0.08 %, 2.15 ± 0.23 % and 1.96 ± 0.05 %, at Rex Junction, PZ Junction, MTD Junction, Kwangila Fly-Over and Control respectively. For ash content, the values were 2.41 ± 0.04 %, 2.32 ± 0.05 %, 2.01 ± 0.02 %, 2.57 ± 0.53 % and 2.70 ± 0.04 %, at the Rex Junction, PZ Junction, MTD Junction, Kwangila Fly-Over and the Control respectively. For the crude protein content, the values were 3.48 ± 0.11 %, 3.51 ± 0.11 %, 3.51 ± 0.18 %, 3.50 ± 0.14 % and 3.42 ± 0.13 % at Rex Junction, PZ Junction, MTD Junction, Kwangila Fly-Over and Control respectively. For crude fibre content, the values were 5.16 ± 0.16 %, 4.89 ± 0.18 %, 5.27 ± 0.21 %, 5.12 ± 0.21 % and 4,13 ± 0.53 % at Control, Rex Junction, PZ Junction, MTD Junction, Kwangila Fly-Over respectively and Control while for the carbohydrate content, the values were 63.70 ± 0.95 %, 64.23 ± 1.16 %, 63.01 ± 0.59 %, 63.46 ± 0.17 % 63.79 ± 0.10 %, at Rex Junction, PZ Junction, MTD Junction Kwangila Fly-Over and Control respectively.

From the values of the proximate composition presented above, it can also be seen that some values of proximate compositions of *Mangifera indica* were even higher in some experimental sites than the control which is not exposed to vehicular emissions. For instance, the values of 28.39 ± 0.89 %, 27.80 ± 0.84 %, 29.31 ± 0.17 % and 28.66 ± 0.06 % at Rex Junction, PZ Junction, MTD Junction and Kwangila Fly-Over respectively were higher than the 28.14 ±0.89 % at the control for moisture content; the values of 2.03 ± 0.06 %, 2.16 ± 0.15 %, 2.12 ± 0.08 %, and 2.15 ± 0.23 % at Rex Junction, PZ

Junction, MTD Junction and Kwangila Fly-Over respectively where higher than the 1.96 ± 0.05 % at the control for fat content; the values of 3.48 ± 0.11 %, 3.51 ± 0.11 %, 3.51 ± 0.18 % and 3.50 ± 0.14 at Rex Junction, PZ Junction, MTD Junction and Kwangila Fly-Over respectively were higher than the 3.42 ± 0.13 % at the control for crude protein content while the values of 5.16 ± 0.16 %, 4.89 ± 0.18 % and 5.27 ± 0.21 % at Rex Junction, PZ Junction, MTD Junction respectively where higher than the 4.13 ± 0.53 % at the control for crude fibre content. This suggests that most nutrients were not affected by vehicular emissions when compared to those at the control sites.

The values for the moisture content at every site (28.39 ± 0.89 %, 27.80 ± 0.84 %, 29.31 ± 0.17 % 28.66 ± 0.06 % and 28.14 ± 0.89 %, for Rex Junction, PZ Junction, MTD Junction, Kwangila Fly-Over and control respectively) were all lower than the 52.03 % reported for *Mangifera indica* by Chauhan (2010) despite the fact that there was no significance effect on moisture content in *Mangifera indica* associated with vehicular emissions in Zaria as that of the Dehradun city as reported by Chauhan, this showed that apart from vehicular emissions, other factors can affect the moisture content of *Mangifera indica* in Zaria. The values for crude protein and ash content at all the sites were respectively lower than the 20.38 % and 10.00 % reported for *Mangifera indica* by Ajayi*et al*., (2005) in a research that was conducted in Ibadan, while the values for fat content and carbohydrate content at all the sites were respectively higher than the 0.48 % and 57.69 % as also reported by Ajayi*et al*., (2005), these could be as a result of differences in other environmental factors like soil composition and temperature between Zaria and Ibadan.

5.5 Proximate Composition of *Amaranthus hybridus* compared to that of *Mangifera indica*

From the result of the proximate composition of *Amaranthus hybridus* and *Mangiferaindica* presented above in sub-sections 5.4.1 and 5.4.2 of this chapter, there were differences in the average proximate composition of the two plants as they are not of the same species coupled with the fact the *Mangiferaindica* have been on the road side for quite a long time than the *Amaranthus hybridus* and more so, they may not have the same Plant Concentration Factor (PCF) which influences the accumulation and absorption of air pollutants by a particular plant (Iqbal and Mahmood, 1992).

The t-test statistical tool was used to determine whether there is a significant difference between the amounts of the proximate composition of the two plants. The value for the t-calculated when the proximate composition of the two plants were compared were 3.75, 11.72, 10.07, 7.25, - 2.80 and -26.56 as presented in Table 4.6 for moisture content, fat content, ash content, crude protein content, crude fibre content and carbohydrate content respectively. All the values for t- calculated were higher than the 2.78 value of the t-critical for two tail analysis. This showed that the difference in the proximate composition of the two plants were statistically significant.

Moisture content, fat content, ash content and crude protein of *Amaranthus hybridus* were significantly higher ($p = 0.05$) than those contained in the *Mangifera indica* while crude fibre and carbohydrate content of the *Mangifera indica* were significantly higher ($p = 0.05$) than those contained in *Amaranthus hybridus*.

5.6 Impact of Vehicular Emissions on Proximate Composition

The impact of vehicular emissions on the proximate composition of both *Amaranthus hybridus* and *Mangifera indica* was determined using the student's t-test statistical tool to examine whether there is a significance difference between the mean proximate composition of plants cultivated at the experimental sites exposed to vehicular emissions and the mean proximate composition of those cultivated at the control site.

5.6.1 Impact on proximate composition of *Amaranthus hybridus*

As presented in Table 4.7, the values for t-calculated when moisture content of the *Amaranthus hybridus* cultivated at the experimental sites was compared to those ones cultivated at the control site were 0.54, 0.23, 1.58 and 2.67 for Rex Junction, PZ Junction, MTD Junction and Kwangila Fly-Over respectively. The values for t-calculated for fat content were - 0.59, 1.08, 1.78, and 0.29 for Rex Junction, PZ Junction, MTD Junction and Kwangila Fly-Over respectively. For ash content, the values for t-calculated were - 0.06, - 1.86, - 1.48 and -2.81 for Rex Junction, PZ Junction, MTD Junction and Kwangila Fly-Over respectively. For the crude protein content, the values for t-calculated were - 2.03, 0.09, 0.29 and - 1.29 for Rex Junction, PZ Junction, MTD Junction and Kwangila Fly-Over respectively. The values for t-calculated for crude fibre content were 0.92, 2.25, 1.13, and 1.5 for Rex Junction, PZ Junction, MTD Junction and KwangilaFly-Over respectively. For carbohydrate content, the values for t-calculated were - 0.44, 0.05, - 0.84 and 1.79 for Rex Junction, PZ Junction, MTD Junction and Kwangila Fly-Over respectively. The value for the t-critical was 3.18

From the values of the proximate composition of the *Amaranthus hybridus* cultivated at the experimental and at the control site, the values of t- calculated when the one at the control were compared to those ones at the experimental sites showed that moisture and crude fibre contents were lower in *Amaranthus hybridus*cultivated at the experimental sites than those ones cultivated at the control site but the difference was not significant (p = 0.05), the ash content was higher in*Amaranthus hybridus* cultivated at all the experimental sites than the ones cultivated at the control site but there was no significant difference (p = 0.05), there was no significant difference (p = 0.05) in other proximate compositions (fat content, crude protein content and carbohydrate content) between the *Amaranthus hybridus* cultivated at the experimental sites and those cultivated at the control sites. This showed that vehicular emissions did not have negative impact on the proximate composition of road side *Amaranthus hybridus* in Zaria.

5.6.2 Impact on proximate composition of *Mangifera indica*

As presented in Table 4.7, the values for t-calculated as the moisture content of the *Mangiferaindica* cultivated at the experimental sites was being compared to those ones cultivated at the control site were - 0.28, 0.50, - 2.90, and - 1.09 for Rex Junction, PZ Junction, MTD Junction and Kwangila Fly-Over respectively. The values for t-calculated for fat content were - 5.70, - 2.67, - 13.85, and - 2.26 for Rex Junction, PZ Junction, MTD Junction and Kwangila Fly-Over respectively. For ash content, the values for t-calculated were 7.26, 10.20, 18.04 and 0.45 for Rex Junction, PZ Junction, MTD Junction and Kwangila Fly-Over respectively. For the crude protein content, the values for t calculated were - 1.78, - 2.05, - 3.95 and - 2.15 for Rex Junction, PZ Junction, MTD Junction and Kwangila Fly-Over respectively. The values for t calculated for crude fibre content were - 4.28, - 2.88, - 3.55, and - 5.39 for Rex Junction, PZ Junction, MTD Junction and Kwangila Fly-Over respectively. For carbohydrate content, the values of t-calculated were 0.10, - 0.65, 1.76 and 0.63 for Rex Junction, PZ Junction, MTD Junction and Kwangila Fly-Over respectively. The value for the t-critical was 3.18.

From the values of the proximate composition of the *Mangifera indica* cultivated at the experimental and at the control site, the values of t- calculated when the one at the control were compared to those ones at the experimental sites showed thatfat content was significantly higher (p = 0.05) at all experimental sites than at the control site, ash content was significantly higher (p = 0.05) at the control site than all experimental sites except at Kwangila, crude protein content at the experimental sites were all higher than the ones at the control site but the difference was not significant (p = 0.05) except at MTD junction. Crude fibre content was higher at all the experimental sites than at the control site and the difference was significant (p = 0.05) except at PZ Junction. For moisture content, there was no significant difference(p= 0.05) between experimental sites and the control site,for the carbohydrate content, there was no significant difference (p = 0.05) between the experimental sites and the control.

This showed that there was no negative impact from vehicular emissions on the proximate compositions of *Mangifera indica* in Zaria except for the ash content that was significantly lower at all the experimental sites than at the control site except at Kwangila. The high percentage of ash in the roadside *Mangifera indica* when compared to the control could be as a result of high concentration of heavy metals in the ash content of those *Mangifera indica* planted by the roadside of Zaria.

5.7 Proximate Composition of *Amaranthus hybridus* as Age increases in Weeks

The average proximate composition as the age of the *Amaranthushybridus* increased in weeks were determined for moisture content, fat content, ash content, crude protein content, crude fibre content and carbohydrate content as presented in Figure 4.11.

For the moisture content, the values were 32.17 ± 0.89 %, 32.71 ± 0.68 %, 27.52 ± 0.14 % and 27.07 ± 0.08 % for the third, fourth, fifth, and sixth week respectively. For the fat content, the values were 3.35 ± 0.09 %, 3.13 ± 0.05 %, 3.04 ± 0.16 % and 3.02 ± 0.05 %, for the third, fourth, fifth, and sixth week respectively. For the ash content, the values were 4.16 ± 0.38 %, 4.60 ± 0.51 %, 4.46 ± 0.32 % and 4.21 ± 0.05 %, for the third, fourth, fifth, and sixth week respectively. For crude protein content, the values were 7.25 ± 0.31 %, 7.30 ± 0.18 %, 6.39 ± 0.05 % and 6.13 ± 0.01 % for the third, fourth, fifth, and sixth week respectively. For the crude fibre content, the values were 3.18 ± 0.36 %, 3.74 ± 0.20 %, 4.62 ± 0.36 % and 5.27 ± 0.05 % for the third, fourth, fifth, and sixth week respectively. For carbohydrate content, the values were 53.04 ± 1.21 %, 52.20 ± 0.68 %, 58.60 ± 0.30 % and 59.66 ± 0.13 %, for the third, fourth, fifth, and sixth week respectively.

The Pearson product moment correlation statistical tool (r) was used to determine how each of the proximate compositions of *Amaranthus hybridus* correlates with age as presented in Table 4.8 so as to determine the impact of age on the proximate composition of the *Amaranthus hybridus*. The moisture content, fat content, and crude protein content were reduced in amount of percentage composition as age increases showing a high negative correlation with age at r = - 0.89, - 0.92 and -0.93 respectively. Crude fibre content and carbohydrate content increased as age increases showing a high positive correlation at r = 1.00 and 0.89 respectively. The ash content showed negligible or no visible correlation with age at r = 0.01. The decrease in protein content with age agrees with Mordi, (2007); Mugerwa and Bwabye, (1974).The behaviour of ash content with age of *Amaranthushybridus* could be due to the fact that at different stages of growth, some individual mineral content decrease while some increase making ash content to exhibit very low correlation with age and this agrees with Mordi (2007) and Amanabo*et al*., (2011).

5.8 Growth Rate of *Amaranthus hybridus*

The growth rate of *Amaranthushybridus* per week was determined as presented in Figure 4.12 . The growth rate of the *Amaranthushybridus* at the end of the first week were 4.80 ± 0.7 cm, 5.30 ± 0.7 cm, 4.70 ± 0.8 cm, 5.10 ± 0.9 cm and 5.00 ± 1.0 cm at Rex Junction, PZ Junction, MTD Junction, Kwangila Fly-Over and Control respectively. At the end of the second week, the growth rate were 14.90 ± 0.8 cm, 15.40 ± 0.6 cm, 14.80 ± 0.8 cm, 15.10 ± 0.8 cm and 15.20 ± 0.7 cm at Rex Junction, PZ Junction, MTD Junction, Kwangila Fly-Over and Control respectively. At the end of the third week, the growth rate were 25.10 ± 0.6 cm, 25.30 ± 0.8 cm, 25.00 ± 0.6 cm, 24.60 ± 0.5 cm and 24.80 ± 1.1 cm at Rex Junction, PZ Junction, MTD Junction, Kwangila Fly-Over and control respectively. At the end of the fourth week, the growth rate were 36.80 ± 0.9 cm, 37.10 ± 0.5 cm, 37.30 ± 0.9 cm, 35.90 ± 0.8 cm and 37.20 ± 0.8 cm at Rex Junction, PZ Junction, MTD Junction, Kwangila Fly-Over and Control respectively. At the end of the fifth week, the growth rates were 44.20 ± 0.8 cm, 43.60 ± 0.6 cm, 44.10 ± 0.7 cm, 45.00 ± 0.7 cm and 43.8 ± 0.9 cm at Rex Junction, PZ Junction, MTD Junction, Kwangila Fly-Over and control respectively. At the end of the sixth week, the growth rate were 52.30 ± 0.7 cm, 52.40 ± 0.4 cm, 52.00 ± 0.6 cm, 51.90 ± 0.4 cm and 51.70 ± 0.7 cm at Rex

Junction, PZ Junction, MTD Junction, Kwangila Fly-Over and Control respectively. The average growth rate of the *Amaranthus hybridus* at each of the sites during the six weeks of study were 29.68 ± 18.06 cm, 29.85 ± 17.79 cm, 29.65 ± 18.06 cm, 29.60 ± 17.94 cm and 29.62 ± 17.79 cm, at Rex Junction, PZ Junction, MTD Junction, Kwangila Fly-Over and control respectively.

5.9 Impact of Vehicular Emission on the Growth Rate of *Amaranthus hybridus*

The impact of vehicular emissions on the growth rate of *Amaranthus hybridus* in terms of height per week was determined using the student's t-test statistical tool to examine whether there is a significant difference between the mean growth rate of *Amaranthus hybridus* cultivated on the road side (experimental sites) and the mean growth rate of the one cultivated at the Control siteas presented in Table 4.9.

There were differences in height of growth when comparing the *Amaranthus hybridus* cultivated at the experimental sites that were exposed to vehicular emissions to those cultivated at the Control site. From the results, the average growth rates in terms of heights at experimental sites were numerically higher than those at the Control site except at Kwangila Fly-Over.

The values for t-calculated when the *Amaranthushybridus* cultivated at the Control site was compared to the ones cultivated at the experimental sites in terms of growth rate in height at 0.05 significance level were - 0.39, - 1.66, - 0.27 and 0.05 for Rex Junction, PZ Junction, MTD Junction and Kwangila Fly-Over respectively. All the values for t-calculated were lower than the 2.57 value for the t-critical. This shows that the difference in the growth rate was not statistically significant. Generally, there was no significant difference ($p = 0.05$) between the growth rates of *Amaranthus hybridus* cultivated on the roadside (experimental sites) and the one cultivated at the Control site. This showed that vehicular emissions did not have negative impact on the growth rate of road side *Amaranthus hybridus* in Zaria.

CHAPTER SIX

6.0 SUMMARY CONCLUSION AND RECOMMENDATIONS

6.1 Summary

Vehicular emissions can cause negative effect on the nutrient content of vegetable consumed by man. In this research work, concentrations of air pollutants emanating from vehicular emissions and their impact on the proximate composition of a roadside vegetable (*Amarathushybridus*) in Zaria was determined.

The air pollutant analysed were particulate matter (PM), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), carbon monoxide (CO), carbon dioxide (CO_2) and hydrocarbons (HCs). These pollutants were measured during morning peak, evening peak and off-peak traffic periods. Traffic count was carried out to know the traffic density [number of vehicle per hour (v/h)] at all experimental sites and its impact on concentration of these air pollutants was determined. The proximate composition determined were moisture content, fat content, ash content, crude protein content, crude fibre content and carbohydrate content. Mobile gas analysers were used to determine the concentration of pollutants in the air while the A.O.A.C 1980 standard method was used to determine the proximate composition of *Amarathushybridus* cultivated at four experimental sites (Rex Junction, PZ Junction, MTD Junction and Kwangila Fly-Over) exposed to vehicular emissions. The percentage proximate composition determined for *Amarathushybridus* cultivated at each of the experimental site was compared to the percentage proximate composition of *Amarathushybridus* cultivated at the Control site which was not exposed to Vehicular emissions so as to know whether air pollutants from vehicular emissions have negative impact on the proximate composition of roadside *Amarathushybridus* in Zaria. For the fact that *Amarathushybridus* have very short life-span, this study was also carried out on *Mangifera indica* which have been on the roadside for some years so as to know whether vehicular emissions can also have impact on a perennial crop in Zaria and to know which of the two plants could be more nutritious. The impact of vehicular emissions on the growth rate of the roadside *Amarathushybridus* was also determined and was compared to the growth rate of the ones cultivated at the Control site.

The concentrations of each of the air pollutants at all the experimental sites which were exposed to vehicular emissions were far higher than those at the Control site which was not exposed to vehicular emissions, showing that vehicular emissions can reduce the air quality of Zaria by increasing the pollutants concentration in the air. All the pollutants were higher in concentration during peak traffic periods than during traffic off-peak period showing that traffic density at a particular time has impact on the concentration of pollutants in the air as a result of vehicular emissions. The concentrations of the pollutants were higher during evening peak periods than the morning peak periods with the exception of SO_2 and Hydrocarbons.

With the exception of PM which showed low correlation with traffic density at all the experimental sites and during peak traffic and off-peak periods, other air pollutants (NO_2 SO_2, CO CO_2 and HCs) showed high positive correlation with traffic density, meaning that the concentration of air pollutants from vehicular emissions can be increased as a result of increase in traffic density.

The peak traffic period average concentration of particulate matter and CO_2 in the air of Zaria was below the Nigerian Ambient Air Quality Standard (NAAQS) of 250 $\mu g/m^2$ and 600 ppm for particulate matter and CO_2 respectively. NO_2, SO_2 and CO average concentrations at peak traffic periods were within the NAAQS limit range of 0.04 – 0.06 ppm, 0.01 – 0.1 ppm and 10 – 20 ppm for NO_2, SO_2 and CO respectively. The average concentration of hydrocarbons at peak traffic periods were higher than the NAAQS limit of 0.05 ppm but was below the 0.05 ppm standard limit at traffic off-peak period. This shows that all the air pollutants from vehicular emissions at the experimental sites were either below or within the NAAQS limit except for HCs where the average concentrations at peak periods were higher than the NAAQS limit at all the experimental sites.

There was no negative impact from vehicular emissions on the proximate composition of road side *Amaranthus hybridus* in Zariasince there was no significant difference between the ones cultivated at experimental sites and the one cultivated at the Control site in terms of proximate composition, so also with the proximate composition of the *Mangifera indica* except for the ash content that was significantly higher at the Control than at all the experimental sites except Kwangila Fly-Over.

Proximate composition (moisture content, fat content, ash content and crude protein content) of the *Amaranthus hybridus* were significantly higher than those in the *Mangifera indica* while only the crude fibre content and moisture content were significantly higher in the *Mangifera indica* thus making the *Amaranthus hybridus* a better source of nutrients compared to the *Mangifera indica*

Vehicular emissions did not have negative impact on the growth rate of *Amaranthus hybridus* since there was no significant different between the average growth rates of the ones cultivated at the experimental site and those cultivated at the Control site.

6.2 Conclusion

The assessment of the impact of vehicular emissions on the air quality of Zaria shows that traffic density can increase the concentration of air pollutants (particulate matter, NO_2 SO_2, CO CO_2 and hydrocarbons) emanating from vehicular emissions as pollutants concentrations showed high correlation with traffic density except for particulate matter. All the pollutants were either below or within the NAAQS limit with the exception of only hydrocarbons meaning that vehicular emissions have not reach the level that can really cause negative impact on the air quality of Zaria. The assessment of the impact of vehicular emissions on the proximate composition of *Amaranthus hybridus* showed that vehicular emissions did not have negative impact on the proximate composition of roadside *Amaranthus hybridus* in Zaria. For the *Mangifera indica* which was also assessed in the course of this research, there was also no negative impact from vehicular emissions on its proximate composition apart from only the ash content which showed higher composition in the ones at the Control than the experimental sites. There was no negative impact from vehicular emissions on the growth rate of the *Amaranthus hybridus.* It was also discovered that *Amaranthus hybridus* has more nutrients than the *Mangifera indica*.

6.3 Recommendations

In order to prevent possible rise in concentration of air pollutants since there was high correlation between vehicular emissions and traffic density in Zaria and to mitigate the already high concentration of hydrocarbons emanating from vehicular emissions, measures and policies should be put in place by the government to checkmate or mitigate any environmental problem that may be caused by vehicular emissions. Such measures includeimproved road network, vehicular emission monitoring/control and enforcement of emission laws.

Further research work of this nature should be carried out on other road side plants in Zaria.

REFERENCES

Abam, F. I. and Unachukwu, G. O., (2009). Vehicular emission and air quality standards in nigeria,*European journal of scientific research*, 34(4): 550 – 560.

Abbaspour, M. and Soltaninejad, A., (2004). Design of an environmental assessment model on the effect of vehicle emission in greater Tehran on air pollution with economics sensitivity, *International Journal of environmental science and Technology*, 1(1): 27 – 38.

Abdulkarim, B. I, Chiroma, T. M., (2007).Assessement of CO, CO_2 and suspended particulate matter emissions, *Leonardo electronic journal of practice and technology*, 6 (11): 109 – 116.

Abechi, E. S., Okunola, O. J., Zubaru, S. M., Usm exan., A. A. and Apene, E., (2010). Evaluation of heavy metals in roadside soil of major streets in Jos metropolis, Nigeria, *Journal ofenvironmental chemistry and ecotoxicology*, 2(6): 98 – 102.

Agyemang-Bonsu, K. W., Dontwi, I. k., Tutu- Benefoh, D., Bentil, D. E., Buateng, O.G., Asuabongteng, K. and Agyemang,W. (2010). Traffic–data driven modelling of vehicular emissions using corpert 111 in Ghana: A case study of Kumasi. *Americanjournal of science and technology*, 1(1): 32 – 40.

Ajayi, A. B and Dosunmu, O. O. (2002). Environmental hazards of importing used vehicles into Nigeria. *Proceedings of international symposium on environmental pollution control and waste management* (pp. 521- 532). Tunis, Algeria.

Ajayi, D. A, Adeneye, J. A and Ajayi, F. T. (2005).Intake and nutrient utilization of West African dwarf goats Fed mango (*Mangifera indica),* Ficus*(Ficusthionningii),* Gliricidia*(Gliricidiasepium)* foliages and concentrates as supplements to basal diet of guinea grass (*Panicum maximum*). *World journal of agricultural sciences*, 1(2): 184 – 189.

Akande, J. M., Ajaka, E. O., Omosogbe, F. M., and Lawal, A.I (2013). Environmental effect of processing marine clay in Olotu in Ondo State, *Nigeria, Civil and environmental research*, 3(2): 82 – 86.

Akanni, C. O. (2010). Spatial and seasonal analysis of traffic related pollutants concentration in Lagos metropolis, Nigeria. *African Journal of Agricultural Research*, 5(11): 1264 – 1273.

Akubugwo, I. E., Obasi, N. A., Chinyere, E. C., and Ugboku, A. E. (2007). Nutritional and chemical value of Amaranthus hybridus leaves from Afikpo, Nigeria. Africa journal of biotechnology, 6(24): 2833 – 2839.

Alves, R. E., Filgueiras H. A. C., Menezes, J. B., Assis, J. S, Lima, M. A. C., Amorim, T. B. F. and Martins A. G. (2002). Colheita e Pos-Colheitapp 383 – 405.

Amanabo, M., Johnson A. O., Matthew, I. S. E., Helmina, O. A., and Emmanuel, O. O. (2011). Effect of heading on some micronutrients, anti-nutrients and toxic substances in *Amaranthus cruentus*grown in 1(4): 147 – 154.

Aminnurul, A. T. M. (2009). *Reducing emissions from private cars: incentive measures for behavioural change, a paper prepared for Economics and Trade Branch, Division of Technology, Industry and Economic*s. United Nations Environmental Programme.

Andrew, N., Conlon, M., Cherry, J and Phillips, M. (2007). Vehicular emissions and red pine growth.http://hdl.handle.net/2007.42/57439 Retrieved, August 6, 2012.

AOAC (1980).Official methods of analysis (13th edition), Association of Official Analytical Chemists, Washington DC.

Asaolu, S. S., Adefemi, O. S., Oyakilome, I. G., Ajibulu, K. E and Asaolu, M. F. (2012) Proximate and mineral composition of Nigerian leafy vegetables. *Journal of Food Research,* 1(3): 214 – 218.

Atayese, M. O., Eigbadon, A. I., Oluwa, K. A and Adesodun, J. K. (2009). Heavy metal contamination of amaranthus grown along major highways in lagos, Nigeria. *African crop science journal* 16(4): 225 – 235.

Audu, A.A andlawal, A. O (2006). Variation of metal content of plants in vegeTable garden sites in Kano metropolis, *Journal of Applied Science and Environmental Management* 10(2): 105 – 109.

Babu, S. K. A. (1993).Effect of atmospheric pollution on soil. A recent trends in biotechnology, in: *proceedings of ninth national convention of chemical engineers and internationalsymposium*. Viskhapatham, India.

Butz,E. (2012), Plant that will withstand pollution and reduce it *Health Guidance* Retrieved may 5, 2012.www.healthguidance.org

Black, W. R. (2010). *Sustainability transport problem and solutions*. The Civil Ford Press, New York.

Caselles, J., Colliga, C. and Zornoza, P. (2001).Evaluation of trace element pollution from vehicle emissions in petunia plants.*Water, air and soil pollution*, 136(1): 1 – 9.

Chauhan, A. (2010) Tree as Bio-Indicator of automobile pollution in Dehradun city: A case study. *New York Science Journal*, 3(6): 88 – 95.

Dara, S. S (2008).*Environmental chemistry and pollution control*. S Chand & Company Limited, New Delhi, India. Pp. 19 – 20.

Durrani, G. F., Hassan, M., Balock, M. K. and Hameed, G. (2004).Effect of traffic pollution on plant photosynthesis.*Journal of chemical society of Parkistan*, 26 (2): 176 – 179.

Emerhi, E. A., Ideriah, T. J. K. and Trinya, W. (2002).Distribution of ambient suspended particulates and volatile organic carbon in a fast developing metropolis in the Niger Delta, Nigeria.*International journal of recent trends in science and technology*, 2(2): 9 – 24.

Enemari, J. J. (2001). *Vehicular emission, environmental and health implication*.Paper presesented at conference on phase- out leaded gasoline in Nigeria, held at Nicon Hilton hotel in Abuja, Nigeria, 15-16 November.

Faize, A., Weaver, C. S., and Walsh, M. P. (1996).*Air pollution from vehicular emissions: standard and technologies for control* Transport Department, World Bank.

Foster, S. and Duke J. A. (1990). *A field guide to medicinal plants. Eastern and Central North America.*HouhtonMiffin Co. U.S.A

Gobo, A. E., Ideriah, T. J. K., Francis, T. E., and Stanley, H. O. (2012).Assessment of air quality and noise around Okrika communities, River State, Nigeria. *Journal of applied science and environmental management*, 16(1): 75 – 83.

Gorham, R. (2002). *Air pollution from ground transport: an assessment of causes, strategies and tactics and proposed actions for the international community.* Division of Sustainable Development, Department of Economic and Social Affairs, United Nations.

Integrated Taxonomic information system of North America.(2013). Classification of plants. Retrieved march 10, 2014. http://www.itis.gov/index.html.

Ipeaiyeda, R. A., Dawodu, M. and Akande, Y. (2007).Heavy metal contamination of top soil and dispersion in the vicinities of relaim auto-repair workshop in Iwo, Nigeria.*Research journal of applied sciences*, 2(11): 1106 – 1115.

Iqbal, Z. M. and Mahmood, T. (1992). Sulphur content in foliage of roadside native plants and soil along the main super highway in the outskirt of Karachi. *Journal of Islamicacademy of sciences*, 5(4): 279 – 281.

Kabir, M., Iqbal, Z. M. and Shafiq, M. (2009).Effect of lead on seedling growth of Thespesiapopulnea. L. *Advances in environmental biology,* 3(2): 284 – 289.

Kammerbauer, Hans. S, Michael. D. and Dick T. T. (1999). Plant response to Motor exhaust emission from gasoline and Alcohol. *RevistaBrisileira de Fisiologia vegetal* 11(1): 35 – 40.

Khanam, N., Agrawal M. and Rao, D. N. (1990). Evaluation of air pollution impact around Dala cement factory. *In*: Singh, T. (Ed.), *Environmental degredation of Obra-Renukoot-Singrauli area and its impact on natural and derived* *ecosystems*, Final Technical report of a MAB project, sponsored by the Ministry of Environment and Forest, Government of India 14/ 167/ 84-MAB/ EN-2/RE, pp. 305 – 335.

Klinkenbera, K. (1970). Soil of Zaria. In: Mortimore, M. J. (Ed) *Zaria and its Region* Department of Geography Occasional Paper NO. 4, Ahmadu Bello University, Zaria, pp. 223 – 238.

Kylander, M. (2002).Platinum group elements and their distribution in Accra, Ghana.Unpublished M.Sc Thesis.Chalmers University of Technology, Sweeden.

LeBlanc, F. and Rao, D. N. (1975). Effects of air pollutants on lichen brophytes.In: Mudd ,J. B. and Kozlowski,T.T (Ed). *Response of air pollution*.Academic Press. New York, pp. 237 – 272.

Lon.T. (2003). An appendix on adverse health and environmental effect from vehicle emissions. In: *Policy guidelines for reducing vehicle emission in Assia,* p.4, Assian development bank, Manilla, Philppines.

Lone, M. I., Raza, S.H., Muhammad, M. A., Naeem, M. A. and Khalid.M. (2006). Lead content in soil and wheat tissue along roads with different traffic load in Rawalpindi District. *Parkistan journal of botany*, 38(4): 1035 – 1042.

Lowry, O. H., Rosenbrough N. J., Farr, A. L. and Randall, R. J. (1951).Protein measurement with folin-phenol reagent.*Journal of Biological Chemistry*, 193: 265 – 275.

Luilo, G. B and Othman, O. C. (2006). Lead pollution in urban roadside environment of Dar Es Salaam city. *Tanzania journal of science*, 32(2): 61 – 67.

Mepba, H. D., Eboh, L and Banigo, D. E. B. (2007).Effect of processing treatments on the nutritive composition and consumer acceptance of some Nigerian edible leafy vegetables.*African journal of food agriculture nutrition and development.* 7(1): 1 – 18.

Mishra, P. C. (2008). *Fundamental of air and water pollution*.A.P.H Publishing Co-operation, New Delhi, India, pp. 20 – 23.

Mordi, A. T. (2007). Growth temperature and plant age influence on nutritional quality of Amaranthus leaves and seed germination capacity.*Water SA*, 33(3): 369-376.

Mortimore, M. J. (1970). Zaria and its Region (Ed).*Department of Geography Occasional Paper* NO. 4, Ahmadu Bello University, Zaria, p. 192.

Mugerwa,,J. S and Bwabye, R. (1974). Yield composition and invitro digestibility of *Amaranthus hybridus* sub species *Incuvatus*, Tropical grassland 8(1): 49 – 53.

Naveed, N. H., Batool, A. I.,Rehman, U. F. and Hameed, U., (2010). Leaves of Roadside plants as bioindicator of traffic related lead pollution during different seasons in SarghodhaParkistan,*African Journal of Environmental Science and technology* 4(11): 770 – 774.

Ndiokwere, C. L., (1984). A study on heavy metal pollution from motor vehicle emissions and its effect on roadside soil, vegetation and crops in Nigeria, *Environmental pollutionseries B, chemical and physical*, 7(1):35 – 42.

Ndoke, P. N., Akpan, .U. G and Kato, M. E. (2006). Contribution of vehicular Traffic to carbon dioxide emission in Kaduna and Abuja, Nigeria.*Leonardo Electronic Journal of practices and Technologies*, issue 9, pp 81 – 99.

Nwachuku, A. N., Chukwuocha, E. O. andIgbudu, O. (2013). A survey on the effect of air pollution on diseases of the people of Rivers State, Nigeria, *African journal of environmental science and technology*, 6(10): 371 – 379.

Odhiambo, G. O., Kinyua, A. M., Gatebe, C. K. and Awanje, J. (2010). Motor vehicle air pollution in Nairobi, Kenya,*Research journal of environmental and earth sciences*, 2(4): 178 – 187.

Ojolo, S. J., Oke, S. A., Dinrifo, P. R. and Eboda, F. Y. (2007). A survey on the effect of vehicle emissions on human health in Nigeria, *Journal of Rural and Tropical Public Health* 6: pp 16 – 23.

Oko, O. O., Ekigbo, J. C., Idenyi, J. N., and Ehihia, L. U. (2012). Nutritional and Phytochemical Compositions of the Leaves of *MucunaPoggei, Journal of Biology and Life Science*, 3(1): 232 – 242.

Okunola, O. J., Uzairu, A., Gimba, C. E and Kagbu, J. A. (2011) Metal inter-relationship and its mobility in samples collected along roadside corridors of Kano metropolis, Nigeria,*Research journal of environmental toxicology*, 5: 336 – 347.

Rejini, M. B. J. and Janardhanan, K., (1989).Effect of heavy metals on seed germination and early seedling growth of groundnut, sunflower and ginger,*Geobios*, 16: 164 – 170.

Ronni, E. R., (2012). The effect of vehicular emission on human health, Retrieved may 6, 2012 from www.yale.edu/ynhti/nationalcurriculum/

Sabo, M., (2009).*Alexandria's state of the air report, past, present and future.*Office of environmental quality transportation and environmental services, city of Alexandria, U.S.A, p.21.

Sauer, J. D,. (1993). *Historical geography of crop plants: a select roster*. Boca Raton u.a CRC Press p17

Sawyer, R. F., (2010).Vehicle emissions, Progress and challenges,*Journal of Exposure Science and Environmental epidemiology*, 2010: 487 – 488.

Seyyednejad, S. M., Niknejad, M. and Yusefi, M. (2009).Study of Air pollution Effect on some physiology and morphology factors of Albizialebbeck in high temperature condition in Khuzestan.*Journal of Plant Science* 4(4): 122 – 126.

Shafiq, M. and Iqbal, Z. M. (2003).Effect of Automobile pollution on the phenology and periodicity of some Roadside plants.*Pakistan journal of botany* 35(5): 31 – 38.

Tsai, W. Y., Chan, L.Y., Blake, D. R. and Chu, K. W. (2006). Vehicle fuel composition and atmospheric emission in south China: Hong Kong, Macau, Ghanzhou and Zhuhai. *Atmospheric chemistry and physical discussions*, 6: 3687 – 3707.

Tsunokowa, K. and Hoban, C. (1997). *Road and the environment: a handbook*, World Bank Technical Paper No. 376.

Tzirakis, E., Pitsas, K., Zannikos, F. and Stournas, S. (2006). Vehicle emissions and driving cycle comparison of the Athens driving cycle (ADC) with ECE-15 and European driving cycle (EDC),*Global network for environmental science and technology journal*, 8(3): 282 – 290.

Ubogu, A. E., Laah, J. G., Udemezue, C. E. and Bako, A. R., (2011). Determinant of the locational decisions of informal sector entrepreneurs in urban Zaria, *Journal of geography and geology*, 3(1): 215 – 226.

Uboh, E. F., Akpanabiatu, I. M., Edet, E. E. and Okon, I. E., (2011). Distribution of heavy metals in fluted pumpkin (*Telferiaocidentalis*) leaves cultivated at different distance from the traffic congested highways,*International journal of advance biotechnology andresearch*, 2(2): 250 – 257.

Uchegbu, S. N. (1998). *Environmental management and protection.*Precission printers and publishers.15 ochumba close, Achara Layout Enugu .pp 25 – 26.

Utang, P. B. and Peterside, K. S., (2011).Spatio-temporal variation in urban vehicular emission in Port Harcourt City, Nigeria,*Ethiopean journal of environmental studies and management*, 4(2): 38 – 51.

Vidosh, M., Praksh, V. and Alock, C. (2011). Impact of bio-fuel use: a review. *Internationaljournal of engineering science and technology*, 3(5): 3776 – 3782.

Viskari, E. L., Kossi, S. and Holoppainen, .J. K. (2000). Norway spruce and spruce shoot aphid as indicator of traffic pollution. *Environmental Pollution*, 107(3): 305 – 314.

Vliet, E. D. S and Kinney, P. L. (2007). Impact of roadway emissions on urban particulate matter concentrations in sub Saharan Africa: new evidence from Nairobi, Kenya.*Environmental research letters*, 2(2007) 045028 (5pp).

Wagh, N. D., Poonam, V. S., Sarika, B. T. and Ingle S. T. (2006). Biological Monitoring of Roadside plants exposed to vehicular pollution in Jalgaon city. *Journal of environmental biology* 27(2): 419 – 421.

Wallington, T. J., Sullivan, J. L., and Hurley, M. D. (2008). Emission of CO_2, CO, NOX, HC, PM, HFC-134a, N_2O and CH_4 from the global light duty vehicle fleet, *MeteorologischeZeitschrift*, 17(2): 109 – 116 (8).

Walsh, M. P. (2001). *Vehicle emissions reduction*, Report of European Conference of Transport Ministers in Prague.OECD publication service, Paris, France.

Whiteley, J. D. (2004). Auto-catalyst derived platinum group element in the roadside environment: occurrence, mobility and fate. Ph.D Thesis, Murdoch University. Retrieved August 8, 2012 from:http://researchrepository.mudorch.edu.au/id/eprint/403

Yusuf, O. R., Ukoji, J. A., and Orrire, J. O. (2012).*The dynamics of rural- urban interaction in sustainable access to fruit and vegetable in Zaria, Nigeria*, A paper presented during the 52nd annual conference of the association of Nigerian Geographers held at the Kano State University of Science and Technology.

Zinada, I. A., Auda, M. A. and Ali, E. S. (2011).Impact of soil lead pollution and iron foliar application on Spinacea oleracea. L. *Advances in agriculture and botanicsinternational journal of the bioflux society*, 3(2): 116 – 126.

APPENDICES

Appendix I: Average Air Quality Parameters Measurement at all the Site

Site	Air Quality Parameters						Meteorology		
	Morning Peak								
	PM ($\mu g/m^3$)	NO_2 (ppm)	SO_2 (ppm)	CO (ppm)	CO_2 (ppm)	HCs (ppm)	Air Temp. (^oC)	Humidity (%)	Wind Speed (ms^{-1})
Rex Junct.	192 ± 3.000	0.040± 0.010	0.040 ± 0.010	14.300 ± 0.300	346.000± 2.100	0.060 ± 0.010	28.00 ± 1.00	36.50 ± 2.00	3.40 ± 0.36
PZ Junct.	181 ± 2.000	0.041± 0.001	0.041 ± 0.000	16.800 ± 0.100	348.000± 2.000	0.070 ± 0.005	28.3 ± 0.70	40.00 ± 2.00	3.73 ± 0.35
MTD Junct.	173 ± 2.000	0.039± 0.003	0.040 ± 0.000	14.600 ± 0.400	347.000± 0.200	0.060 ± 0.003	29.20 ± 0.02	37.00 ± 2.00	3.70 ± 0.26
Kwangila Fly-Over	213 ± 2.000	0.042± 0.004	0.042 ± 0.001	18.100 ± 0.200	347.000 ± 2.000	0.060 ± 0.000	29.20 ± 0.02	40.00 ± 1.00	3.40 ± 0.36
Control	54 ± 0.010	0.002± 0.000	0.003 ± 0.001	1.000 ± 0.001	337.000± 2.000	0.003 ± 0.001	29.30 ± 0.03	40.00 ± 2.00	3.53 ± 0.15
	Off- Peak								
Rex Junct.	125 ± 2.00	0.023± 0.001	0.027 ± 0.001	11.000 ± 0.500	342.000± 0.000	0.031 ± 0.000	33.00 ± 2.00	35.00 ± 0.00	3.53 ± 0.50
PZ Junct.	126 ± 1.00	0.033± 0.001	0.037 ± 0.000	12.000 ± 0.500	343.000± 1.000	0.040 ± 0.001	33.50 ± 1.00	35.10 ± 1.90	3.77 ± 0.25
MTD Junct.	120 ± 1.00	0.029± 0.001	0.033 ± 0.000	10.000 ± 0.500	341.000± 1.000	0.030 ± 0.000	34.20 ± 0.80	35.20 ± 0.40	3.53 ± 1.52
Kwankila Fly-Over	139 ± 1.00	0.035± 0.001	0.032 ± 0.002	11.500 ± 0.500	342.000± 1.000	0.030 ±0.000	35.30 ± 0.20	30.00 ± 0.50	3.67 ± 0.30
Control	53 ± 0.000	0.002± 0.001	0.003 ± 0.002	1.000 ± 0.100	338.000± 2.000	0.001 ± 0.000	34.30 ± 0.70	33.00 ± 0.80	3.06 ± 0.38
	Evening Peak								
REX Junct.	192 ± 2.000	0.042± 0.002	0.040 ± 0.010	14.700 ± 0.200	347.000± 2.000	0.060 ± 0.020	33.30 ± 0.70	30.20 ± 0.40	3.57 ± 0.15
PZ Junct.	193 ± 2.000	0.043± 0.000	0.041 ± 0.000	17.300 ± 0.300	349.000± 1.000	0.070 ± 0.010	33.0 ± 1.00	30.96 ± 0.41	3.67 ± 0.30
MTD Junct.	202 ± 2.000	0.040± 0.001	0.040 ± 0.002	15.100 ± 0.100	348.000± 0.000	0.057 ± 0.001	33.00 ± 0.5	32.00 ± 0.20	3.53 ± 0.50
Kwangila Fly-Over	213 ± 1.000	0.045± 0.002	0.042 ± 0.002	18.600 ± 0.100	348.000± 2.650	0.060 ± 0.001	34.00 ± 1.00	32.00 ± 0.00	3.77 ± 0.25
Control	54 ± 0.300	0.002± 0.000	0.003 ± 0.001	1.000 ± 0.500	338.000± 1.000	0.003 ± 0.000	34.00 ± 0.50	31.27 ± 0.12	3.53 ± 0.50

Appendix IIa: Average Traffic Count at Morning Peak Traffic Period (Number of

vehicle type	Traffic Count at each Junction in v/h			
	Rex Junction	PZ Junction	MTD Junction	Kwangila Fly-Over
Cars	1024.67 ±4.73	1348.00 ± 3.61	1156.67 ± 12.90	1391.33 ± 7.31
Mini Buses	498.33 ±8.5	487.67 ± 1.53	411.00 ± 6.93	413.00 ± 6.08
Big Buses, Lorries/ Trailers	28.33 ±2.52	57.67 ± 2.08	52.67 ± 3.06	90.33 ± 3.79
Motorcycles	1248.67 ±9.92	1320.67 ± 1.53	1223.00 ± 4.36	1254.00 ± 1.00

vehicles Per Hour (v/h))

Tricycles	45.33 ± 3.06	43.33 ± 1.53	33.67 ± 1.53	25.67 ± 0.58
Total	2845.33 ± 4.16	3257.33 ± 0.58	2877.00 ± 19.29	3174.33 ± 15.89
vehicle type	Traffic Count at each Junction in v/h			

Appendix IIb: Average Traffic Count at Evening Peak Traffic Period (Number of vehicles Per Hour (v/h))

	Rex Junction	PZ Junction	MTD Junction	Kwangila Fly-Over
Cars	1025.67 ±4.73	1349.00 ±3.79	1157.00 ±12.49	1393.00 ±7.21
Mini Buses	502.00 ±6.08	488.67 ±3.21	410.33 ±6.03	415.67 ±6.66
Big Buses, Lorries/ Trailers	29.00 ±2.00	57.33 ±4.16	51.67 ±3.06	90.33 ±5.69
Motorcycles	1249.00 ±9.29	1322.67 ±1.53	1222.00 ±7.00	1257.33 ±1.15
Tricycles	46.67 ±2.52	46.00 ±3.61	34.67 ±1.53	29.00 ±2.00
Total	2852.34 ±4.58	3264.00 ±1.73	2875.67 ± 20.21	3175.22 ±26.08

Appendix IIc: Average Traffic Count at Off-Peak Traffic Period (Number of

vehicle type	Traffic Count at each Junction in v/h			
	Rex Junction	PZ Junction	MTD Junction	Kwangila Fly-Over
Cars	600.67 ± 5.03	648.00 ± 5.57	574.67 ± 11.5	637.00 ± 9.85
Mini Buses	283.33 ± 2.08	318.00 ± 7.02	304.67 ± 4.7	300.00 ± 6.08
Big Buses, Lorries/ Trailers	51.33 ± 1.53	57.00 ± 2.00	51.33 ± 3.05	58.66 ± 1.53
Motorcycles	825.33 ± 6.11	808.67 ± 7.57	839.67 ± 2.25	799.00 ± 10.82

vehicles Per Hour (v/h)

Tricycles	23.00 ± 1.00	29.33 ± 2.08	25.33 ± 1.53	28.33 ± 2.08
Total	1783.67 ± 7.0[illegible]	1861.33 ± 16.5[illegible]	1795.67 ± 10.26	1823.67 ± 17.24

Weeks of Proximate Composition (%)

Growth (Age)	Moisture Content	Fat Content	Ash Content	Crude Protein	Crude Fibre Content	Carbohydrate Content
3	32.17 ±0.89	3.35 ±0.09	4.16 ±0.38	7.25 ±0.31	3.18 ±0.36	53.04 ±1.21
4	32.71 ±0.68	3.13 ±0.05	4.60 ±0.51	7.30 ±0.18	3.74 ±0.20	52.20 ±0.68
5	27.52 ±0.14	3.04 ±0.16	4.46 ±0.32	6.39 ±0.05	4.62 ±0.36	58.60 ±0.30
6	27.07 ±0.08	3.02 ±0.05	4.21 ±0.05	6.13 ±0.01	5.27 ±0.05	59.66 ±0.13

Appendix III: Site Weekly Average Proximate Composition of *Amaranthus hybridus*

Sites	Growth Rate (cm)

Appendix IV: Growth Rate of *Amaranthus Hybridus*

	1^{ST} week	2^{ND} week	3^{RD}week	4^{TH} week	5^{TH} week	6^{TH} week	
Rex Junction	4 .80 ±0.80	14.90 ± 0.80	25.10 ± 0.60	36.80 ± 0.90	44.20 ± 0.80	52.30 ± 0.70	29.68 ± 18.06
PZ Junction	5.30 ± 0.70	15.40 ± 0.60	25.30 ± 0.80	37.10 ± 0.50	43.60 ± 0.60	52.40 ± 0.40	29.85 ± 17.79
MTD Junction	4.70 ± 0.80	14.80 ± 0.80	25.00 ± 0.60	37.30 ± 0.90	44.10 ± 0.70	52.00 ±0.60	29.65 ± 18.06
Kwangila Fly-Over	5.10 ± 0.90	15.10 ±0.80	24.60 ± 0.50	35.9 ± 0.80	45.00 ± 0.70	51.90 ± 0.40	29.60 ± 17.94
Control	5.00 ± 0.70	15.20 ± 0.10	24.80 ± 0.80	37.20 ± 0.8	43.80 ± 0.90	51.70 ± 0.70	29.62 ± 17.79

Appendix V (a): Air Quality Parameters Measurements for Morning Peak (Field Triplicate analysis)

Site	Air Quality Parameters Morning Peak						Meteorology		
	PM ($\mu g/m^3$)	NO_2 (ppm)	SO_2 (ppm)	CO (ppm)	CO_2 (ppm)	HCs (ppm)	Air Temp. (^oC)	Humi-dity (%)	Wind Speed (ms^{-1})
Rex Junction	192.00	0.040	0.040	14.300	346.000	0.060	28.0	36.50	3.00
	195.00	0.030	0.050	14.000	348.100	0.050	29.0	38.50	3.50
	189.00	0.050	0.030	14.600	343.900	0.070	27.0	34.50	3.70
Mean	192.00	0.040	0.040	14.300	346.000	0.060	28.0	36.50	3.40
SD	3.00	0.010	0.010	0.300	2.000	0.010	1.0	2.00	0.36
PZ Junction	181.00	0.041	0.040	16.800	348.000	0.070	28.3	40.00	4.10
	183.00	0.040	0.040	16.900	346.000	0.065	29.0	42.00	3.70
	179.00	0.042	0.040	16.700	350.000	0.075	27.6	38.00	3.40
Mean	181.00	0.041	0.000	16.800	348.000	0.070	28.3	40.00	3.73
SD	2.00	0.001	0.000	0.100	2.000	0.005	0.7	2.00	0.35
MTD	173.00	0.039	0.041	14.600	346.000	0.060	29.2	39.00	3.60

Junction									
	171.00	0.036	0.041	14.200	346.500	0.063	29.0	37.00	4.00
	175.00	0.042	0.041	15.000	345.500	0.057	29.4	35.00	3.50
Mean	173.00	0.039	0.041	14.600	346.000	0.060	29.2	37.00	3.70
SD	2.00	0.003	0.000	0.400	0.500	0.003	0.02	2.00	0.26
Kwangila	213.00	0.042	0.041	18.100	347.000	0.060	29.2	41.00	3.70
	211.00	0.046	0.040	18.300	344.000	0.060	29.0	40.00	3.40
	215.00	0.038	0.042	17.900	350.000	0.060	29.4	39.00	3.50
Mean	213.00	0.042	0.041	18.100	347.000	0.060	29.2	40.00	3.40
SD	2.00	0.004	0.001	0.200	3.000	0.000	0.02	1.00	0.36
Control	54.00	0.002	0.003	1.000	337.00	0.003	29.3	40.00	3.70
	53.99	0.002	0.004	0.999	339.00	0.002	29.0	42.00	3.50
	54.01	0.002	0.002	1.001	335.00	0.004	29.6	38.00	3.40
Mean	54.00	0.002	0.003	1.000	337.00	0.003	29.3	40.00	3.53
SD	0.01	0.000	0.001	0.001	2.000	0.001	0.03	2.00	0.15

Appendix V (b):Air Quality Parameters Measurements for Off- Peak (Field Triplicate Analysis)

	Air Quality Parameters Off Peak						Meteorology		
Site	PM ($\mu g/m^3$)	NO_2 (ppm)	SO_2 (ppm)	CO (ppm)	CO_2 (ppm)	HCs (ppm)	Air Temp. (^oC)	Humidity (%)	Wind Speed (ms^{-1})
Rex Junction	135.00	0.023	0.027	10.000	343.000	0.030	33.0	35.00	3.70
	134.00	0.022	0.026	09.500	342.000	0.031	35.0	35.00	3.40
	136.00	0.024	0.028	10.500	344.000	0.029	31.0	35.00	3.50
Mean	135.00	0.023	0.027	10.000	343.000	0.030	33.0	35.00	3.53
SD	1.00	0.001	0.001	0.500	1.000	0.001	2.0	0.00	0.15
PZ Junction	126.00	0.030	0.032	12.000	342.000	0.030	33.5	35.10	3.80
	127.00	0.031	0.030	11.500	341.000	0.029	34.5	37.00	4.00
	125.00	0.029	0.034	12.500	343.000	0.031	32.5	33.20	3.50
Mean	126.00	0.030	0.032	12.000	342.000	0.030	33.5	35.10	3.77
SD	1.00	0.001	0.002	0.500	1.000	0.001	1.0	1.90	0.25
MTD Junction	120.00	0.029	0.033	11.000	341.000	0.040	34.2	35.20	3.40

	121.00	0.030	0.033	11.500	342.000	0.041	35.0	35.60	3.50
	119.00	0.028	0.033	10.500	340.000	0.039	33.4	34.80	3.70
Mean	120.00	0.029	0.033	11.000	341.000	0.040	34.2	35.20	3.53
SD	1.00	0.001	0.000	0.500	1.000	0.001	0.8	0.40	1.52
Kwangila	139.00	0.035	0.037	11.500	343.000	0.030	35.3	30.50	4.00
	138.00	0.034	0.036	11.000	344.000	0.030	35.1	30.00	3.60
	140.00	0.036	0.038	12.000	342.000	0.030	35.5	29.50	3.00
Mean	139.00	0.035	0.037	11.500	340.000	0.030	35.3	30.00	3.67
SD	1.00	0.001	0.001	0.500	1.000	0.000	0.2	0.50	0.30
Control	53.00	0.002	0.003	1.000	338.000	0.001	34.3	32.20	3.50
	53.00	0.001	0.001	0.100	336.000	0.001	35.0	33.00	2.90
	53.00	0.003	0.005	1.900	340.000	0.001	33.6	33.80	2.80
Mean	53.00	0.002	0.003	1.000	338.000	0.001	34.3	33.00	3.06
SD	0.00	0.001	0.002	0.100	2.000	0.000	0.7	0.80	0.38

Appendix V (c): Air Quality Parameters Measurements for Evening Peak (Field Triplicate analysis)

	Air Quality Parameters Evening Peak						Meteorology		
Site	PM ($\mu g/m^3$)	NO_2 (ppm)	SO_2 (ppm)	CO (ppm)	CO_2 (ppm)	HCs (ppm)	Air Temp. (^oC)	Humiddity (%)	Wind Speed ms^{-1}
Rex Junction	202.00	0.042	0.040	14.700	348.000	0.070	33.3	30.20	3.70
	202.50	0.040	0.041	14.500	347.000	0.650	34.00	30.60	3.60
	201.50	0.044	0.390	14.900	349.000	0.075	32.60	29.80	3.40
Mean	202.00	0.042	0.040	14.700	348.000	0.070	33.30	30.20	3.57
SD	0.50	0.002	0.010	0.200	1.000	0.005	0.70	0 .40	0.15
PZ Junction	193.00	0.042	0.040	17.300	348.000	0.060	33.00	31.30	4.00
	195.00	0.040	0.041	17.000	347.000	0.070	34.00	30.50	3.36
	191.00	0.044	0.039	17.600	349.000	0.050	32.00	31.10	3.00
Mean	193.00	0.042	0.040	17.300	348.000	0.060	33.00	30.96	3.67
SD	2.00	0.002	0.001	0.300	1.000	0.010	1.00	0.41	0.30
MTD Junction	192.00	0.040	0.040	15.100	347.000	0.057	33.00	32.00	3.40

	190.00	0.039	0.042	15.000	345.000	0.058	33.50	31.80	3.50
	194.00	0.041	0.038	15.200	349.000	0.056	32.50	32.20	3.70
Mean	192.00	0.040	0.040	15.100	347.000	0.057	33.00	32.00	3.53
SD	2.00	0.001	0.002	0.100	2.000	0.001	0.50	0.20	0.50
Kwangila	213.00	0.045	0.042	18.600	349.000	0.060	34.00	32.00	3.50
	212.00	0.047	0.040	18.700	348.000	0.061	35.00	32.00	4.00
	214.00	0.043	0.044	18.500	350.000	0.059	33.00	32.00	3.55
Mean	213.00	0.045	0.042	18.600	349.000	0.060	34.00	32.00	3.77
SD	1.00	0.002	0.002	0.100	1.000	0.001	1.00	0.00	0.25
Control	54.00	0.002	0.003	1.000	338.00	0.003	34.00	31.20	3.40
	54.30	0.002	0.004	1.500	339.00	0.003	34.50	31.40	3.50
	53.70	0.002	0.002	0.500	337.00	0.003	33.50	31.20	3.70
Mean	54.00	0.002	0.003	1.000	338.00	0.003	34.00	31.27	3.53
SD	0.30	0.000	0.001	0.500	1.00	0.000	0.50	0.12	0.50

Appendix VI (a): Traffic Count in Number Vehicles per Hour (v/h) at REX Junction (Field Work)

Vehicle Type	First Count (v/h)			Second Count (v/h)			Third count (v/h)			Ave. no. of vehicles per hour (v/h)	Standard Deviation
	In-flow	Out-flow	Total (T1)	In-flow	Out-flow	Total (T2)	In-flow	Out-flow	T3		

Vehicle	First Count (v/h)			Second Count (v/h)			Third count (v/h)			Ave. no. (T1+T2+T3)/3	Standard
Cars	523	498	1021	487	499	986	510	513	1023	1024.67	4.73
Mini Buses,	238	257	495	247	261	508	232	260	492	498.33	8.5
Big Buses, Lorry/ Trailers	17	14	31	15	11	26	12	16	28	28.33	2.52
Motorcycles	624	631	1255	597	641	1238	635	618	1253	1248.66	9.92
Tricycles	21	27	48	23	19	42	22	24	46	45.33	3.06
Total	1423	1427	2850	1369	1431	2800	1411	1431	2842	2845	4.16

Type	In-flow	Out-flow	Total (T1)	In-flow	Out-flow	Total (T2)	In-flow	Out-flow	T3	of vehicles per hour (v/h) (T1+T2+T3)/3	Deviation
Cars	663	688	1351	675	669	1344	659	690	1349	1348.00	3.61
Mini Buses,	213	275	488	287	199	486	217	272	489	487.67	1.53
Big Buses Lorries/ Trailers	33	24	57	28	32	60	29	27	56	57.67	2.08
Motorcycles	673	649	1319	665	657	1322	669	652	1321	1320.67	1.53
Tricycles	23	19	42	18	27	45	17	26	43	43.33	1.53
Total	1605	1652	3257	1673	1584	3257	1591	1667	3258	3257.33	0.58

Appendix VI (b): Traffic Count at PZ Junction in Number of Vehicle per Hour (v/h) (Field Work)

Appendix VI (c): Traffic Count in Number of Vehicles per Hour (v/h) at MTD Junction (Field Work)

Vehicle Type	First Count (v/h)			Second count (v/)			Third count (v/h)			Ave. no. of vehicles per hour (v/h) (T1+T2+T3)/3	Standar Deviati n
	In-flow	Out-flow	Total (T1)	In-flow	Out-flow	Total (T2)	In-flow	Out-flow	Total T3		
Car	596	557	1153	607	539	1146	589	582	1171	1156.67	12.90
Mini Buses	205	198	403	218	197	415	216	199	415	411.00	6.93
Big Buses Lorries/ Trailers	27	29	56	19	31	50	32	20	52	52.67	3.06
Motorcycle	597	628	1225	587	631	1218	624	602	1226	1223.00	4.36
Tricycles	17	15	32	19	15	34	14	21	35	33.67	1.53
Total	1442	1427	2869	1450	1413	2863	1475	1424	2899	2877.00	19.29

Appendix VI (d): Traffic Count in Number of Vehicles per Hour (v/h) at Kwangila Fly-Over (Field Work)

Vehicle Type	First Count (v/h)			Second Count (v/h)			Third count (v/h)			Ave. no. of vehicles per hour (v/h) (T1+T2+T3)/3	Standard Deviation
	In-flow	Out-flow	Total (T1)	In-flow	Out-flow	Total (T2)	In-flow	Out-flow	Total (T3)		
Car	701	693	1394	685	698	1383	708	689	1397	1391.33	7.31
Mini Buses	202	215	417	189	217	406	200	216	416	413.00	6.08
Big Buses, Lorries/ Trailers	52	41	93	49	37	86	49	43	92	90.33	3.79
Motorcycle	661	592	1253	587	643	1230	657	597	1254	1254.00	1.00
Tricycles	15	11	26	12	14	26	17	8	25	25.67	0.58
Total	1631	1552	3183	1522	1609	3131	1631	1553	3184	3174.33	15.89

s/n	Sample	Parameters

Appendix VII (a): Proximate Composition of *Amaranthus hybridus* at third week of growth(**Laboratory Triplicate Analysis)**

		Moisture	Fat	Ash	Protein	Fibre	Carbohydrate
1	C3A	33.20	3.50	4.26	7.51	3.25	51.53
2	C3B	33.44	3.49	3.98	7.52	3.00	51.61
3	C3C	33.32	3.30	4.12	7.25	2.99	52.01
	Mean	33.31	3.43	4.12	7.43	3.08	51.72
	SD	0.10	0.11	0.14	0.15	0.15	0.26
4	R34	32.20	3.00	3.37	7.56	3.21	53.77
5	R3B	32.00	2.94	4.35	7.36	2.86	53.35
6	R3C	30.25	3.37	4.00	7.45	3.12	54.93
	Mean	31.52	3.44	3.57	7.46	3.06	54.02
	SD	1.11	0.47	0.37	0.10	0.12	0.82
7	P3A	33.00	3.30	4.32	6.75	2.88	53.63
8	P3B	31.55	3.43	4.15	7.02	2.97	53.85
9	P3C	32.02	2.98	4.20	7.03	3.65	53.77
	Mean	31.86	3.24	4.22	6.93	3.16	53.75
	SD	0.27	0.23	0.09	0.16	0.43	0.11
10	M3A	29.89	3.28	4.90	8.00	2.85	53.93
11	M3B	30.70	3.57	3.70	7.01	3.25	55.02
12	M3C	33.19	2.99	4.22	6.56	2.95	53.04
	Mean	31.26	3.29	4.27	7.19	3.02	53.99
	SD	1.73	0.29	0.60	0.74	0.21	0.99

13	K3A	32.50	3.19	4.72	7.30	3.00	52.29
14	K3B	33.13	3.67	4.56	6.96	2.75	51.68
15	K3C	33.05	3.12	4.62	8.02	2.85	51.19
	Mean	32.89	3.33	4.63	7.43	2.87	51.72
	SD	0.34	0.29	0.08	0.54	0.13	0.55

NOTE: The first letters C, R, P, M and K represents the different sites which are Control, Rex Junction, PZ junction, MTD junction and Kwangila Fly-Over respectively. The middle number 3 represents weeks of growth for the *Amaranthus hybridus* (third week of growth in the above table). The last letters A, B and C represents number of sample for each experiment set. They represent first sample, second sample and third sample respectively.

Appendix VII (b): Proximate Composition of *Amaranthus hybridus* at Forth Week of Growth (Laboratory Triplicate Analysis)

s/n	sample	parameters					
		moisture	fat	ash	protein	fibre	carbohydrate
1	C4A	33.40	3.40	4.26	7.52	3.45	51.42
2	C4B	31.50	2.60	3.43	6.89	4.10	55.56

3	C4C	33.10	3.32	3.82	7.23	3.55	51.53
	Mean	32.67	3.11	3.84	7.21	3.70	52.84
	SD	1.02	0.44	0.41	0.32	0.35	2.36
4	R4A	34.20	3.20	4.37	6.83	3.65	51.40
5	R4B	32.40	3.30	4.46	7.43	3.75	52.41
6	R4C	33.50	2.92	4.51	7.46	4.03	51.61
	Mean	33.37	3.14	4.45	7.24	3.81	51.81
	SD	0.91	0.20	0.07	0.36	0.20	0.53
7	P4A	32.70	2.86	5.26	8.01	3.46	51.17
8	P4B	33.30	3.42	4.81	7.40	2.98	51.07
9	P4C	34.20	3.21	3.75	7.45	3.89	51.39
	Mean	33.40	3.16	4.61	7.62	3.44	51.21
	SD	0.75	0.28	0.78	0.34	0.46	0.16
10	M4A	33.20	3.32	4.86	7.23	4.23	51.39
11	M4B	32.60	2.25	5.36	6.88	3.75	52.91
12	M4C	29.80	3.55	5.42	7.56	4.02	53.67
	Mean	31.87	3.04	5.21	7.22	4.00	52.66
	SD	1.81	0.69	0.31	0.34	0.24	1.16
13	K4A	28.90	3.01	4.23	7.44	4.54	56.42
14	K4B	34.70	3.20	5.42	7.23	3.89	49.45

15	K4C	33.10	3.34	4.98	7.01	2.78	51.57
	Mean	32.23	3.18	4.88	7.23	3.74	52.48
	SD	3.00	0.16	0.60	0.22	0.88	3.57

S/n	Sample	Parameters

NOTE: The first letters C, R, P, M and K represents the different sites which are Control, Rex Junction, PZ junction, MTD junction and Kwangila Fly-Over respectively.

The middle number 4 represents weeks of growth for the *Amaranthus hybridus* (fourth week of growth in the above table). The last letters A, B and C represents number of sample for each experiment set. They represent first sample, second sample and third sample respectively.

Appendix VII (c): Proximate Composition of *Amaranthus hybridus* at Fifth Week of Growth (Laboratory Triplicate Analysis)

		Moisture	Fat	Ash	Protein	Fibre	Carbohydrate
1	C5A	28.26	2.78	3.80	6.55	5.35	58.64
2	C5B	27.56	3.25	4.45	6.46	4.80	58.29
3	C5C	27.01	2.98	4.43	5.98	4.70	59.60
	Mean	27.60	3.00	4.23	6.32	4.95	58.84
	SD	0.61	0.24	0.37	0.30	0.35	0.68
4	R5A	28.04	3.25	4.2	5.89	5.20	58.62
5	R5B	27.42	2.85	5.3	6.75	4.60	57.68
6	R5C	26.78	3.75	3.1	6.65	5.10	59.80
	Mean	27.41	3.28	4.20	6.43	4.97	58.70
	SD	0.63	0.45	1.10	0.47	0.32	1.06
7	P5A	28.10	3.00	2.95	6.19	3.95	59.76
8	P5B	28.00	2.95	5.73	6.85	4.89	56.47
9	P5C	27.05	2.82	4.65	5.99	5.23	59.49
	Mean	27.72	2.92	4.44	6.34	4.69	58.57
	SD	0.58	0.09	1.40	0.45	0.66	1.83
10	M5A	26.89	2.45	4.20	6.75	4.30	59.71
11	M5B	27.52	2.86	5.02	5.85	3.98	58.75
12	M5C	28.01	3.32	4.00	6.73	4.45	57.94
	Mean	27.47	2.88	4.41	6.44	4.24	58.80
	SD	0.56	0.44	0.54	0.51	0.24	0.89

13	K5A	28.23	3.10	4.65	5.87	4.40	58.15
S/n	Sample	Parameters					
14	K5B	27.10	2.56	5.25	6.78	4.45	58.31
		Moisture	Fat	Ash	Protein	Fibre	Carbohydrate
15	K5C	26.85	3.65	5.10	6.55	3.85	57.85
1	C6A	27.02	3.14	4.42	6.22	5.28	59.38
	Mean	27.39	3.10	5.00	6.40	4.23	58.10
2	C6B	26.55	2.89	4.36	5.89	5.35	60.31
	SD	0.74	0.55	0.31	0.47	0.33	0.23

NOTE: The first letters C, R, P, M and K represents the different sites which are Control, Rex Junction, PZ Junction, MTD Junction and Kwangila Fly-Over respectively.

The middle number 5 represents weeks of growth for the *Amaranthus hybridus* (fifth week of growth in the above table)The last letters A, B and C represents number of sample for each experiment set. They represent first sample, second sample and third sample respectively.

Appendix VII (d): Proximate Composition of *Amaranthus hybridus* at Sixth Week of Growth (laboratory triplicate analysis)

3	C6C	27.46	3.02	3.86	6.25	5.24	59.41
	Mean	27.01	3.02	4.15	6.12	5.29	59.70
	SD	0.46	0.13	0.26	0.26	0.06	0.53
4	R6A	27.25	3.24	4.23	6.13	5.18	60.15
5	R6B	27.10	3.00	4.15	6.15	5.16	59.60
6	R6C	27.00	2.98	4.16	6.10	5.23	59.79
	Mean	27.12	3.07	4.18	6.13	5.19	59.84
	SD	0.13	0.14	0.04	0.03	0.04	0.02
7	P6A	28.03	2.89	3.96	6.14	4.98	58.98
8	P6B	27.35	3.03	4.46	6.09	5.48	59.07
9	P6C	26.15	3.12	4.37	6.12	5.37	60.24
	Mean	27.18	3.01	4.26	6.12	5.28	59.43
	SD	0.09	0.12	0.27	0.03	0.26	0.07
10	M6A	27.04	3.15	4.26	6.25	5.47	59.30
11	M6B	27.00	2.65	4.35	5.98	5.39	60.02
12	M6C	27.01	3.03	4.16	6.19	4.99	59.61
	Mean	27.02	2.94	4.26	6.14	5.28	59.64
	SD	0.02	0.26	0.09	0.14	0.26	0.36
13	K6A	26.85	3.05	3.96	6.11	5.35	60.03
14	K6B	27.13	3.12	4.27	6.14	5.34	59.34

15	K6C	27.02	3.01	4.38	6.13	5.31	59.46	
	Mean	27.00	3.06	4.20	6.13	5.33	59.61	
Site		moisture content				Site		Standard
	SD	0.14	0.06	0.22	0.02	0.02	0.37	
		Weeks of Analysis				Average		Deviation

NOTE: The first letters C, R, P, M and K represents the different sites which are Control, Rex Junction, PZ Junction, MTD Junction and Kwangila Fly-Over respectively.

The middle number 6 represents weeks of growth for the *Amaranthus hybridus* (sixth week of growth in the above table).

The last letters A, B and C represents number of sample for each experiment set. They represent first sample, second sample and third sample respectively.

Appendix VIII: Average Proximate Composition of *Amaranthus hybridus*

	3rd	4th	5th	6th		
Control	33.31	32.67	27.60	27.01	30.15	3.30
Rex Junction	31.52	33.37	27.41	27.12	29.86	3.09
PZ Junction	31.86	33.40	27.72	27.18	30.04	3.06
MTD Junction	31.26	31.87	27.47	27.02	29.41	2.5
Kwangila fly-Over	32.89	32.23	27.39	27.00	29.88	3.1
		Fat Content				
Control	3.43	3.11	3.00	3.02	3.14	0.20
Rex Junction	3.28	3.14	3.28	3.07	3.19	0.11
PZ Junction	2.92	3.16	2.92	3.01	3.00	0.11
MTD Junction	2.88	3.04	2.88	2.94	2.94	0.08
Kwangila Fly-Over	3.10	3.18	3.10	3.06	3.11	0.05
		Ash Content				
Control	4.12	3.84	4.23	4.15	4.09	0.17
Rex Junction	3.57	4.45	4.20	4.18	4.10	0.37
PZ Junction	4.22	4.61	4.44	4.26	4.38	0.18
MTD Junction	4.27	5.21	4.41	4.26	4.54	0.45
Kwangila Fly-Over	4.63	4.88	5.00	4.20	4.68	0.35
		Crude Protein				
Control	7.43	7.21	6.32	6.12	6.77	0.64
Rex Junction	7.46	7.24	6.43	6.13	6.82	0.63

PZ Junction	6.93	7.62	6.34	6.12	6.75	0.67
MTD Junction	7.19	7.22	6.44	6.14	6.75	0.54
Site	moisture content Weeks of Analysis				Site Average	Standard Deviation
Kwangila Fly-Over	7.42	7.23	6.40	6.13	6.80	0.06
	3rd	4th	5th	6th		
		Crude Fibre				
Control	27.30	28.49	27.32	29.43	28.14	0.89
Control	3.80	3.70	4.95	5.29	4.44	0.80
rex junction	28.56	29.52	28.45	27.03	28.39	0.89
Rex Junction	3.06	3.81	4.97	5.19	4.26	1.00
PZ Junction	3.16	3.44	4.69	5.28	4.14	1.00
MTD Junction	3.02	4.00	4.24	5.28	4.14	0.93
Kwangila Fly-Over	2.87	3.74	4.23	5.33	4.04	1.03
		Carbohydrate				
Control	51.72	52.84	58.84	59.70	55.78	4.08
Rex Junction	54.02	51.81	58.70	59.84	56.09	3.81
PZ Junction	53.75	51.21	58.57	59.43	55.74	3.92
MTD Junction	53.99	52.66	58.80	59.64	56.27	3.46
Kwangila Fly-Over	51.72	52.48	58.10	59.61	55.47	3.96

Appendix IX: Average Proximate Composition of *Mangifera indica*

pz junction	27.06	26.85	28.62	28.65	27.80	0.84
mtd junction	29.32	28.98	29.02	29.92	29.31	0.17
Kwangila fly-over	28.65	28.67	28.58	28.75	28.66	0.06
			Fat Content			
Control	1.88	1.98	1.97	2.02	1.96	0.05
Rex junction	1.96	2.03	2.02	2.12	2.03	0.06
PZ junction.	2.12	1.96	2.22	2.32	2.16	0.15
MTD Junction	2.02	2.12	2.15	2.20	2.12	0.08
kwangila Fly - Over	2.45	2.45	2.20	1.98	2.15	0.23
			Ash Content			
Control	2.65	2.73	2.66	2.75	2.70	0.04
Rex junction	2.44	2.43	2.40	2.35	2.41	0.04
PZ junction	2.35	2.25	2.30	2.36	2.32	0.05
MTD junction	2.04	1.99	2.03	1.99	2.01	0.02
kwangila Fly - Over	3.36	2.27	2.32	2.33	2.57	0.53
			Crude Protein			
Control	3.47	3.23	3.48	3.49	3.42	0.13
Rex Junction	3.59	3.33	3.46	3.52	3.48	0.11
PZ Junction	3.64	3.37	3.54	3.47	3.51	0.11
MTD Junction	3.57	3.28	3.65	3.68	3.51	0.18
kwangila Fly-	3.45	3.32	3.57	3.65	5.50	0.14

Over

	Crude Fibre						
Control	4.24	3.36	4.40		4.52	4.13	0.53
			Growth Rate (cm)				
Rex Junction	5.27	5.02	5.32		5.02	5.16	0.16
	1st Week	2nd Week	3rd Week	4th Week	5th Week	6th Week	Site Average
PZ Junction	4.89	4.86	4.67		5.12	4.89	0.18
MTD Junction	5.25	5.36	5.47		4.98	5.27	0.21
			Rex Junction				
Kwangila fly-	4.99	4.89	5.23		5.35	5.12	0.21
1st Measurement	4.70	14.10	25.10	35.90	43.40	52.20	
Over							
2nd Measurement	4.10	15.70	24.50	36.70	44.10	51.60	
	Cabohydrate						
3rd Measurement	5.50	14.90	25.70	37.70	45.00	53.00	
Control	64.70	63.57	64.57		62.31	63.79	12.10
Average	4.80	14.80	25.10	36.80	44.20	52.30	29.68 $\pm$18.06
Rex junction	63.45	62.69	63.67		64.98	63.70	0.95
PZ junction	64.83	65.57	63.32		63.20	64.23	1.16
mtd junction	63.05	63.63	63.15		62.21	63.01	0.59
Kwangila fly	63.57	63.63	63.33		63.29	63.46	0.17

– Over

Appendix X: Weekly Measurement of the Growth Rate of *Amaranthushybridus* (Field Work)

Std. Dev.	0.70	0.80	0.60	0.90	0.80	0.70	
			MTD Junction				
1st Measurement	3.90	14.70	25.10	36.40	44.00	51.90	
2nd Measurement	5.50	14.00	24.40	38.20	43.40	51.40	
3rd Measurement	4.60	15.60	25.50	37.20	44.80	52.60	
Average	4.70	14.40	25.00	37.30	44.10	52.00	29.65 ± 18.00
Std. Dev.	0.80	0.80	0.60	0.90	0.70	0.60	
			PZ Junction				
1st Measurement	6.00	15.30	26.10	37.10	43.00	52.40	
2nd Measurement	4.60	14.80	25.30	37.60	43.50	52.80	
3rd Measurement	5.20	16.00	24.50	36.60	44.20	54.30	
Average	5.30	15.40	25.30	37.10	43.60	52.40	29.85 ±17.97
Std. Dev	0.70	0.60	0.8	0.50	0.60	0.40	
	Kwangila Fly-Over						
1st Measurement	4.00	15.90	24.50	35.10	45.00	51.80	
2nd Measurement	5.00	14.30	24.10	36.70	45.70	51.50	
3rd Measurement	6.00	15.00	25.10	35.90	45.00	52.30	
Average	5.10	15.10	24.60	35.90	45.00	51.90	26.6 ±17.94
Std. Dev.	0.90	0.80	0.50	0.80	0.70	0.40	
			Control				
1st Measurement	6.00	15.90	24.70	37.10	44.70	52.40	
2nd Measurement	5.00	15.10	23.80	38.40	42.90	51.60	
3rd Measurement	4.00	14.50	25.90	36.40	43.70	51.00	
Average	5.00	15.20	24.80	37.20	43.80	51.70	29.62 ± 17.79

Std. Dev.	0.70	0.70	1.10	0.80	0.90	0.70

Appendix XI: Apparatus

- Portable gas analyzers with deferent sensors for each of the pollutants.
- Digital camera.
- GPS instrument
- Planting pots/ hand trowel
- Desiccator
- Muffle furnace
- Crucible
- Soxhlet extractor
- Aluminium Plate
- Heating mantle
- Volumetric flasks
- Kjeldahl digestion flask
- Grinder / sieve
- Analytical weighing balance
- Filter paper
- Stoppered bottles

Blender