EFFECTIVENESS OF VEGETATION IN REDUCING SOME TRAFFIC EMISSION POLLUTANTS IN BENIN CITY, EDO STATE, NIGERIA.

By

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DECLARATION

I declare that the work in this thesis entitled the Effectiveness of Vegetation in Reducing Some Traffic Emission Pollutants in Benin City; Edo State, Nigeria has been performed by me in the Department of Geography under the supervision of Dr. J. O. Folorunsho and Rev. Dr. S. S. Obeka. 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 thesis titled 'EFFECTIVENESS OF VEGETATION IN REDUCING SOME TRAFFIC EMISSION POLLUTANTS IN BENIN CITY, EDO STATE, NIGERIA' by ESEUWA NAOMI AIGBOBO meets the regulations governing the award of the degree of Master of Science (Environmental Management) of the Ahmadu Bello University, and is approved for its' contribution to knowledge and literary presentation.

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DEDICATION

This thesis is dedicated to God Almighty that made this work a reality.

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ABSTRACT

This study investigated vegetation effectiveness in bringing to the barest minimum some traffic emission pollutants in Benin City, Edo State, Nigeria. The following were the set objectives: to examine the emission levels of CO, SO_2, and NO_2 pollutant in the sample points where there are no vegetation, to assess the emission levels of CO, SO_2, and NO_2 in the sample points where there are vegetation and to compare the emission levels of these gases at the vegetated sample points with that of the non vegetated sample points for any variable difference. Four sampling locations were selected, and classified as vegetative and non-vegetative sampling locations. Plymonth Road and Sapele Road A were classified under non-vegetative sampling locations and Reservation Road and Sapele Road B were classified under vegetative sampling locations. The sampling locations were geo-referenced using high sensitivity etrex garmin GPS. Data for the study was derived from the measurement of the concentration of these traffic emission pollutants with the aeroqual air quality kit. Data was analyzed descriptively using bar chart, mean, and standard deviations. Independent t-test was also used to verify if there was significant difference between vegetation and air quality at the sampling points at 0.05 level of significance. The results obtained revealed variations in the amount of CO, SO_2 and NO_2 in the study area. Sampling locations with no vegetation showed a higher concentration of these traffic emission pollutants than the sampling locations with vegetation cover. Plymonth Road has an average concentration of 11.11401ppm for CO and 0.11335ppm for NO_2 while Sapele Road A has an average concentration of 0.145665ppm for SO_2 and these were the highest. Sapele A has the least average concentration of 2.195825ppm for CO and 0.007685ppm for NO_2 and Reservation Road has the least average concentration of 0.0795ppm for SO_2. Sapele Road B has a constant average concentration of 0.00ppm for CO, 0.13ppm for SO_2 and 0.001ppm for NO_2 at all times measured. Result also indicated a significant difference in the levels of the air pollutants (CO, SO_2 and NO_2) between the vegetated sampling locations and the non-vegetated locations. The study concludes that the presence of vegetation along urban roads reduces the concentration of these traffic emission pollutants present in the atmosphere, thus improving the air quality of the locality.

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LIST OF ABBREVIATIONS AND TERMS

Abbreviation	Translation
$\mu g/m^3(\mu gm^3)$	micro gram per metre cube
μgm^{-3}	micro gram per metre cube
µm	micro metre
ACFA	Asian Clean Fuel Association
AQI	Air quality index
$CaCO_3$	Calcium carbonate (limestone)
$CaSO_4$	Calcium sulphate
$CaSO_4.2H_2O$	Gypsum
CEC	Commission of the European Communities
CFC	Chloro flouro carbon
CH_4	Methane
CO	Carbon monoxide
CO_2	Carbon IV oxide
CxHy	Hydrocarbons
DNA	Dioxyribonucleic acid
ECOWAS	Economic Community of West African States
EPA	Environmental Protection Agency
EU	European Union
FEPA	Federal Environmental Protection Agency
FRAME	Fine Resolution Atmospheric Multi-pollutant Exchange
FRSC	Federal Road Safety Commission
$g/m^2/yr$	gram per metre square per year
GPS	Global Positioning System

H_2S	Hydrogen sulphide
HC	hydrocarbon
HEI	Health Effects Institute
Kg $year^{-1}$	Kilogram per year
Kg/yr	kilogram per year
mg/m^3	miligram per metre cube
N_2	Nitrogen
NESREA	National Environmental Standards and Regulations Enforcement Agency
NH_3	Ammonia
NO_2	Nitrogen IV oxide
NO_x	Nitrogen oxides
NPC	National Popultaion Commission
PAHs	Polycyclic aromatic hydrocarbons
PCBs	Polychloro biphenyls
PM	Particulate matter
ppb	Part per billion
ppm	parts per million
SEM	Scanning Electron Microscope
SO_2	Sulphur IV oxide
THCs	Total hydrocarbons
Tons	Tonnes
TSP	Total Suspended Particulate
USEPA	United State Environmental Protection Agency
VOCs	Volatile Organic Compounds
WHO	World Health Organization

CHAPTER ONE: INTRODUCTION

1.1 Background of the Study

Over 600 million people globally are exposed to hazardous level of traffic–generated pollutants (United Nation UN, 1998). Human exposure to these air pollutants is believed to have posed severe health problems especially in urban areas where pollution levels are on the increase. Pollution due to traffic constitute up to 90 – 95% of the ambient carbon monoxide (CO) levels, 80 – 90% of nitrogen oxides (NO_n), hydrocarbon and particulate matter in the world, posing a serious threat to human health (Savile, 1993). Research conducted a decade and half ago has shown that transportation sources in the USA were responsible for 77% of CO levels, 80 -90% of NO_n, 36% of volatile organic compounds and 22% of particulate matter (USEPA, 1993). Similarly, in United Kingdom (UK) the average concentration of nitrogen dioxide 'NO_2' was found to increase by 35% from 1986 to 1991 due to increase in vehicular emission (CEC, 1992).

In Nigeria, increased pollution from mobile sources is on the increase with per capita increase in vehicle ownership. The consequence of this is the congestion of most Nigeria city roads and a corresponding increase in the burden of air pollutants and their associated effects. According to Koku and Osuntogun (1999), in their study of the impacts of urban road transportation on the ambient air quality in three cities of Nigeria: Lagos, Ibadan and Ado – Ekiti, air quality indicators namely CO, sulphur dioxide (SO_2), nitrogen (iv) oxide (NO_2), and total suspended particulates (TSP) were determined. Conclusions of this investigation show a growing risk of traffic-related problems in Nigeria cities and demand for serious air quality measures.

Air pollution is the contamination of air by discharge of harmful substances, which can cause health problems including burning eyes and nose, itchy irritated throat and breathing problems (USEPA, 1994). Air pollution leads to an increase in the amount of some gases in the atmosphere beyond normal conditions that could be seriously harmful to human health. According to Dara (2004), any major disturbance in the composition of the atmosphere resulting from anthropogenic activities may lead to disastrous consequences or may even endanger the survival of life on earth. Examples of air pollutant include: nitrogen (IV) oxide (NO_2), sulphur (IV) oxide (SO_2), carbon monoxide (CO), particulate matter (PM), photochemical oxidants and heavy metals like Lead (Pb), and other volatile organic compounds (VOCs).

In urban areas, automobiles form a significant source of a number of air pollutants, namely: particulate matter, NO_2, hydrocarbons, carbon monoxide and Lead. These pollutants are produced when fuel is burnt under less than ideal conditions. Non uniform oxygen supply within the combustion chamber and lower flame temperature leads to incomplete combustion releasing CO, hydrocarbon (HC) and un-burnt particles in the exhaust (Garret and Newton, 2001). From the report of the US Environmental Protection Agency (2007), vehicles account for 51% of carbon monoxide, 34% of nitrogen oxides and 10% of particulate matter released each year in the US. Clearly, vehicle emissions are a major source of ambient air pollution that must be controlled if air quality is going to be maintained. Gheorghe and Ion (2012) confirmed that vegetation plays an important positive role in atmospheric purification and air pollutants reduction. Generally, urban trees and shrubs (hereafter referred to collectively as "vegetation") offer the ability to remove significant amounts of air pollutants and consequently improve environmental quality and human health. Trees remove gaseous

air pollutants primarily by uptake via leaf stomata, though some gases are removed by the plant surface. Once inside the leaf, gases diffuse into intercellular spaces and may be absorbed by water films to form acids or react with inner-leaf surfaces (Smith, 1990). Trees also remove pollution by intercepting airborne particles. Some particles can be absorbed into the tree, though most particles that are intercepted are retained on the plant surface. The intercepted particle often is re-suspended to the atmosphere, washed off by rain, or dropped to the ground with leaf and twig fall (Ibid).

In 1994, it was estimated that in New York trees removed 1,821 metric tonnes of air pollution at an estimated value to society of $9.5 million. Air pollution removal by urban forests in New York was greater than in Atlanta (1,196 tonnes; $6.5 million) and Baltimore (499 tonnes; $2.7 million), but pollution removal per m^2 of canopy cover was fairly similar among these cities (New York: 13.7 $g/m^2/yr$; Baltimore: 12.2$g/m^2/yr$; Atlanta: 10.6 $g/m^2/yr$) (Nowak and Crane, 2000). These standardized pollution removal rates differ among cities depending on the amount of air pollution, length of in-leaf season, precipitation, and other meteorological variables. Large healthy trees greater than 77 cm in diameter remove approximately 70 times more air pollution annually (1.4 kg/yr) than small healthy trees less than 8 cm in diameter (0.02 kg/yr) (Nowak, 1994). Air quality improvement in New York City due to pollution removal by trees during daytime of the in-leaf season averaged 0.47% for particulate matter, 0.45% for ozone, 0.43% for sulphur dioxide, 0.30% for nitrogen dioxide, and 0.002% for carbon monoxide. Air quality improves with increased percent tree cover and decreased mixing-layer heights. In urban areas with 100% tree cover (i.e., contiguous forest stands), short-term improvements in air quality (one hour) from pollution removal by

trees were as high as 15% for ozone, 14% for sulfur dioxide, 13% for particulate matter, 8% for nitrogen dioxide, and 0.05% for carbon monoxide (Ibid).

Sturman and Spronken-Smith (2001) stated that "Vegetation" signifies palatable plants to a pastoral farmer, commercially important trees to a forester, diverse textures to an artist, and valued species to a conservationist. To a geographer, the vegetation cover of an area is a three-dimensional, organised, dynamic, and functional aggregation of living things that protects soil and rocks from accelerated erosion, moderates the flow of water into streams, provides shelter to people and their livestock, tempers local climates, enhances visual appearance, fosters feelings of identity with place, creates opportunities for recreation, records past human activities and extreme environmental events, mops up atmospheric carbon dioxide, and affects albedo (Ibid). Urban forest consists of multiple species of vegetation which are intentionally planted or naturally grown within the urban areas. It contains a diverse mix of plant species which are arranged in heterogeneous or homogenous patterns (McPherson, *et al*., 1997).

Studies have shown that trees could contribute significantly to air pollution reduction in cities. Nowak, Crane, and Stevens (2006) estimated that urban trees remove a total of 711 000 metric tons of pollutants annually in the U.S. These findings led to the inclusion of tree planting as a state implementation strategy for improving air quality by the United States Environmental Protection Agency (US EPA, 2004); Powe and Willis (2004) estimated that for Britain as a whole, the economic value of health benefit of woodlands is £900 000 per year in terms of savings from deaths brought forward, and reduced hospital bills; Stewart, *et al*. (2002) estimated that doubling the number of trees in the West Midlands of the UK could result in saving 140 lives from the effects of air

pollution; Nowak (1994) estimated that trees in Chicago resulted in an average air quality improvement of 0.3% with the greatest overall removal effects for particulates less than 10μm (PM_{10}) removing 234tons; Nowak, Mchale, Ibarra, Crane, Stevens, and Luley (1998) estimated that trees in Philadelphia improved air quality by 0.72%.

1.2 Statement of the Research Problem

Air is a universal gas that is odourless, colourless and essential for the existence of all life forms on earth. Air quality is very essential for the sustenance of life. Air pollution due to human activities is an abuse to the environment thereby degrading the air quality. Air quality in urban areas is significantly being affected by traffic-related pollutants resulting from the increase use of transportation. City air often contains high levels of pollutants that are harmful to human health (Mayer, 1999). The American Lung Association (ALA, 2007) reported that over 3700 premature deaths annually in the United States could be attributed to a 10-ppb increase in O_3 levels. Worldwide, the World Health Organization (WHO, 2002) estimated that more than 1 million premature deaths annually could be attributed to urban air pollution in developing countries. The United Nations Population Fund (UNFPA, 2007) predicted that the urban population worldwide would increase from 3.3 billion in 2008 to 5 billion by 2030, meaning that there will be an increase in sensitive population groups such as children and the elderly. Therefore, cities with serious air pollution problems need to come up with ways to control the problem and reduce the damages.

Benin City, the capital and largest city of Edo State has a population of about 1.3 million (National Population Commission NPC, 2006). It is a commercial city with few petroleum and allied industries. Traffic volume is high in the city year round, because

the city is a gateway to other parts of the country. Increasing automobiles traffic in the city and the use of agricultural land for constructing buildings has destroyed the environment of the city. The major sources of air pollutant in Benin City are poorly maintained automobile that run on diesel and leaded fuel which emit black smoke of incomplete combustion fuel all over the city. The emissions released by motor vehicles depend largely on the fuel type and quality as well as on the state of the engine of the vehicles. Other sources of air pollutant are industrial emissions and open burning of refuse waste. Studies have shown that the city air contains a high level of pollutant that is harmful to human health (Ukpebor, Ukpebor, Eromomene, Odiase, and Okoro, 2010).

Ukpebor and Ahonkhai (2000) monitored the NO_2 levels in Benin City. They recorded the highest concentration of NO_2 13.53 $\mu g/m^3$ in dry season and lowest of 3.02 $\mu g/m^3$ in wet season and observed a positive relationship between NO_2 levels and traffic density. Ukpebor, Ukpebor, Eromomene, Odiase, and Okoro (2010), also evaluated the diurnal variation of CO generation and distribution at several road junctions and motor parks in Benin City and at the five sampling locations selected, very high CO concentrations were measured with a mean range of 14.8-28.3ppm. It was observed that the baseline ambient level of CO in Benin City exceeds the available national and international regulatory limits. Vehicular exhaust was identified as the main CO source in the city. Frequent traffic jams resulting from poorly maintained roads, high traffic density, unfavourable traffic handling, inadequate traffic discipline and very low wind speed are identified as the main factors responsible for the high emissions, accumulation, and low dilution and dispersion of the generated CO.

Olumayede and Okuo (2012) studied the Volatile Organic Compound (VOC) concentrations in ambient air of Benin City to understand the composition and concentration distribution. Fifteen species of VOCs were detected in the samples from seven sampling sites in Benin City. Among the VOC species detected are 4 alkanes, 6 aromatic compounds, 4 chlorinated hydrocarbons, and 1 ketone. The concentrations of VOCs at the seven sampled sites of Benin City showed obviously diurnal and seasonal variations. The results showed that ambient VOC levels in the atmosphere of Benin City are driven by high traffic; hence high concentrations were observed in most traffic junctions sampled.

Ediagbonya, Tobin, and Ukpebor (2013) assessed the level of suspended particulate matter in sawmills in Benin City. Sawdust particulate matter was captured from nine different locations of Benin metropolis at a flow rate of 21/min and a sampling duration of eight hours. The total suspended particulate (TSP) were in the range of 833.33 – 1,666.56 obtained which indicate that the available national standard, 250µg/m^3 were clearly exceeded.

All these studies (Ukpebor and Ahonkhai (2000); Ukpebor *et al*. (2010); Olumayede and Okuo (2012); Ediagbonya *et al*. (2013)) have all concluded that the city air is polluted but they have not considered the effectiveness of urban vegetation as a suitable means of reducing the concentration of pollutants in the atmosphere and this is the gap this study wants to fill. In view of these, the following research questions were raised to guide the study:

i. What are the emission levels of CO, SO_2 and NO_2 pollutant at the sample points where there is no vegetation?

ii. What are the emission levels of CO, SO_2 and NO_2 pollutant at the sample points where there is vegetation?

iii. Is there any difference between the emission levels at the vegetation free sample point and the sample point where there are vegetation?

1.3 Aim and Objectives

The aim of this study is to assess the effectiveness of vegetation in mitigating some traffic emission pollutants to improve air quality in Benin City. This will be achieved through the following objectives which are to;

i. examine the emission levels of CO, SO_2, and NO_2 pollutant in the sample points without vegetation,

ii. assess the emission levels of CO, SO_2, and NO_2 in the sample points where there are vegetation,

iii. compare the emission levels of these gases at the vegetated sample points with that of the non vegetated sample points.

1.4 Hypothesis

The following null hypothesis was stated for testing at 0.05 level of significance:

H_0: There is no significant difference between vegetation cover and traffic emission pollutant of the study area.

1.5 Justification of the Study

Exposure to traffic-related air pollutants has been linked to a wide variety of health concerns, including respiratory and cardiovascular problems, birth and developmental defects, and cancer (HEI, 2010). For example nitrogen oxides and sulphur oxides, are

associated with immune system impairment, exacerbation of asthma and chronic respiratory diseases, reduced lung function, and cardiovascular disease (Schwela, 2000). Particulates are dangerous and are linked as facilitators in the development of lung cancer and increase rate of mortality (Ibid). Exposure to carbon monoxide can result in fatigue, headaches, dizziness, loss of consciousness, and even death at very high concentrations (Ibid). Carbon monoxide causes blood clotting when it reacts with haemoglobin, which cuts the supply of oxygen in the respiration system after long exposure. This is a common occurrence in urban centres with a high level of commercial activity (Ackerman, Davies, Jefferson, Longhust, and Marquez, 2002; Gibbs, Betty, Dolaty, and Angento, 1995; Glen, Zelenka, and Graham, 1996; Johnson, Jamriska, Morawska, and Ferreira, 2000).

There are a number of mechanisms by which vegetation can improve air quality thereby reducing the impact of air pollution. Trees can intercept atmospheric particles and absorb various gaseous pollutants; various tree configurations can alter wind profiles or create local inversions to trap pollutant such that the localized removal of pollutants is enhanced (Nowak, 1994; Khan and Abbasi, 2001). Trees can lower air temperatures through transpiration, which affects the photochemistry of ozone, and reduces ozone production (Cardelino and Charmeides, 1990). Furthermore, trees can reduce building energy use by shading buildings and altering air flows, thereby indirectly reducing pollution emission from power plants (Nowak, 1994).

Given the enormous health and societal impacts resulting from near-road air pollution, it is critical to develop effective strategies to mitigate near-road air pollution. It is in this

light that the effectiveness of vegetation in mitigating air quality impact of traffic emission is being assessed.

1.6 Scope of the Study

This research focuses on assessing the effectiveness of vegetation in reducing the emission levels of some traffic emission pollutants in Benin City and the concentration of these gases were sampled at four different traffic points in Benin City, Edo State. No weather element was considered in the study because it will increase the cost of the research. Two sample points were located at Reservation Road (with vegetation) and Plymonth Road (without vegetation) while the other two were located at Sapele Road; one of the sampling point was sited at a place where there are vegetations along the road and the other in the non-vegetative part of Sapele Road.

The pollutants considered in this study included; CO, SO_2, and NO_2 which are important in the assessment of air quality of urban environments (Ndiokwere, 2004). The study was aimed at confirming if vegetation actually helps to reduce traffic related air pollutant or not.

The collection of these emission values were carried out for a period of three days in a week for each sampling point in the month of October/November, 2013, with each day taking into consideration the heavy-traffic in the morning, low-traffic hours during afternoon and high-traffic during the evening hours (Ukpebor *et al*., 2010).

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

Air is a part of the Earth's atmosphere, and one of its most important natural resources. Air is shared and used by all humans, animals and plants to sustain life. Near major industrial centres and in big cities, the air often is of unsatisfactory quality. Air quality degradation is not new – since the middle of the 19th century, the atmosphere of the major British cities was regularly polluted by coal smoke in winter, giving rise to an infamous mixture of fog and smoke known as smog. Today the emphasis has shifted from the pollution problems caused by industry to the ones associated with motor vehicle emissions. Even in Benin City studies have confirmed that the air is polluted and it has been attributed mainly to vehicular exhaust. Literatures related to this study are reviewed under the following sub-headings; conceptual framework, and review of related empirical studies.

2.2 Pollution

Seyyednjad, Majdian, Koochak, and Niknejad (2011) defined air pollution as the human introduction into the atmosphere of chemicals, particulate matter, or biological materials that cause harm or discomfort to humans or other living organism, or damage the environment.

Pollutants are substances introduced into the environment in an amount sufficient to cause adverse measurable effects on human beings, animals, or materials. Pollutants are referred to as primary pollutants, if they exert the harmful effects in the original form in which they enter the atmosphere e.g. CO, NO_n, HCs, SO_n, particulate matter and so on. On the other hand, secondary pollutants are products of chemical reactions, among

primary pollutants are ozone, hydrogen peroxide, peroxyacetylnitate (PAN) and peroxybenzoyl nitrate (PBN). Classification of pollutants can also be according to chemical compositions i.e. organic or inorganic pollutants or according to the state of matter i.e. gaseous or particulate pollutants. Air pollution is basically made up of three components and these are source of pollutants, the transporting medium, which is air and target or receptor which could be man, animal, and structural facility (Abdul Raheem and Adekola, 2011).

2.2.1 Traffic air pollutants

Transportation involves the combustion of fossil fuels to produce energy translated into motion. Pollution is created from incomplete carbon reactions, unburned hydrocarbons or other elements present in the fuel or air during combustion. The principal pollutants from the transport sector responsible for adverse health effects include lead, various types of particulate matter, ozone (formed from atmospheric reactions of oxides of nitrogen and volatile organic compounds), various toxic VOCs, nitrogen dioxide, carbon monoxide, ammonia and sulphur dioxide (Gorham, 2002).

According to Ajayi and Dosunmu (2002), the exhaust, the crankcase, the fuel tank and the carburettor are the sources of unburned hydrocarbon (HC). However, the proportion of these various pollutants attributable to the transport sector varies significantly across different cities.

Carbon monoxide is an odourless and colourless gas that is produced during the incomplete combustion of carbon-containing materials, including gasoline, natural gas, oil, coal, wood, and tobacco (Haley, 2003). According to Ndiokwere (2004), the

principal source of carbon monoxide in outdoor air is motor vehicle emissions and the worldwide concentration of CO is estimated at between 0.1 and 0.5ppm but its concentration in air over cities can be well over 50 times as great. Outdoor concentrations of carbon monoxide vary depending on how and where and when the gas is produced. For example, in urban areas, carbon monoxide levels are greatest in downtown areas where motor vehicle density is high, during peak commuting times, and in the passenger compartments of motor vehicles. Carbon monoxide binds reversibly with haemoglobin and inhibits oxygen uptake and thus, interferes with the ability of the blood to carry oxygen to tissues; the most sensitive of these tissues are in the heart and brain (Henry *et al*., 2006).

The health effects of carbon monoxide poisoning ranges from impaired mental alertness and performance, headaches, nausea, fatigue, and dizziness to coma and death. Long-term (chronic) exposure to low levels of CO may produce heart disease and damage to the nervous system. Exposure of pregnant women to CO may cause low birth weight and nervous system damage to the offspring (Henry *et al*., 2006). Apart from its lethality, CO is an indirect greenhouse gas that increases the amount of other greenhouse gases and eventually oxidizes into the main greenhouse gas, CO_2. It also plays a role in the generation of ground-level ozone (Ukpebor *et al*., 2010).

Nitrogen oxides (NO and NO_2, referred together as NO_n) are highly reactive gases formed when oxygen and nitrogen react at high temperatures during combustion or lightning strikes. Nitrogen present in fuel can also be emitted as NO_n during combustion. In the atmosphere NO_n reacts with volatile organic compounds (VOCs) and carbon monoxide to produce ground-level ozone through a complicated chain

reaction mechanism. It is eventually oxidized to nitric acid (HNO_3). Like sulfuric acid, nitric acid contributes to acid deposition and to aerosol formation. Nitrogen dioxide is the most abundant oxidized nitrogen compound in background air that is a product of high-temperature combustion. Motor vehicle emissions are the primary source of nitrogen dioxide in outdoor air, but power plants and fossil fuel-burning industries also contribute. Nitrogen dioxide can irritate the lung and alter its defense mechanisms, thereby increasing a person's risk for respiratory infections. Its role in the formation of photochemical oxidants and smog has attracted the attention of several scientific researchers in recent years.

Ukpebor and Ahonkhai (2000) monitored the NO_2 levels in Benin City. They recorded the highest concentration of NO_2 13.53 $\mu g/m^3$ in dry season and lowest of 3.02 $\mu g/m^3$ in wet season and observed a positive relationship between NO_2 levels and traffic density. In the assessment of air quality in Benin City Ukpebor and Ahonkhai (2000) also studied the levels of tropospheric ozone. The highest and lowest ozone levels were recorded at the Ring Road location and University of Benin campus respectively. The monthly mean concentrations varied spatially. Differences in traffic volume or density and industrial activities seem to be responsible for this observation. Tropospheric ozone is a "greenhouse" gas and NO_2 is the limiting precursor for the formation of ozone in the free troposphere. Though, Benin City can still be seen as relatively safe in terms of ozone pollution. Other world cities record higher ozone concentrations. For example, about a decade ago, the state of California, U.S.A. reached a crisis point concerning its air pollution levels. With the population of California exceeding 30m in 1990 there were 23m registered vehicles in the state, and the total vehicle miles traveled were 242 billion. The state-wide average for NO_n emissions per vehicle was 3.0g/mile; 2.7g/mile

per vehicle for hydrocarbons. The cumulative California vehicle emissions for nitrogen oxides and hydrocarbons totaled about 1.4m tons/year. The South Coast Air Basin's maximum one-hour ozone concentration recorded was 0.33pm and the area exceeded the stage I Smog Alerts (0.20 pm ozone) on 42 days of the year. This crisis led California to tackle the problem head-on to monitor and restrict pollution levels. These statistics are important to us here in Nigeria living in big cities because vehicles are increasing in large numbers, of all makes without regulations as to the maximum allowable emissions (Jody, 2004).

Sulphur dioxide is an unpleasant gas formed when sulfur is exposed to oxygen at high temperatures during fossil fuel combustion, oil refining, or metal smelting. SO_2 is toxic at high concentrations, but its principal air pollution effects are associated with the formation of acid rain and aerosols (Haley, 2003). Sulfur dioxide combines with atmospheric water, oxygen, and oxidants to create weak acids that fall to the Earth as dry particles, snow, fog, or rain, which is commonly referred to as acid rain. When these acidic substances fall to the Earth, they can harm and acidify lakes and streams. Sulphur dioxide can also constrict air passages, making breathing difficult for those with asthma, and may also alter the immune system and aggravate existing cardiovascular disease (Haley, 2003).

VOCs (Volatile Organic Compounds), including hydrocarbons (CxHy) but also other organic chemicals are carbon-based compounds that have vapour pressure to significantly vaporize and enter the atmosphere (US EPA 2005, EU Directive 2000). Some anthropogenic VOCs such as benzene are known carcinogens. Ambient VOCs largely originate from mobile and industrial sources, including industrial operations,

vehicle emissions, and the use of all kinds of artificial panels such as plywood, laminated wood floor by some furniture industries (US EPA 2005; EU Directive 2000; Wieslander, Nonback, Bjornsson 1997; US EPA 2003). VOCs are also of interest as chemical precursors of ground-level ozone and aerosols. The importance of VOCs as precursors depends on their chemical structure and atmospheric lifetime, which can vary considerably from compound to compound. Large VOCs oxidize in the atmosphere to produce non volatile chemicals that condense to form aerosols. Short-lived VOCs interact with NO_n to produce high ground-level ozone in polluted environments. Methane (CH_4), the simplest and most long-lived VOC, is of importance both as a greenhouse gas and as a source of background tropospheric ozone. Major anthropogenic sources of methane include natural gas production and use, coal mining, livestock, and rice paddies. Upon their release, VOCs' fate and dilution are controlled by atmospheric transport, dispersion, and removal mechanisms; hence, they are commonly encountered by people as they go about their daily routine.

Epidemiological studies (Bolla 1991, US EPA 2008) have addressed the effects of short- and long-term exposures to VOCs (volatile organic compounds) and provided important results. Recent epidemiological studies also strengthened the evidence that there are short-term VOCs effects on mortality and respiratory morbidity and provided further information on exposure response relationships (Ostro, Lipsett, Hazel, Owens, White, 2001). There is also growing evidence that chronic exposure to VOCs has adverse health effects to human (Park, 2001; Rumcher, Spickett, Bulsara, Philip, Stocks, 2004; Suh, Bahadori, Vallarino, Spengler, 2000). The short-term adverse effects include conjunctive irritation, nose and throat discomfort, headache and sleeplessness, allergic skin reaction, nausea, fatigue and dizziness. Meanwhile, the long-term adverse effects

include loss of coordination, leukaemia, anaemia, cancer and damage to liver, kidney and central nervous system (Kinney and Ozkaynak, 1991; Eljarrat and Barcelo, 2003; Nazarrof and Weschler, 2004; Wallace, 2001; Kerbachi, 2006).

Particulate matter includes naturally occurring dust and pollen as well as soot and aerosols from combustion activities such as agricultural burning, transportation, manufacturing, and power generation. The most harmful particles are not the large particles, which are mostly removed in the upper airways, but the small particles that may be deposited deep in the lungs. Before 1987, the standard for measuring particulate matter was based on total suspended particulate matter, no matter the size. In 1987, EPA changed its standard to measure only the percentage of particles with an aerodynamic diameter of 10 microns or less. However, recent research has shown that fine particulate matter which includes particles with an aerodynamic diameter smaller than 2.5 micrometers is inhaled deeper into lung tissue, and is therefore more harmful. In 1997, EPA issued new standards to address these smaller particles, which several epidemiological studies have linked with decreased lung function, increased respiratory symptoms, increased school absenteeism, increased respiratory hospital admissions, and increased mortality, especially from respiratory and cardiovascular failure (Haley, 2003).

2.2.2 Nigeria air quality standards

In Nigeria, pollutants emanate from different sources. The common air pollutants in the chemical industries are sulphur dioxide, which are emitted from process and from fuel combustion, while the major pollutant from automobiles is carbon monoxide. The national agency responsible for setting and maintaining environmental standards in

Nigeria, Federal Environmental Protection Agency (FEPA), has stated the air quality standard as presented in Tables 2.1 and 2.2 below.

Table 2.1: Nigerian Ambient Air Quality Standard

Pollutants	**Time of Average**	**Limits**
Particulates	Daily average of hourly values	250µg/m^3
	1 hour	600µg/m^3
Sulphur dioxide (SO_2)	Daily average of hourly values	0.01ppm (26µg/m^3)
	1 hour	0.1ppm (260µg/m^3)
Non-methane hydrocarbon	Daily average of 3 hourly values	160µg/m^3
Carbon monoxide	Daily average of hourly values	10ppm (11.4µg/m^3)
	8 hourly values	20ppm (22.8µg/m^3)
Nitrogen oxide	Daily average of hourly values	0.04ppm – 0.06ppm
	(range)	(75.0µg/m^3 - 113µg/m^3)
Photo chemical oxidants	Hourly values	0.06ppm

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

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

Tolerance Limits for Ambient Air Pollutants

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

Source: (Federal Environmental Protection Agency, 2000).

2.2.3 Sources of air pollutants

The presence of airborne pollutants is due to the anthropogenic sources, industrial activities and the effects of natural activities such as volcanoes eruption. These sources

emit both primary (directly into the air) and secondary pollutants (formed by chemical reactions within the atmosphere) into the atmosphere (Pooley and Mille, 1999). However, according to Mayer (1999), Pooley and Mille (1999) and ADB (2006) most of the airborne particulates are emitted from the combustion engines from vehicles contributing at least 70-75% of the total air pollution. This happened due to the increase of the number of registered road vehicles every year which then become a dominant source of urban air pollution (Brimblecombe, 1999; D'Angiola, Dawidowski, Gomez, and Osses, 2010). The emission contains carbon monoxide (CO), sulphur dioxide (SO_2), Total Suspended Particulates (TSP), Nitrogen Oxides (NO_n) and Volatile Organic Compound (VOC) (Mayer, 1999; Percy and Ferretti, 2004) as well as the particulates matter (ADB, 2006) which are released through combustion, fluid leakage, component wear and corrosion metals (Okunola, Uzairu, Ndukwe, and Adewusi, 2008). The common air pollution sources in Nigeria aside traffic emission are; biomass combustion, bush burning, refuse burning, generator emission, gas flaring, industrial emissions and indiscriminate refuse disposal. The table 2.3 below shows the percentage distribution of principal pollutants from various sources.

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

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

Source: European Fuel Oxygenates Association (2013).

Biomass in form of firewood, coal, bamboo trunks and dead leaves are commonly used sources of cooking fuel. Of all these the most frequently used is firewood. This fuel woods are usually logged from nearby bushes and forests or are collected as dead branches within the residential vicinities by the women and sometimes children and are used to generate energy for cooking. The combustion of firewood releases gaseous pollutants and particulate matter. From literature the gaseous pollutants from cooking emissions are carbon monoxide CO, carbon dioxide CO_2, sulphur dioxide SO_2, nitrogen dioxide NO_2, volatile organic compounds VOCs and particulate matter. The particulate matter generated is in the form of carbon black, sooth and fly ash which are major components of smoke and are most often within the 10μm size range (Ana, 2012).

Bush burning is a common phenomenon in Nigeria. Most times the burning of bush is done prior to land cultivation as one of the initial steps of land preparation. This constitutes part of the pre planting preparation. The process of bush burning leads to the release of various types of gaseous pollutants and particulate matter. Very often the gas stream is inundated with volatile organics and oxides of carbon (CO_n), sulphur (SO_n) and nitrogen (NO_n) depending on the fuel composition and intensity of the flame. Particulate matter usually within the 10μm size range is also produced in the course of the combustion process (Ana, 2012).

Refuse disposal is a major environmental problem in the Nigeria communities particularly in the urban areas. The refuse is usually from multiple sources including domestic, municipal, agricultural and industrial sources. One of the environmentally unfriendly methods of managing the waste is by open burning either on nearby lands or

open dumps within the residential vicinities. The composition of the refuse, age of the dump and intensity of the flame usually determines the nature of the air pollutants. Often times the air within refuse burning sites is inundated with VOCs, CO_n, SO_n, NO_n, total hydrocarbons (THCs), as well as various classes of toxic and hazardous compounds viz polycyclic aromatic hydrocarbons(PAHs), dioxins, PCBs(Polychloro Biphenyls) and heavy metals such as lead, nickel and mercury (ibid). The diesel or petrol-fired electricity generator is also a source of air pollution, and it is contributing to the choking air in cities in Nigeria. According to Ukpebor *et al.* (2010) in the months of May and June 2008, about 22 deaths from CO poisoning were reported by the Nigerian media and the cause of this death was suffocation by CO fumes from power generators. In Nigeria, the electricity supply is highly erratic, with a resulting increase in the use of generators as the main source of electricity and, consequently, a higher probability of CO poisoning.

According to Cedigaz (2000) Nigeria holds the highest record (19.79%) of natural gas flaring globally and is responsible for about 46 % of Africa's total gas flared per tonne of oil produced. Until present there are not less than 123 flaring sites in the region making Nigeria one of the highest emitter of green house gases in Africa (Uyigue and Agho, 2007). Similarly, analytical assessment of the statistical bulletin of the Central Bank of Nigeria (2004) showed that the average rate of gas flaring in Nigeria during the period 1970-1979 stood at 97%, while 97% and 95% were flared between 1980 and 1989, and 1990 to 1999 respectively. Between 2000 and 2004 51% was flared. In the same vein, between 1970 and 2004 Nigeria has flared an average of 76% of the total gas produced. Much of the natural gas extracted in oil wells in the Niger Delta is immediately flared into the environment at a rate that approximates 70 million /m^3 per

day. This is equivalent to 40% of African natural gas consumption and forms the single largest source of greenhouse gas emissions on the planet (Moffat and Linden, 1995).

Nigeria has oil and non oil related industries including refinery, petrochemical, liquefied natural gas, chemical fertilizer, aluminum smelter, paper, cement, flour, wood, battery and textile industries etc which are major sources of greenhouse gas emissions. Greenhouse effect occurs when CO_2 and other greenhouse gases that are relatively, transparent to incoming Short-wave solar radiation absorb and emit the Long-wave radiations from the earth's surface and reflect downwards some of these re-emitted radiation towards the lower atmosphere (Horsfall and Spiff, 2001). It is called greenhouse effect because the glass in a greenhouse acts in a heat retentive way (NSCA, 1989). The warming of the earth due to the above phenomenon is called global warming. The pollution from these industries adds to the burden of gaseous and particulate pollutants in the air. There is also air pollution emitted from indiscriminate dumping of solid waste which decomposed to a number of gases, that are present in the exposed dumping solid waste, including ammonia (NH_3), carbon dioxide (CO_2) carbon monoxide (CO), hydrogen (H_2), hydrogen sulphide (H_2S), methane (CH_4), nitrogen (N_2) and an exposed solid waste can produce some odorous material in the atmosphere (methane and carbon dioxide), can also be released by both convective flow and diffusion to different strata of soil (Prasad, 1995).

2.2.4 Causes of air pollution from transportation

A number of factors can be identified as influencing the amount of emissions attributable to the transport sector, and an effective strategy will need to take all these factors into account. They include: (a) the amount of vehicles that are used in a given

country or metropolitan area, including the extent to which this use can be called "excessive"; (b) the age of the vehicle fleet and the technology used within it; (c) the extent to which vehicles are properly maintained; (d) the availability of appropriate fuels and the extent to which they are used properly; and (e) atmospheric, climatological and topological conditions. Four of these factors can be influenced through policy (Gorham, 2002).

Level of activity or vehicle use is an important factor to take into account in the overall analysis of transportation emissions, particularly in those cases where long-run solutions are envisioned to help avoid the development of a problem. In a number of developed countries (where data and information are more readily available), studies have shown that growth in activity has either significantly increased the amount of CO_2 emitted in the sector or substantially dampened the reduction of CO_2 emissions that would have occurred, the latter because of efficiency improvements during the last three decades of the twentieth century. In the absence of a policy to address vehicle use, growth in vehicle kilometres travelled in developing countries is projected to average between 2.5 and 4 per cent per year between 1990 and 2030. It follows that a central question for policy makers is whether avoiding this growth is possible or desirable. A number of unknown but controversial factors affect this question, including whether growth rates of car use and those of car ownership are necessarily the same, and the extent to which transport activity drives economic growth, rather than being an indicator of it. On a macroeconomic scale, transport activity can be described as "excessive" if there are more vehicle kilometres travelled than are necessary to achieve and maintain an aspired-to quality of life for a given income or level of wealth. In micro-economic terms, it is linked to the mispricing of the transport system, excessive transport activity being the

difference between actual activity and that which would occur if all marginal social costs were included in the costs seen by travellers (Gorham, 2002).

Excessive car use is a particular and likely manifestation of excessive travel under conditions where a cultural phenomenon of car (or motorcycle) dependence develops, in combination with a number of potential price distortions that favour car use. These might include: fuel subsidies to other sectors with unintended but predictable effects on the transport sector; general subsidies to road users built into the financing of how roads are constructed and maintained, and ancillary services delivered; hidden and fixed costs in road infrastructure and land-use provision, which send unclear price signals to potential travellers; and secondary price distortions in land values that incorporate or capitalize these other (primary) distortions (Gorham, 2002). Older vehicles are associated with higher emissions of both global and local pollutants than newer vehicles, both because performance deteriorates as a function of age and because older vehicles are more likely to use obsolete, higher emitting technology (Ibid).

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

Fuel is a factor for a number of reasons. Regulatory authorities may inappropriately specify fuel types for a given area's conditions, leading to unnecessary emissions of certain kinds of pollutants. Vehicle owners may mix fuel, out of ignorance or in response to a poorly established price signal. Finally, dishonest retailers might adulterate or substitute fuels, again often in response to an unfortunate price signal (Ibid).

2.2.5 Factors that increases air pollutant

The increase of air pollutants in the atmosphere can be due to the following; temperature, wind speed, humidity, increase in population, rapid urbanization, increased motorization, and low quality fuel. According to Roberts (2004), there is an interaction between meteorological condition and air pollution phenomenon where high temperature stimulates the level of airborne particulates concentration. Another finding is that during hot days, particulates matter has largest effect on mortality with the aid of physiological stress that alters the person's response towards toxic matter. Hydrocarbon (HC) emissions can be influenced by ambient temperature. Very low ambient temperatures (e.g., below 20^0F or -6.67^0C) can influence emissions at ignition and cause the catalytic converters, in vehicles that have it, to cool during short stops. Very high ambient temperatures can also have a secondary influence on exhaust emissions because engine load is increased by air conditioner use. Effects can include higher Nitrogen oxides. The amount of water vapour in the air can affect nitrogen oxide gaseous emissions in older and malfunctioning vehicles (Utang and Peterside, 2011).

Wind speed is the rate of the movement of the wind per unit time. The concentrations of all pollutants are lower at higher wind speeds (Levy, 2003). Traffic emissions are

substantially greater in cold weather (high humidity) because cars need more fuel to start at cold temperatures and some emission control devices such as oxygen sensors and catalytic converters operate less efficiently when they are cold (Tubal, Estoque, Holdsworth, and Villarin, 2002).

In Nigeria, there has been rapid increase in population from 3,340,000 in 1950 to 38, 159,000 in 1990 and by 1995, there were about 40 million people living in Nigerian cities and towns. This population increase has led to the migration of individuals from the rural to the urban areas. Cities all over the world present opportunities and limitations. As in the case of Nigeria and many other developing countries, large population concentration and the rapid growth of urban centres pose serious problem in the provision and management of services and the entire living environment (UN, 1995). The various opportunities offered by cities are therefore accompanied by problems of congestion, environmental degradation, unemployment, poverty, violence and all sorts of environmental risks. Traffic is a function of activities. Good roads aid accessibility and functionality of any environment. But the problem, especially in Nigeria, is that (in the last few years) nearly all roads in many cities as well as many inter-city expressways and highways have become impassable due to lack of maintenance (Awogbemi, 1998).The more developed areas in towns and cities naturally tend to generate a great deal of movement. But they have become so congested with new buildings - houses, offices, shopping centres, banks and so many new structures that movement within them and to them is always difficult.

Ambient pollution is further compounded by the rapid urbanization of many developing countries. The global urban population reached 50% in 2008 and is expected to increase

to 60% by 2030. This increase will be particularly pronounced in developing countries, in which 80% of the urban population will be living in 2030 (UNFPA, 2007). Accompanying this rise in urban populations will be a fourfold increase in the number of motorized vehicles in cities by 2050, making transport-related pollution a hazard even in countries with overall low motorization rates (World Bank, 2004). For example, in Chinese cities, concentrations of particulates and other transport-related pollutants are up to six times higher than WHO-recommended guidelines, even though China only has 8 vehicles per 1000 persons compared to 750 vehicles per 1000 persons in the US (Faiz, 2000). Citizens of cities in the developing world, particularly in Asia and Africa, are therefore at great risk for exposure to hazardous levels of transport-related pollution (Moen, 2008).

In developing countries, motorization growth has been largely unchecked by environmental regulations, creating high levels of pollution (Han and Naeher, 2006). Traffic contributes more to ambient pollution in developing countries, accounting for upwards of 40-80% of NO_2 and CO concentrations (Fu, 2001; Goyal, 2006; Abbaspour and Soltaninejad, 2004). This can partly be explained by the vehicle profile. The economic constraints faced by these countries has led to increase in the importation of poorly maintained, older vehicles, leading to an automobile fleet dominated by a class of vehicles known as "super emitters" which release higher concentrations of harmful pollutants in comparison to properly maintained vehicles. In developed countries, these super emitters represent 10% of the vehicles on the road, yet generate 50% of emissions (Brunekreef 2005). In Mexico City, although these super emitters account for roughly 60% of the kilometers traveled, they are responsible for 90% of hydrocarbon and CO emissions and 80% of NO_n emissions (OECD 1999).

In Nigeria, the total number of vehicles increased substantially from 38,000 to 1.6 million between 1950 and 1992 (Enemari 2001). The number of used vehicles imported from abroad is estimated to have represented 30% of the increase in vehicle numbers from 2001 to 2005 (Ajayi and Dosunmu, 2002). Data from the Federal Road Safety Commission (FRSC) of Nigeria however, indicates that between 1999 and 2004 about six million vehicles (6,000,000) were registered in Nigeria of which 70% of the registered vehicles were cars and 30% busses and trucks. The reason for the large increase of registered vehicles in 1999 was due to the deadline given for the registration of all vehicles in the country by FRSC. The subsequent years indicate vehicles coming in for the first time into the country. The increase recorded in 2002 was the climax due to favourable government policies on importation of fairly used vehicles at the inception of democratic rule in Nigeria. Although there was a decline in 2004, it is obvious that the number of vehicles plying Nigerian roads had continued to increase. In Lagos alone about 223,764 vehicles were registered in 2008 compared to 160,134 vehicles registered in 2007. Also in the first quarter of 2009 more than 58,000 vehicles were registered and a total of 27,587 motorcycles were also registered between July 2006 and July 2009 (http//alafrica.com/stories). From the above data it is apparent that the average emission concentration from motor vehicles and motorcycles in the country is in the increase (Abam and Unachukwu, 2009).

Vehicle emissions are affected by fuel type, especially sulfur content. As sulfur content increases, the fuel efficiency decreases and emissions of sulfur oxides, particulate matter, and volatile organic compounds increase (World Bank, 2003). In the US, gasoline has a standard of 15 ppm of sulphur, and in the EU, it has a standard of 50ppm. The concentrations of sulfur in fuels in Nigeria most often range from 500-2,000 ppm,

with a maximum allowable sulfur level of 5,000ppm (UNEP 2007). Therefore, it can be expected that vehicles will release remarkably more pollution, especially sulphur oxides and particulates. In addition, lack of traffic regulation and infrastructure, and lack of air quality enforcement contribute to the high levels of traffic-related pollution. The table below shows the generally accepted ambient air quality standards for the pollutants considered in this study and its health effect.

Table 2.4: Ambient Air Quality Standards of SO_2, NO_2, and CO

Compound	Health Effects	WHO(2005) Guideline Value(ppm)	NigerianAmbient Standard(ppm)	Averaging Time
Carbon monoxide	Headache, weakness,	90	-	15mins
(CO)	dizziness, fainting,	50	-	3mins
	confusion and nausea.	26	35	1hour
Nitrogen dioxide	Aggravation of asthma			
(NO_2)	and allergies, coughing,			
	shortness of breath,	0.10	0.04 – 0.06	1hour
	increased respiratory			
	infections.			
Sulphur dioxide	Change in lung function,			
(SO_2)	difficulty breathing,			
	aggravation of respiratory	0.175	-	10min
	diseases eye irritation	-	0.1	1hour

Source: Moen, 2008.

2.2.6 Impacts of air pollution

Literatures have established that high concentrations of pollutants have a negative impact on lives, properties and the environment. The impacts of air pollution will cover its health effects on humans and its effects on materials.

2.2.6.1 Adverse health effects associated with high concentrations of transport-related pollutants

Researchers have found that airborne pollutants may cause adverse effects on human health such as hypertension, stroke and mortality (Allen *et al.*, 2009; Suruchi and Khanna, 2011).

Afroz, Hassan and Ibrahim (2003) stated that the total number of patients affected by respiratory diseases such as asthma and bronchitis (Ainuddin and Chong, 2008) in Selangor has increase significantly during haze on September 1997. The major airborne pollutant that causes those diseases is PM_{10} which is well known as a respirable airborne particulate matter. PM_{10} is a very tiny dust which cannot be seen individually with the naked eyes. Various studies have shown that affected lung with PM_{10} and other microscopic particles will cause chronic asthma, acute respiratory illness and cardiopulmonary diseases (ADB, 2006; Aditama, 2000; Ackplakorn *et al.*, 2004; Agarwal, Jayaraman, Anand, and Marimuthu, 2006). The life expectancy could also be reduced in the long-term exposure especially to the elderly and children (GreenFacts, 2005; Cui *et al.*, 2003; Dai, Song, Gao, and Chen, 2004).

In addition, the epidemiological studies have shown that a rise of 10µg m^{-3} of PM_{10} could increase mortality case up to 1% (Steward, Owen, Donovan, MacKenzie, and Hewitt, 2005). As a whole, air pollution is an episode that causes disruption in daily living, physical discomfort, and illness and reduces life expectancy. Nitrogen oxides and sulfur oxides, for example, are associated with immune system impairment, exacerbation of asthma and chronic respiratory diseases, reduced lung function, and cardiovascular disease (Schwela, 2000). Exposure to carbon monoxide can result in

fatigue, headaches, dizziness, loss of consciousness, and even death at very high concentrations (Schwela, 2000). Particulates are especially dangerous because they have been implicated in the development of lung cancer and higher rates of mortality (Schwela, 2000). Lead is similarly dangerous as poisoning causes irreversible neurobehavioral consequences, such as decreased IQ and attention deficits, and death at high levels of poisoning (Schwela, 2000). In addition to these pollutants, vehicle emissions contain volatile organic compounds (VOCs), a class of petroleum combustion by-products which includes many known and probable carcinogens and reproductive toxicants. VOCs are also hazardous because they can react with sunlight to form ozone, which exacerbates asthma and has other adverse respiratory effects (WHO, 2000).

Studies conducted in Ethiopia, Mozambique, and Kenya found significantly higher prevalence of asthma in urban school children exposed to traffic pollution compared to rural children (Yemaneberhan, 1997; Mavale-Manuel, 2004; Ng'ang'a, 1998). In a small city in Ethiopia, individuals living closer to roads experienced more wheeze at levels comparable to those observed in developed countries with twice the traffic volume, resulting from the high proportion of super emitters (Venn, 2005). Developing cities in Asia and Africa are at high risk to exposure of this traffic-related pollution. Research conducted in Ethiopia, Mozambique, Kenya and Republic of Benin, show that there is a high level of DNA damage in urban residents and higher prevalence of asthma in urban school children exposed to traffic pollution compared to rural children (Autrup, 2006). The African continent may be highly heated if priority is not given in understanding the scale of this problem and its control.

A number of epidemiological studies have similarly linked exposure to vehicle emissions with adverse health outcomes. For example, in the US, chronic exposure to vehicle emissions over 10 years decreased lung function among tunnel officers (Evans, 1988). A comparison of the prevalence of chronic bronchitis and asthma among street cleaners, a high exposure group, and cemetery workers, who acted as controls, found that exposure to vehicle pollutants in concentrations lower than WHO-recommended guidelines resulted in a significant increase in respiratory effects (Raaschou, 1995). Moreover, a significant relationship between residence proximity to high traffic roads and prevalence of asthma and cardiovascular disease in children has been documented (Schwela, 2000), in addition to a strong relationship between proximity to congested roads and respiratory morbidity in infants. There is mixed evidence for a relationship between exposure and low birth weight, preterm birth and birth defects (Sram, 2005). Clearly, the public health impacts of exposure to traffic pollution are serious and diverse.

2.2.6.2 Effects on material

Material deterioration occurs when the following factors; moisture, temperature and sunlight are involved. This mechanism of deterioration has been attributed to air pollution. It also involves five systems, namely abrasion, deposition and removal, direct chemical attack, indirect chemical attack and electrochemical corrosion (Otti, Nwajuaku, and Ejikeme, 2011).

Some solid particles of large enough sizes and travelling at high enough speeds can cause deterioration by abrasion. Liquid and solid particles that settle on exposed surfaces cause enough aesthetic deterioration on certain monuments and building.

Solubilisation and oxidation/reduction reaction occur directly by chemical attack on some materials; example is the chemical reaction between sulphur dioxide (SO_2) and limestone ($CaCO_3$) in the presence of water to form calcium sulphate ($CaSO_4$) and gypsum ($CaSO_4.2H_2O$) (Otti *et al*., 2011).

More so, some pollutants react with some components indirectly, there always would be chemical attack on the material that might lead to destruction, when leather absorbs some sulphur dioxide (SO_2) which reacts to form sulphuric acid and the leather becomes totally brittle. Investigation showed that those people living in Lagos at Ilepuju Industrial Layout complained of rapid deterioration of their leather seats because of sulphur dioxide emitted from some of the industries, also Kano, Gboko and Nkalagu residents suffered from the ordeal on their buildings (ibid). The presence of acidified rain water in the environment also increases the corrosion rate of roofing sheets, monuments and other economic structures. In the Niger delta area there is glaring evidence of the impacts of corrosion on several building structures and arts work and these cases have been observed to deteriorate at rather alarming rates (Ana, 2012).

2.2.7 Role of vegetation in pollutant removal

Several studies have shown that there are various ways and technologies applied in removing the airborne pollutants by using the trees. Trees are the effective scavengers in ameliorating the pollutants concentration in atmosphere. Therefore, the trees planting scheme in a city would be the most effective way in achieving the objective of improving the air quality. Even though most of the researchers could not find the exact amount of pollutants concentration removed by the trees, the estimation gained by them

is simply enough to conclude that the trees in urban areas are significant tools in removing the air pollutants in atmosphere (Sarma, 2011).

Steward *et al*. (2005) measured the rate of pollutants deposition on woodland, grassland and other short vegetation in the West Midlands conurbation for 50 years. The pollutants present as a naturally occurring radioactive compounds in the soil and atmosphere. These researchers examined the effects of trees on the deposition rate of the pollutants. They found that woodland captures pollutants three times higher than the grassland as woodland had greater leaf surface area and the trees which were located at the edge of woodland were exposed to the wind and heavy traffic. Airborne particulates can also be removed by sequestering process. Gratani and Varone (2007) determined the amelioration capability of trees towards CO_2 concentration by measuring the photosynthetic activities of the plants as well as the plant structures. These traits were being correlated with the traffic density and atmospheric CO_2 concentration at the study sites to determine whether the relation was significant or not. As a result, they found that *Platanus hybrida* Brot. which was largely distributed in the city of Rome was capable in sequestering CO_2 emitted by the heavy traffic of about 117±13 kg $year^{-1}$. They recommended that the plants traits were very important to be considered in urban tree planting programme in relation to the amelioration of airborne pollutants.

The deposition of airborne pollutants onto the trees can occur in two ways which are wet deposition and dry deposition. Wet deposition is a removal of pollutants by precipitation while the dry deposition is due to the gravity, impaction and diffusion which depend on the particle size. McDonald, Bealey, Fowler, Dragosits, and Skiba (2007) conducted a study on the effect of urban tree planting on concentration and

deposition of PM_{10} in two UK conurbations by determining which way of deposition occurred through modelling. To develop the modelling framework, these researchers applied the fine resolution atmospheric multi-pollutant exchange (FRAME) atmospheric transport model. This model was used to calculate wet and dry deposition with the use of statistical meteorology. Dry deposition rates were higher for larger particles as the particles will deposit faster especially onto the trees compared to the short vegetations. They found that dry deposition of PM_{10} in urban areas (West Midlands) was higher than the moor/grassland due to the emission of PM_{10} from road transport. Hence, the model showed that trees in that area were able to remove 39 tons of primary PM_{10} from the atmosphere. The model was also predicting that by applying a maximum planting potential (FPP_{100}) in West Midlands from 3.7 to 16.5%, the PM_{10} concentration will be reduced by 10% from 2.3 to 2.1 $\mu g\ m^{-3}$ removing of about 110 tons of primary PM_{10} per year from the atmosphere (the behaviour and **spatial distribution** of primary PM_{10} were assumed to be similar with the secondary PM_{10} due to the insufficiently advanced model used).

Airborne particulates can be removed through the accumulation of particulates onto leaf surface. Trees leaf has the capability in capturing the particulates very effectively. Various studies have been carried out on the removal of particulates in atmosphere by using tree leaves. For example, Freer-Smith, Holloway, and Goodman (1997) conducted a study on the uptake of particulates by the oak (Rough wood) leaves in urban woodland. The objectives of their study were to measure and identify the accumulated particulates, determine the frequency distribution of different particulates sizes as well as to determine the composition and sources of particulates by an elemental analysis. Twenty leaves were collected from the lower branch of six trees which closed to a

motorway. The leaves were washed with 100ml distilled water for 3 min, vacuum filtered through pre-weighed filter papers (0.45 μm) while the water soluble ammonium sulphate and nitrates remain dissolved in the water after the filtration. The remaining 10 leaves were washed with chloroform for ten seconds and passed through PTFE filters of 0.2 μm of pore size. By using scanning electron microscope (SEM), the researchers found that the oak leaf had hairy surface which enabled it to capture more particulates from the atmosphere. They also found that there was significant correlation between distance from motorway and total number of particles ($r = 0.702$ and $r = 0.709$, respectively). Number of particles accumulated on the leaf surface was greater as the leaves were close to the motorway. The most elements present were aluminium, silicon and iron which were assumed to be derived from pulverized coal fuel from the power station while sodium and chlorine were possibly resulted from the sea salt.

Urban forest encompasses wide ranges of vegetation species being planted. However, due to some reasons, trees are likely to be more effective in capturing pollutants compared to small vegetations. Each species of trees has its own capability in reducing the airborne particulates. The relative effectiveness of these contrasting species of trees in particulates uptake has been quantified by Beckett, Freer-Smith, and Taylor (2000). These Researchers conducted a study on capturing the particulate pollution by urban trees through an exposure of five trees species, pine (*Pinus nigra* var. *maritime*), cypress (X *Cupressocyparis leylandii*), maple (*Acer campestre*), whitebeem (*Sorbus intermedia*), poplar (*Populus deltoides* X *trichocarpa* Beaupré) to NaCl droplets (1μm diameter) at a range of **wind speed** in two wind tunnels. They measured the deposition velocity (Vg) and particle trapping efficiency (Cp) as well as determining the trees morphology. As a result, they found that the finer and complex structure of foliage (*P.*

nigra and *C. leylandii*), the more increase on effectiveness of the conifers' ability in capturing particles. The significant complex structures of trees were broadleaved, coarse and hairy leaves. Greater deposition of particles on trees was aided by the turbulent of air flows. This was supported by the natural mechanism of leaf's boundary layer that helped the particulates to drop off onto the leaf by the inertia forces.

2.2.8 Factors that affect pollutant removal

According to Nowak *et al*. (2006) pollution removal values for each pollutant will vary among cities based on the amount of tree cover (increased tree cover leading to greater total removal), pollution concentration (increased concentration leading to greater downward flux and total removal), length of in-leaf season (increased growing season length leading to greater total removal), amount of precipitation (increased precipitation leading to reduced total removal via dry deposition), and other meteorological variables that affect tree transpiration and deposition velocities (factors leading to increased deposition velocities would lead to greater downward flux and total removal). All of these factors combine to affect total pollution removal and the standard pollution removal rate per unit tree cover.

2.2.9 Role of vegetation in urban centres

Urban forest consists of multiple species of vegetation which are intentionally planted or naturally grown within the urban areas. It contains a diverse mix of plant species which are arranged in heterogeneous or homogenous patterns (McPherson *et al*., 1997). The urban forest plays multiple roles both in human and ecosystem services (Wolf, 2006). Urban forest helps in maintaining the oxygen released through photosynthesis and absorbing carbon dioxide through carbon sequestration which helps

in improving the air quality of the urban areas (Johnson and Gerhold, 2001; Yang, McBride, Zhou, and Sun, 2005; McPherson and Simpson, 1999). The trees cool down the cities by shading and evapo-transpiration as well as reducing the urban heat island intensity (Yang *et al.*, 2005). Nowak (2000) and Sanusi, Nuruddin, and Hamid (2011) found that the trees canopy and transpiration process may alleviate the temperature of a city besides controlling the **wind speed,** relative humidity and heat storage efficiency. Wolf (2006) stated that the air conditioner is one of the contributors towards global warming due to the increase in the concentration of CFC present in the atmosphere. In order to mitigate this problem, urban forest strategy and implementation should be planned accordingly.

These benefits, known as ecosystem services, have been associated with improved physical, and mental health and community vitality (Bell, Wilson, and Liu, 2008; Guite, Clarke, and Ackrill, 2006; Kuo, Sullivan, Coley, and Brunson, 1998). Besides for greening purpose, the roles of the trees have been widely studied by scientists worldwide as the trees are able to act as ground covers, for beautification, shading and slope covers (Givoni, 1991). The trees' advantages are not limited into ecosystem services as human are also gaining various benefits from the urban forest. Human will gain better lifestyle without physical and physiological stress due to noise problem as leaves, stems and branches of trees will absorb, reflect and refract the high frequency of sound (Wolf, 2006; Givoni, 1991). Urban forest provides green open spaces such as children playground, recreational sites and sports area that act as an isolation for human to escape from the stress of urban life (Givoni, 1991). Urban forest also consists of plants which are having therapeutic constituents. Farnsworth (1990) discovered that people living in urban areas depend on traditional medicine for their health care needs

where the main source of the drug therapy originates from higher plants which can easily be found in the urban environment. These services provided by urban vegetation can yield significant concomitant economic returns, such as energy and medical costs averted, increased worker productivity, and increased property values.

2.3 Review of Related Empirical Studies

The situation of increased pollution from mobile transportation source is on the increase with per capital increase in vehicle ownership, thus resulting to high congestion on Nigeria city road and increase in the concentration of pollutants in the air, consequently, increasing health risk on human population. A study carried out by Ndoke, Akpan, and Kato (2006) on the contributions of vehicular traffic to carbon dioxide emissions in Kaduna and Abuja, Northern Nigeria confirmed that Nigeria air quality is poor. In this study, the quantity of carbon dioxide (CO_2) contributed by automobile emissions to the environment was determined at some areas in Kaduna and Abuja in Northern Nigeria. Five census stations were selected in each of the two towns. In Kaduna, Jabi road in Ungwan Rimi, Kawo Motor Park, Stadium roundabout, Sabo and Kasuwa (Kaduna Main Market), were selected for Kaduna, while Asokoro (behind ECOWAS), Area One junction, A.Y.A. junction, Wuse market bus-stop, and Mabushi round-about were selected for Abuja. A gas sampling pump and tubes that could detect carbon dioxide were used to detect the quantity of CO_2 in the environment at a certain time. The detection tube was broken at both ends using the tube tip-breaker, and then inserted into the sampling pump according to the arrow shown on the tube. Then a sample volume of 50ml was selected. The handle was pulled quickly until it stopped at ½ strokes, which indicated 50ml. This was left for a sampling time of 1 minute to allow the air to be drawn through the tube. When the flow of air was complete, the end-of-

flow indicator was completely bright to show that air-sampling was complete. After the completion of the sampling time of 1 minute, the colour of the reagent in the tube changed from white to light yellow. The length of the colour change was measured and recorded. Another sampling volume was taken and the procedure repeated. This was done after an interval of 5 minutes from the first sampling. Several readings were taken using this procedure and the averages for each period for each day calculated. The results obtained show a variation in the amount of CO_2 in the environment. Areas with relatively heavy congestion show a high concentration of CO_2, while areas with minimal traffic show a lower concentration of CO_2. Sabo in Kaduna has an average concentration of 18.40ppm being the highest, while Asokoro (behind ECOWAS), Abuja has the least average concentration of 11.60ppm. Though, these concentrations are still not high enough to cause any serious health effects but they provide a baseline study for Policy makers and Town planners.

Abam and Unachukwu (2009) studied the vehicular emissions and air quality standards in Nigeria and concluded that traffic related pollution is on the increase. This paper reported the results of the investigation of vehicular emissions in selected areas in Calabar, Nigeria. Three areas MP_1, MP_2, and MP_3 were considered with nine sampling points ($SP_1 - SP_9$) in each area placed 8.0m away from the edge of the road in downwind direction. Priority parameters: CO, NO_2, SO_2, PM_{10} and noise level were monitored. Other relevant parameters monitored includes ambient temperature, wind direction, wind velocity and traffic count. The CO, SO_2, NO_2 and PM_{10} where determined using standard method. CO was monitored using a portable analyser model 2002, made in USA, in compliance with USEPA method. The CO was investigated for 24 hours and the Total weighted Average (TWA) of CO was calculated. Samples of SO_2 were

collected using APM 410 and 415 sampler (model 2001 manufactured by VBU ltd., India) and analysed by calorimetric method in accordance to USEPA method, 40 CFR 50 Appex. The duration of sampling at individual sampling points was 3 days on 24 hours duration. NO_2 and PM_{10} were collected also for 3 days and 24 hour duration. The sampling methods were in accordance to NIOSH method CAS 10102-43-9 and USEPA method 40 CFR 50 Apex.

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

All the five monitored air pollutants when compared with AQI level (Air quality index) were in the range of: CO – poor to moderate and moderate to poor in different locations. SO_2 – was from very poor to poor, NO_2- from very poor to poor, PM_{10} and noise level was poor at all locations. The overall comparison of data for different sections show that concentration of pollutants is highest at (SP_{1-3}) and (SP_{8-9}) and this is was due to

volume of traffic and pollution in the three areas MP_1, MP_2, and MP_3. The study concludes that transport-related pollution in Calabar is indeed significant with possible severe health consequences.

Ukpebor *et al*. (2010) evaluated the diurnal variation of CO generation and distribution at several road junctions and motor parks in Benin City. Five sampling locations were selected for the study. In this study, a preliminary attempt was made to evaluate the diurnal trend in CO generation and distribution at several road junctions and motor parks in Benin City. The sites were created at roadside verges, junctions and motor parks. The monitoring sites were geo-referenced using a GARMIN GPS MAP 765 chart plotting receiver.

A dosimeter (*in situ* method) that uses an electrochemical sensor to measure ambient levels of CO was used. Continuous CO measurements were carried out in the dry season months of November 2006 – February 2007. The CO concentrations were determined on a half-hourly basis from 8 a.m. to 7 p.m., four times a week for a total of a 16-week sampling period at the five selected monitoring sites at a height of 1.5-2.0m from ground level. Air temperatures and humidity were measured simultaneously before and after the CO measurements using a humidity/temperature meter, with resolutions of 0.1% RH and 0.1ºC (model RS 1364, RS components Ltd, UK). At the same time, wind speeds were measured using an LM -8000 anemometer with a resolution of $0.1ms^{-1}$ (Heatmiser UK Ltd).

At the 5 sampling locations selected, very high CO concentrations were measured with a mean range of 14.8-28.3 ppm. The 10.0 ppm statutory limit set by the Federal

Ministry of the Environment, Housing and Urban Development (FMEH&UD) was clearly exceeded. Diurnal variations in the data were statistically significant ($P < 0.05$), with the highest CO concentrations recorded in the morning hours. Spatial variations were also statistically significant, with the highest mean CO load of 28.3ppm measured at Sokponba road junction. Vehicular exhaust was identified as the main CO source in the city. Frequent traffic jams resulting from poorly maintained roads, high traffic density, unfavourable traffic handling, inadequate traffic discipline and very low wind speed are identified as the main factors responsible for the high emissions, accumulation, and low dilution and dispersion of the generated CO. This study actually confirms that the air in Benin City (which is the study area of this research work) is polluted.

All of the work reviewed above reveals the poor air quality in our environment but none has considered vegetation as a means of reducing this pollution. Studies have shown that plants play important role in monitoring and maintaining the ecological balance by actively participating in the cycling of nutrients and gases like carbon dioxide, oxygen and also provide enormous leaf area for impingement, absorption and accumulation of air pollutants to reduce the pollution level in the air environment (Escobeda et al., 2008).

Nowak *et. al*., 2006 worked on air pollution removal by urban trees and shrubs in the United States. This was a modeling study that used hourly meteorological and pollution concentration data from across the conterminous United States to demonstrate that urban trees remove large amounts of air pollutants that consequently improve urban air quality. To investigate the magnitude of air pollution removal by urban trees throughout

the lower 48 United States, computer modeling of air pollution removal of carbon monoxide (CO), nitrogen dioxide (NO_2), ozone, particulate matter less than 10 μm (PM_{10}) and sulphur dioxide (SO_2) was performed for 55 US cities and for the entire nation based on meteorological, pollution concentration, and urban tree cover data. Due to the need for various assumptions within the model, the model provides a first-order estimate of the magnitude of pollution removal by urban trees. Pollution removal (O_3, PM_{10}, NO_2, SO_2, CO) varied among cities with total annual air pollution removal by US urban trees estimated at 71 1,000 metric tons ($3.8 billion value). Pollution removal is only one of various ways that urban trees affect air quality. Integrated studies of tree effects on air pollution reveal that management of urban tree canopy cover could be a viable strategy to improve air quality and help meet clean air standards.

Nur and Ahmad (2012), worked on the impact of vegetations in urban green spaces for automobile discharged particles removal. The study attempts to view on the capabilities of urban forest in filtering the atmospheric environment by reducing the airborne particulates concentration. It provides an overview on the sources of the airborne pollutants, the consequences towards human health and living ecosystem and how to quantify the urban forest's ability in reducing the concentration of particulate matter through various scientific methodological ways.

However, the overall levels of vehicular related air pollution in Nigeria from all the studies conducted show an increasing trend and thus posses a potential hazard to the population. Planting of trees and shrubs for abatement of pollution and improvement of environment is an effective way of improving urban air quality and this is well recognized throughout the world (Nugrahani, Prasetyawati, Sugijanto, and Pumobasuki,

2012). This method of using vegetation to improve the air quality of the environment should also be considered in Nigeria.

CHAPTER THREE: THE STUDY AREA AND METHODOLOGY

3.1 Introduction

This chapter captures the study area and methodology. The following sub-title was considered on the study area; its location, geology, relief, climate, drainage, soils, vegetation, transportation and economic activities.

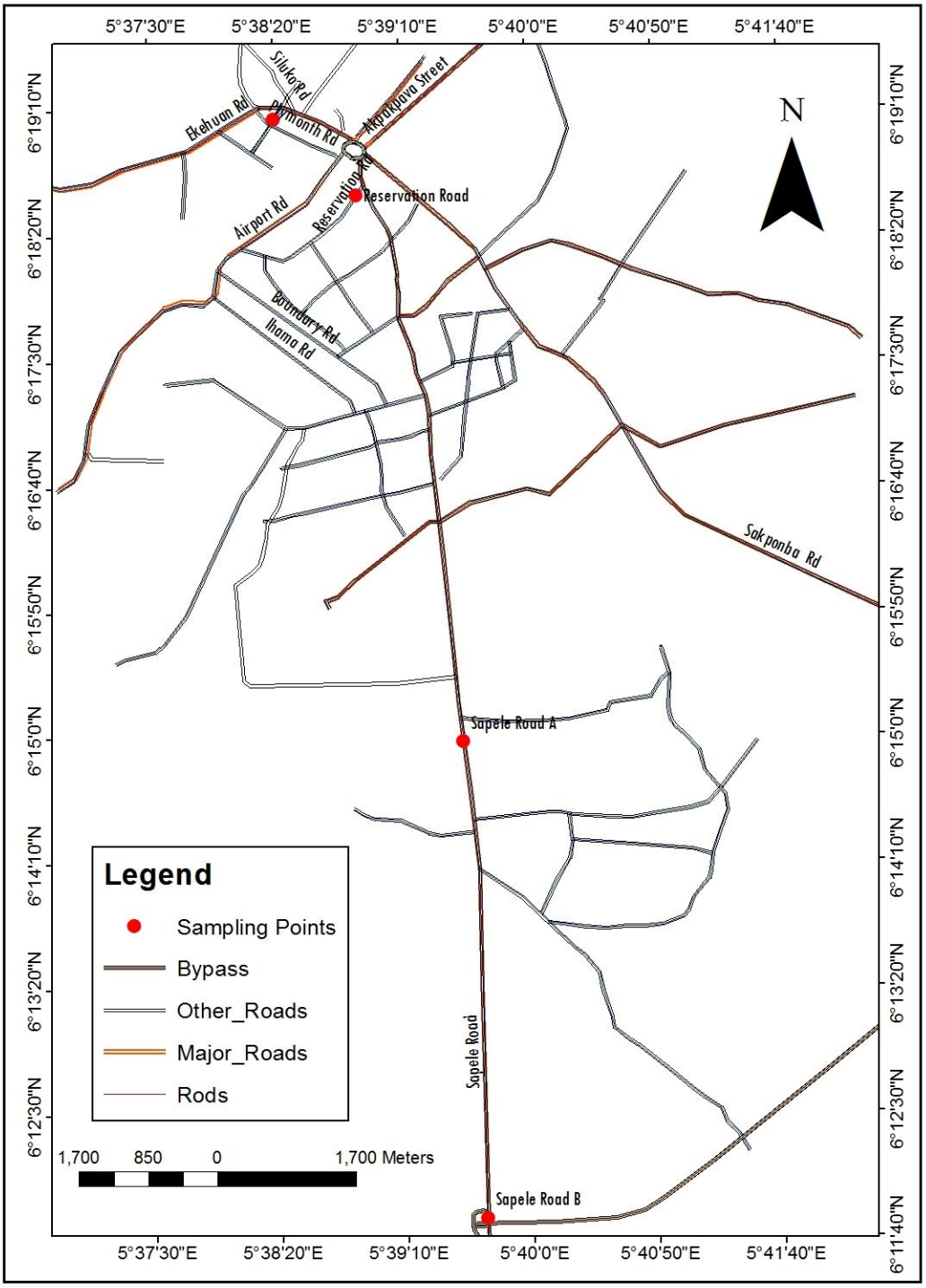
3.2 The Study Area

3.2.1 Location

Benin City, the capital of Edo State, lies within the equatorial climate region between latitude 6º23□55□N to 6º27□39□N and longitude 5º36□18□E to 5º44□30□E and one of the largest cities in southern Nigeria (Aiyesanmi and Imoisi, 2011). Benin City is the headquarters of Oredo, and Egor local government areas (Fig. I). Edo state is located in the heart of the tropical rain forest. To the north, Edo State is bounded by Kogi State; to the east, it is bounded by Anambra State; to the south, by Delta State and to the west, by Ondo state. Edo state is a low lying area, except in the north i.e Akoko Edo area, where it is characterised by undulating hills rising to a peak of about 572 metres (Edo Culture Home, 2013).

3.2.2 Geology and relief

Benin City is underlain by sedimentary formation of the Miocene -Pleistocene age often referred to as the Benin formation. The local relief in the City is 91 meters above sea level. A topographical map of the city scale of 1,27,778 produced by Balasha-Jalon consultants shows that the city contained 15 local depressions which may have been formed during the arching in the Neogene of the lower Tertiary Beds (Odemerho, 1988).



Source: Satellite Imagery, 2013.

Figure 1: Map of Benin City Showing the Study Area

3.2.3 Climate and vegetation

Benin City has a tropical climate, characterised by two distinct seasons, the wet and dry seasons. It lies in the thick equatorial rainforest zone which experiences heavy rainfall. The wet season lasts from April to November and the dry season from December to March. Benin City therefore enjoys abundant rainfall almost all the year round, except December to March when dry season sets in, due to the influence of the north-east trade wind or the Tropical Continental Air mass. Average rainfall between 2000mm-2500mm occurs with a mean monthly temperature of 28°C (82.4^0F). The vegetation is predominantly the evergreen rainforest but urban development has drastically reduced the vegetation (Ezemonye and Emeribe, 2014; Edo Culture Home, 2013).

3.2.4 Drainage and Soils

Benin City is built on a nearly undulating low-lying surface. The eastern edge of it is tilted towards the Ikpoba River that drains the eastern portion of the city while the Western edge slopes gently towards Ogba stream that drains the Western portion of the City. Benin City is drained by a series of entrenched river and small streams such as Ikpoba River, Ogba Stream and Osse stream. Many depositional land forms results especially flood plains characterized with point bar, islets,levees, backswamps and channel filling, alluvial fan and Delta (Eseigbe and Ojeifo, 2012). The City is underlain by sedimentary formation described by Short and Stauble (1967). The formation is made up of top reddish clayey sand capping highly porous fresh water bearing loose pebbly sands, and sandstone with local thin clays and shale inter-beds which are considered to be of braided stream origin. Sands, sandstones and clays vary in colour from reddish brown to pinkish yellow on weathered surfaces to white in the deeper fresh surfaces. Limonitic coatings are responsible for the brown reddish-yellowish

colour. The formation is covered with loose brownish sand (quaternary drift) varying in thickness and is about 800m thick; almost all of which is water bearing with water level varying from about 20m to 52m. It is generally believed to be highly permeable, porous and prolific in water yield. The aquifer yields range from 28.4m^3hr^{-1} at Iyanomo (south of the City), 125m^3hr^{-1} at Uselu (central part) to 208m^3hr^{-1} at Ogba (northern part) with a draw down ranging from 4.8m at Iyanomo, 1.8m at Uselu to 6.7m at Ogba (Short and Stauble, 1967).

3.2.5 Transportation

Benin City, as the State capital, is a major centre of traffic. Routes to Warri and Sapele (both in Delta State); to the eastern cities of Onitsha, Enugu, Calabar and Port Harcourt; and to the western cities of Ibadan, Abeokuta and the former political capital of Lagos, are especially well-travelled. A major federal trunk road runs east-to-west through Benin City, connecting Lagos and the western states, and incorporating the Benin-Shagamu Expressway. The A2 north-south route through Kaduna, Abuja, Lokoja, Auchi, Benin City and Warri, is also well-used. Buses and taxis in Benin City operate on many routes providing connecting service for all parts of the State. Intra-town services are also provided by the Edo Municipal Transport Service, as well as by the many private transportation companies in Benin City. Benin City also has an airport that is serviced by Nigerian Airways, ADC Airlines, EAS Airlines, Kabo Air, etc (Edo People Forum, 2011).

3.2.6 Economic activities

There are many socio-economic activities carried out in Benin City and these include: primary, secondary and tertiary activities dominated by government in the

formal sector and trading in the informal sector. The notable economic activities include brass casting, wood carving and blacksmith (Ezemonye and Emeribe, 2014). Another major business in the city is transportation. However, there are two brewing factories, furniture factories, four small-scale pharmaceutical production factories, a petroleum storage depot, oil pipeline, metal works, colour photo laboratories, and a battery assembly factory (Erah, Akujieze and Oteze, 2002).

3.3 Methodology

The methodology covered the following sub-titles; the types and sources of data, techniques of data collection and the techniques of data analysis.

3.3.1 Types and sources of data

The types of data collected were primary and secondary data. The primary datum was collected through the measurement of the emission levels of CO, SO_2 and NO_2 at the sampling points with the aeroqual air quality kit. The secondary data was gotten from a review of existing textbooks, journals, conference papers, research thesis, documents and materials from websites. The photographs of the sampling area were also taken to give a visual understanding of the difference between the vegetative and the non vegetative sampling points.

3.3.2 Techniques of data collection

In this study four sampling points were identified and mapped out. Two of the sampling points were located at Plymonth Road (where there are no vegetation) and Reservation Road (where there is vegetation). The other two were mapped out in the vegetative part of Sapele Road (Sapele Road B) and the non vegetative part of Sapele Road (Sapele Road A). The aeroqual air quality kit series 500 was used to continuously measure and record CO, NO_2 and SO_2 concentrations at the sampling points in the study area (Figure I). The series 500 monitor from aeroqual is a feature-rich portable monitor with the ability to accurately measure multiple target gases at different concentrations. Its built-in data-logging and a long-life, fast-charging lithium battery makes the series 500 the ultimate choice for air quality professionals, consultants, and researchers. The Aeroqual handheld monitors have been specifically designed to incorporate Aeroqual's

in-depth knowledge of accurate ambient gas measurement and can be used with a wide range of gas sensor heads. The sensor heads are interchangeable and therefore multiple heads can be used on the same base unit. Gases are measured by electrochemical sensors with a calibrated range of 0 to 100ppm for CO, 0 to 100ppm for SO_2 and 0 to 1ppm for NO_2. It's operating temperature and humidity is 24.8^0C (76.64^0F) and 42% for CO, 24.1^0C (75.38^0F) and 38% for SO_2 and 23.8^0C (74.84^0F) and 42% for NO_2. The monitoring sites were geo-referenced using the high sensitivity etrex garmin GPS (Global Positioning System). Levels of CO, SO_2, and NO_2 were monitored at each intersection three days a week with each day considering only one of the pollutant. Measurement were taken for one hour during morning peak hours (7:30am.-8:30pm.), one hour during afternoon off peak hours (12:30pm.-1:30pm.) and one hour during evening peak hours (4:30pm.-5:30pm.) for a total of 4weeks. Concentrations were averaged over the one-hour measurement period for the morning, afternoon and evening periods for each day. The qualitative observations on the traffic density were also recorded in a minute interval. Table 3.1 below shows the sampling point's descriptions and coordinates.

Table 3.1: Characteristic Features of Study Locations

Site	Coordinates	Sites Description
Reservation Road (vegetative)	N06^{0}19′39.8″ E005^{0}37′25.8″	Presence of traffic light, a single lane road with a traffic volume of about 1,300cars/hour.
Plymonth Road (non-vegetative)	N06^{0}20′11.9″ E005^{0}36′45.7″	Presence of traffic light, a single lane road with a traffic volume of about 1,400cars/hour.
Sapele Road A (non-vegetative)	N06^{0}17′15.4″ E005^{0}37′59.2″	Beside Samosa Oil, a double lane road with a traffic volume of about 2000cars/hour.
Sapele Road B (vegetative)	N06^{0}12′52.7″ E005^{0}38′18.2″	Beside the bypass, a double lane road with a traffic volume of about 1500cars/hour.

Source: (Field survey, 2013).

3.3.3 Techniques of data analysis

Data were analysed under the following sub-heading.

Objective/Research Question 1: Emission levels of CO, SO_2, and NO_2 at the sample point where there is no vegetation.

The emission levels of these gases were measured at the sample points where there is no vegetation. A total of 20 readings were recorded during the one hour measurement duration. The total and mean emission levels of pollutant for each period (morning, afternoon and evening) taken for each gas was calculated and represented in a table. This was achieved by using the formula below:

$TE_L(M) = \sum EL_S(M)$ ..... (i)

$TE_L(N) = \sum EL_S(N)$ ..... (ii)

$TE_L(E) = \sum EL_S(E)$ ..... (iii)

$$ME_L(M) = \frac{\sum EL_S(M)}{20} \quad \text{..... (iv)}$$

$$ME_L(N) = \frac{\sum EL_S(N)}{20} \quad \text{..... (v)}$$

$$ME_L(E) = \frac{\sum EL_S(E)}{20} \quad \text{..... (vi)}$$

Where: TE_L = Total Emission Level

EL_S = Emission Levels

ME_L = Mean Emission Level

$\sum$ = Sum

M = Morning

N = Noon

E = Evening

Objective/Research Question 2: Emission levels of CO, SO_2, and NO_2 at the sample points where there are vegetation.

The emission levels of traffic pollutants gases were measured at the sample points where there is vegetation. The total and mean emission levels for all the morning, afternoon and evening periods were calculated and represented in a table.

Objective/Research Question 3: Differences in emission levels of these gases at the two different sample points.

The differences in the emission levels of these pollutant gases at the different sample points were represented in a bar chart. For each location the mean and standard deviation of the pollutants were calculated. The mean emission levels of these gases for each day were also calculated and the values gotten were used to calculate the independent t-test. This was achieved by using the formula below;

$$ME_L = \frac{EL_S(M+N+E)}{3} \quad \text{..... (vii)}$$

Test of hypothesis

To test for the significant differences in the concentrations of each pollutant measured at the vegetative and non vegetative sampling points, the independent t-test was used to verify the hypothesis stated on the assumption that "there is no significant difference between vegetation and air quality at the sampling area". This test was done at 0.05 level of significance. This will help to confirm if vegetation help in the reduction of air pollutant.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Introduction

This study was carried out to assess the effectiveness of vegetation in mitigating traffic emission pollutants in order to improve air quality in Benin City and this would help to provide objective inputs for air quality management and also inform the public about air quality, the dangers associated with poor air quality and the importance of vegetation in air quality management. This section presents the mean and total emission levels of the air quality parameter (CO, SO_2, and NO_2) for each period (morning, afternoon and evening) measured at the sampling points where there are no vegetation and the sampling points where there are vegetation and this is aimed at achieving objectives/research i and ii of the study. These objectives include; examining the emission levels of CO, SO_2, and NO_2 pollutant in the sample points where there are no trees or vegetation and also assessing the emission levels of CO, SO_2, and NO_2 in the sample points where there are trees (vegetation). It also shows the analysis of the differences in emission levels of these gases at the vegetative and non-vegetative sampling points. This will help in achieving objective/research question iii, which is; to compare the emission levels of these gases at the vegetated sample points with that of the non-vegetated sample points for any variable differences.

Appendix I and II are the location of the two sampling points that was compared. It shows that there is no vegetation along the road side of Plymonth Road when compared to Reservation Road. Appendix III and IV are the pictorial representation of the other sampling points that was compared. It could be seen that Sapele Road A has no vegetation along its road side as when compared with Sapele Road B.

4.2 Concentration of Pollutants at the Non-Vegetative Sampling Points

Table 4.1 shows the mean and total concentration of CO, SO_2 and NO_2 measured within an hour duration in the morning, afternoon and evening period. These measurements were taken near the road side of Plymonth road and Sapele road A.

Table 4.1: Emission Levels of Air Quality Parameters at the Sample Points where there is Vegetation

		Air Quality Parameters (ppm)					
		CO		SO_2		NO_2	
Sample Point	**Time of Day**	**Total**	**Mean**	**Total**	**Mean**	**Total**	**Mean**
Plymonth Road	Morning	280.61	14.0305	2.41	0.1205	0.882	0.0441
	Afternoon	121.63	6.0815	1.84	0.0920	0.531	0.0266
	Evening	264.60	13.2300	2.30	0.1150	0.854	0.0427
Sapele Road A	Morning	41.76	2.0880	3.21	0.1605	0.171	0.0086
	Afternoon	40.62	2.0310	2.28	0.1140	0.118	0.0059
	Evening	49.37	2.4685	3.25	0.1625	0.173	0.0087

Source: Field Survey, 2013.

Table 4.1 shows that the emission levels of CO for Plymonth Road during the peak periods (morning and evening) which were 14.0305ppm and 13.23ppm were beyond the Nigerian ambient air quality standard which is 10ppm (11.4µg/m^3) according to FEPA, (2000). The emission levels of SO_2 which were 0.1205ppm for morning period, 0.092ppm for afternoon period and 0.115ppm for evening for Plymonth Road and 0.1605ppm for morning, 0.114ppm for afternoon and 0.1625ppm for evening period for Sapele Road A were also above the Nigerian air quality standard limit that is 0.01ppm (26µg/m^3) (ibid). For NO_2, the emission levels fell within (for Plymonth Road peak periods which were 0.0441ppm and 0.0427ppm for morning and evening) and below

(for Sapele Road which were 0.0086ppm, 0.0059ppm and 0.0087ppm for morning, afternoon and evening periods) the Nigerian air quality standard that is within the range of 0.04ppm – 0.06ppm (75.0µg/m^3 - 113µg/m^3) (ibid). This finding actually confirms that Benin City air is polluted (Ukpebor *et al*. 2010).

4.3 Emission Levels of Pollutants at the Vegetative Sampling Points

To achieve objective/research question II, the concentration of CO, SO_2 and NO_2 were measured near the road side in the vegetative sampling areas for an hour in the morning, afternoon and evening period. The mean and total concentration of these pollutants were evaluated and represented in table 4.2 below.

Table 4.2: Emission Levels of Air Quality Parameters at the Sample Points where there is vegetation

		Air Quality Parameters (ppm)					
		CO		SO_2		NO_2	
Sample Point	**Time of Day**	**Total**	**Mean**	**Total**	**Mean**	**Total**	**Mean**
Reservation Road	Morning	124.67	6.2335	1.86	0.0930	0.455	0.0228
	Afternoon	106.77	5.3385	1.22	0.0610	0.277	0.0139
	Evening	160.45	8.0225	1.69	0.0845	0.503	0.0252

Source: Field Survey, 2013.

Table 4.2 shows that the emission levels of CO which were 6.2335ppm, 5.3385ppm and 8.0225ppm at all the times of the day for Reservation Road did not exceed the Nigerian ambient air quality standard which is 10ppm (11.4µg/m^3) according to FEPA (2000). The emission levels of SO_2 which were 0.093ppm, 0.061ppm and 0.0845ppm for the morning, afternoon, and evening period respectively were above the Nigerian air quality standard limit that is 0.01ppm (26µg/m^3) (Ibid). For NO_2, the emission levels which

were 0.0228ppm, 0.0139ppm and 0.0252ppm for the morning, afternoon and evening period fell below the Nigerian air quality standard that is within the range of 0.04ppm – 0.06ppm (75.0µg/m^3 - 113µg/m^3) (Ibid).

The average emission levels of CO for Sapele Road B at all times tested were 0.00ppm, for SO_2 were 0.13ppm and while for NO_2 were 0.001ppm which were all below the Nigerian air quality standard except for SO_2. This could be because, this sampling point was sited at the outskirt of the city, beside the bypass where there are vegetation, less human activities, no traffic congestion and low traffic density when compared to Sapele Road A. The high concentration of SO_2 noticed at the sampling area could be traceable to the high sulphur content of fuel because according to Aminu (2009), SO_2 is emitted from vehicle exhaust, in direct proportion to the amount of sulphur in fuel and the Nigeria maximum allowable amount of sulphur in diesel was reported to be 1330ppm while that of gasoline was reported to be 1000ppm by the Asian Clean Fuel Association 'ACFA' (2010). Due to the significant difference in the traffic density, level of human activities between Sapele Road A and B, and regular or consistent data gotten at Sapele Road B, the results could not be further analyzed in terms of comparison of morning, afternoon and evening values and in terms of the differences in the concentration of pollutants at the two sampling points.

4.4 The Differences in the Concentration of Pollutants between the Vegetative and Non-Vegetative Sampling Points

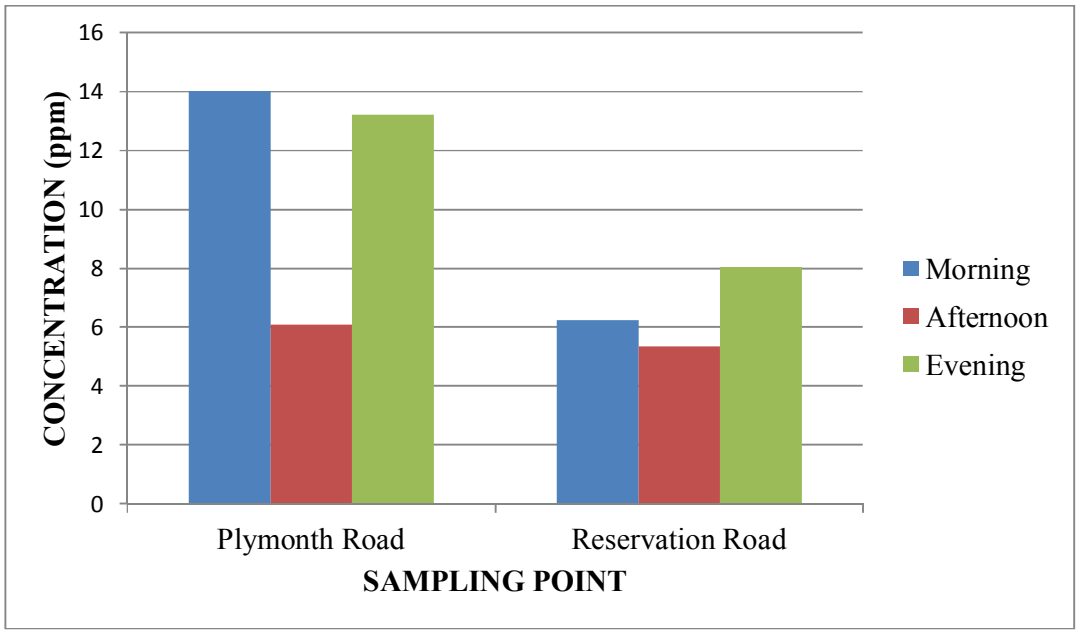


Figure 2 - Emission levels of CO at Plymonth Road and Reservation Road

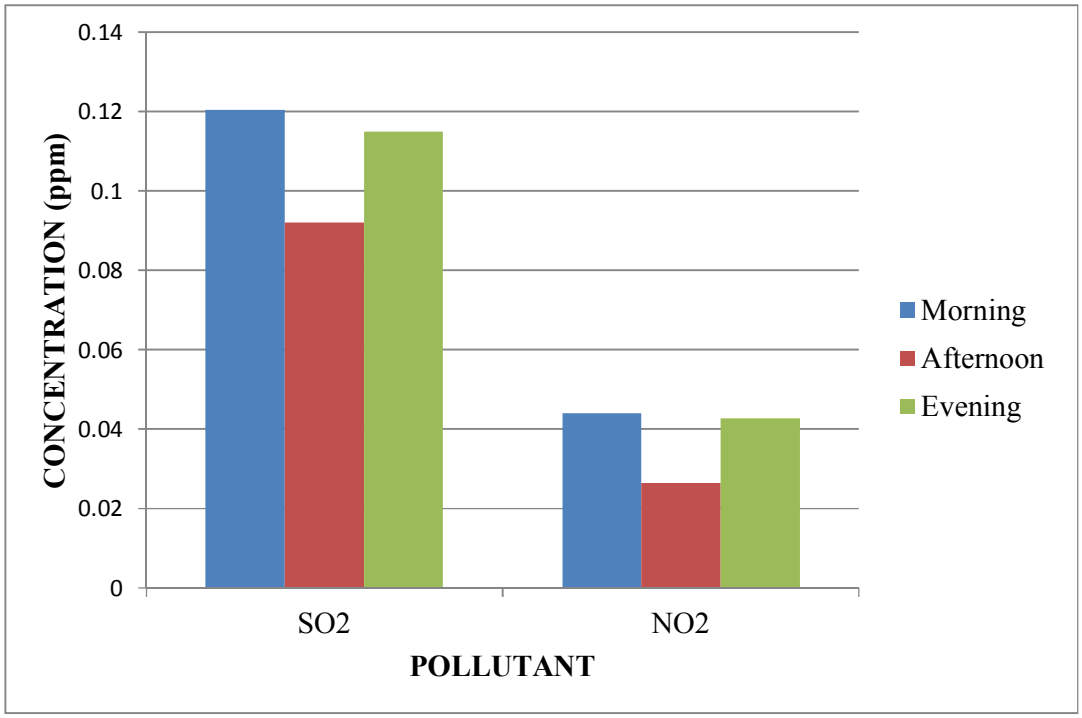


Figure 3 - Emission levels of SO_2 and NO_2 at Plymonth Road

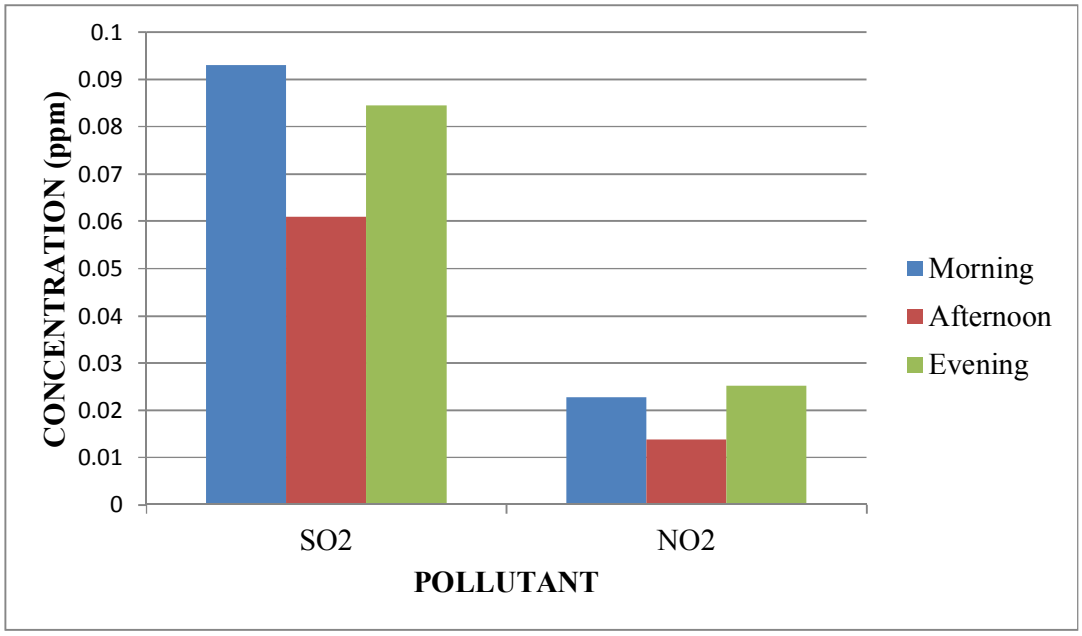


Figure 4 - Emission levels of SO_2 and NO_2 at Reservation Road

Figure II, III and IV show the differences in the emission levels of these pollutant gases in Plymonth Road (non vegetative) and Reservation Road (vegetative). It could be seen that all the emission levels of air pollutants taken at the vegetative sampling points are of lower concentration when compared to that taken at the non vegetative sampling point and this actually shows that vegetation contributes to the reduction of air pollutant which confirms that plants provide enormous leaf area for impingement, absorption and accumulation of air pollutants to reduce the pollution level in the air environment (Escobedo *et al.*, 2008). Although, the volume of pollutant removed was not ascertained. It also shows that concentrations of air pollutants are lowest in the afternoon.

Table 4.3: Mean and Standard Deviation of Emission Levels Measured for all Air Pollutants at Sampling Points

		Concentration (ppm)			
Sample Points	**Air Pollutants**	**Max.**	**Min.**	**Mean**	**SD**
Plymonth Road	CO	27.53	1.10	11.11401	2.942159
(non-vegetative)	SO_2	0.21	0.01	0.10917	0.0356824
	NO_2	0.083	0.01	0.11335	0.0271332
Sapele Road A	CO	4.40	0.19	2.195825	0.71629348
(non-vegetative)	SO_2	0.31	0.01	0.145665	0.04294026
	NO_2	0.017	0.001	0.007685	0.00292979
Reservation Road	CO	16.28	1.07	6.5315	1.892664
(vegetative)	SO_2	0.17	0.01	0.0795	0.0006395
	NO_2	0.049	0.002	0.020585	0.00761474

Source: Field Survey, 2013.

The maximum, minimum, mean, and standard deviation of air quality parameters determined for the different sampling sites are shown in table 4.3. The CO concentration range of Plymonth Road was between 1.1-27.53ppm, 0.19-4.4ppm for Sapele Road A and 1.07-16.28ppm for Reservation Road. The SO_2 concentration of Plymonth Road was between 0.01-0.21ppm and that of Sapele Road A and Reservation Road were between 0.01-0.31ppm and 0.01-0.17ppm. The NO_2 concentration range of Plymonth Road was between 0.01-0.083ppm, 0.001-0.017ppm for Sapele Road A and 0.002-0.029ppm for Reservation Road. CO has the highest mean concentration of 11.11401ppm at Plymonth Road and the lowest mean concentration of 2.195825ppm at

Sapele Road A. SO_2 has its highest mean concentration of 0.145665ppm at Sapele Road A and its least mean concentration of 0.0795ppm at Reservation Road. NO_2 has a highest mean concentration of 0.11335ppm at Plymonth Road and its lowest mean concentration of 0.007685ppm at Sapele Road A. It could still be seen that Reservation Road did not have the highest mean concentration of any of the air quality parameter measured when compared to the other sampling area.

4.5 Test of Hypothesis

To test for the significant differences in the levels of CO, SO_2, and NO_2 for the vegetative (Reservation Road) and non-vegetative (Plymonth Road) sample points, the independent T-test was conducted at 0.05 level of significance which was used to test the hypothesis that is predicated on the assumption that "there is no significant difference between vegetation and air quality at the sampling points". The result is shown in table 4.4 below.

Table 4.4: T-test for Level of Significant Difference between Vegetation and Air Quality

Air Pollutant	$\overline{X}_1$	$\overline{X}_2$	σ^2_1	σ^2_2	df	P-value	T-crit
CO	11.11401	6.5315	8.656299	3.582179	38	4.1423	2.042
SO_2	0.10917	0.0795	0.0012732	0.0006395	38	2.1453	2.042
NO_2	0.11335	0.020585	0.00073621	0.00005798	38	10.4093	2.042

Source: Field Survey, 2013.

Where $\overline{X}_1$ = Mean concentration of pollutants at Plymonth Road (non-vegetative sampling point)

$\overline{X}_2$ = Mean concentration of pollutants at Reservation Road (vegetative sampling point)

σ^2_1 = Variance of pollutants at Plymonth Road

σ^2_2 = Variance of pollutants at Reservation Road

df = Degree of freedom

T-crit = T critical

The result which was statistically significant (since calculated T which is P-value was greater than tabulated T which is T-critical) shows that there is a significant difference in the levels of the air pollutants (CO, SO_2 and NO_2) between the vegetated roadsides and the non-vegetated roadsides. This confirms that vegetation helps in air pollutant reduction which agrees with the work of Nowak *et al.* (2006) which demonstrated that urban trees remove large amounts of air pollutants that consequently improve urban air quality. Conclusively, the planting of vegetation along urban road side could be a viable strategy to improve air quality.

4.6 Discussion of Results

In general, the concentration levels of pollutant corresponded with the levels of traffic with significantly higher concentrations occurring during the morning and evening peak period. The concentrations also fluctuated greatly as a result of the vehicle composition and speed. The presence of traffic light which leads to long queues of idling cars and slow moving traffic may also explain CO, SO_2, and NO_2 concentrations, as slower moving vehicles emit more pollutant. For Plymonth Road, CO, SO_2 and NO_2 concentration levels were detected highly during the morning peak period while for Sapele Road A, CO, SO_2 and NO_2 concentration were highest in the evening period and for Reservation Road the concentration levels detected for CO and SO_2 was highest in

the morning periods and that of NO_2 was highest in the evening period. The variation in air quality between the locations and period of data collection is consistent with previous findings in Port Harcourt City. In that study done by Utang and Peterside (2011), highest variation between locations was in the evening peaks, for carbon monoxide and hydrocarbon (C_nH_n), both of which accounted for the highest variation during all periods. Sulphur oxides were generally not detected in the area, CO and C_nH_n were detected highly during the evening peak period while NO_n was highest during the morning peak period and lowest or not detected during the off peak period. These variations were attributed to the prevailing meteorological conditions and traffic flow, quality of vehicles, including age, maintenance and fuel type vehicle (i.e. diesel or petrol) because areas of concern were associated with intersections, traffic lights, queues and cars parking due to engine being temporarily switched off. Since, driving involves repeated acceleration, idling and decelerating cycles, the low concentration of CO and C_nH_n during off peak periods were attributed to the rate of acceleration when driving. During this period, the combustion is efficient and there is excess air.

Furthermore, in a similar work done by Ukpebor *et al*. (2010) in Benin City in which CO was the only air pollutant considered also confirms that variation existed in air quality between the locations and period of data collection. For almost all the sites, the highest CO concentration was measured in the morning hours. For example, at the Agbor Park sampling area, the morning hours CO range was 9.0-45.3ppm, while the afternoon and evening ranges were 5.5- 8.3ppm and 6.0-18.3ppm, respectively. At the ring road sampling station, the morning, afternoon and evening CO ranges were 18.3-35.5ppm, 10.8-21.5ppm and 11.9-21.5ppm, respectively. Similar trends were observed for the other three sampling locations. The factors responsible for the observed diurnal

variations in the CO distributions include; differences in local urban traffic volume at different times of the day, traffic flow, and meteorological conditions in Benin City.

In Nigeria, the Federal Environmental Protection Agency (FEPA) set its limit for CO at 10ppm, SO_2 at 0.01ppm and NO_2 between the ranges of 0.04-0.06ppm (FEPA, 2000). It was observed that the mean concentration of some of these pollutants at the different sampling sites exceeded these limits set by FEPA. For Plymonth Road, all the pollutants exceeded their limit, the mean concentration of CO was 11.11401ppm, for SO_2 was 0.10917ppm, and for NO_2 was 0.11335ppm as shown in table 4.3 of the results. While for Sapele Road A, SO_2 and NO_2 exceeded the FEPA limit, the mean concentration of CO was 2.195ppm, for SO_2 was 0.145665ppm and for NO_2 was 0.007685. Moreover, for Reservation Road only SO_2 exceeded the limit, the mean concentration was 6.5315ppm, 0.0795ppm and 0.020585ppm for CO, SO_2 and NO_2 respectively. A study on air pollution from automobiles at intersections on some selected major roads in Ogbomoso similarly found that the mean concentration of CO, SO_2, and NOx pollutants were much higher when compared with FEPA limit (Ojo and Awokola, 2012). The high concentration of these pollutants does have obvious health implications. As has been documented by many studies, SO_2 and NO_2 exposure are associated with immune system impairment, exacerbation of asthma and chronic respiratory diseases, reduced lung function, and cardiovascular disease, while CO has neurobehavioural and cardiovascular effects, such as headache, dizziness, and heart palpitations (Schwela, 2000).

The study has shown that the concentration of these pollutants at the non vegetative sampling sites were higher than that of the vegetative sampling sites. Plymonth Road

which is the non vegetative sampling site when compared with Reservation Road, a vegetative sampling site that have almost the same traffic volume (Table 3.1) had a higher level of concentrations of measured pollutant and Sapele Road A a non vegetative sampling site had a higher level of measured pollutant when compared to Sapele Road B (see Table 4.1 and 4.2 of the results). Even, the result of the T-test (Table 4.4) revealed that there is a significant difference between vegetation and air quality of the study area for all the air quality parameters measured. This has shown that the presence of vegetation along road sides reduces the concentration of pollutant present in that environment (Cavanagh, 2006). In a modeling study using hourly meteorological and pollution concentration data from across the coterminous United States confirms that urban trees remove large amounts of air pollution that consequently improve urban air quality (Nowak *et al*., 2006).

Pollution removal (0_3, PM_{10}, NO_2, SO_2, CO) varied among cities with total annual air pollution removal by US urban trees estimated at 711,000 metric tons ($3.8 billion value). In another similar study that attempts to view on the capabilities of urban forest in filtering the atmospheric environment by reducing the airborne particulates concentration confirms that one of the most efficient and environmentally method of the various methods that could be applied to alleviate the pollutant concentration in ambient air is by planting the vegetations in urban areas which are closely connected to the busy roads of a city (Nur Dina Shazani and Ainuddin Bin Nuruddin, 2012). In fact, urban forest is the best particulate scavenger to reduce the level of air pollutant concentration to ameliorate the air quality of urban areas that will create a healthy living and pleasant community and natural ecosystem (Ibid).

CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This study was designed to educate the public on the importance of the presence of trees in our environment, especially near the road side as this would help improve the air quality of the environment. This chapter captures the summary, conclusion and recommendations of the study.

5.2 Summary

This study estimated the level of air pollutant gases which include majorly CO, SO_2, and NO_2 found along the road sides at Plymonth Road, Reservation Road and Sapele Road in Benin City and considered vegetation as a means of reducing the concentration of these air pollutant gases.

Four sampling points were selected for the study which are: Plymonth Road, Reservation Road and Sapele Road (which was divided into Sapele Road A and B). Plymonth Road and Sapele Road A was classified as non-vegetative sampling areas because they have little or no vegetation present along its road sides while Reservation Road and Sapele Road B was classified as vegetative sampling areas because they have vegetation along their road sides. The concentration of these gases were measured using the aeroqual air quality kit and monitored at each sampling points three days a week for one hour during morning peak hours (7:30am.-8:30pm.), one hour during afternoon off peak hours (12:30pm.-1:30pm.) and one hour during evening peak hours (4:30pm.-5:30pm.) for a total of 4weeks. The analytical tools used were bar chart, mean, and standard deviation. The independent t-test was also used to test the hypothesis.

From this study, the average concentration of CO was found to be 11.11401ppm for Plymonth Road, 2.195825ppm for Sapele Road A and 6.5315ppm for Reservation Road respectively. The average concentration of SO_2 of 0.10917ppm was observed for Plymonth Road, 0.145665ppm for Sapele Road A and 0.0795ppm for Reservation Road respectively. The mean concentration of NO_2 was 0.11335ppm for Plymonth Road, 0.007685ppm for Sapele Road A and 0.020585ppm for Reservation Road. Sapele Road B had a constant average emission level of 0.00ppm for CO, 0.13ppm for SO_2 and 0.001ppm for NO_2 at all times tested.

The independent T-test analysis which compared the concentration of these air pollutant present in Plymonth Road to that present in Reservation Road showed that there is a significant difference. This means that the presence of vegetation near road sides helps to reduce the level of traffic emission pollutant present in that environment, thus improving the air quality and consequently can help improve human health.

5.3 Conclusion

This study has shown that vegetation is effective in reducing traffic emission pollutants like CO, SO_2 and NO_2 in an urban environment. The findings from this study showed that the concentration of these air quality parameters was higher in the non-vegetative sample area when compared to the vegetative sample area. Moreover, it was observed that the concentration levels of pollutant corresponded with the levels of traffic and most of them exceeded the available national regulatory limits. This therefore calls for urgent precautionary measures, so as to protect the population against the adverse impacts of these air pollutants. One of the ways to protect the population against these adverse impacts of traffic emission pollutant is by planting trees and

shrubs along the urban road sides. The establishment of urban green in a vast development of a city to achieve modernization is often being overlooked by the responsible authorities. Hence, it is of utmost important to construct a framework of greening programme in urban areas in respect to the protection of the environment.

5.4 Recommendations

Mitigating this pollution should be of high priority for human health and amelioration of environmental conditions in the city. As such, one possible approach is to establish appropriate plants at strategic locations such as in towns and along the road sides. Conventional air pollution management programs focus on controlling the source of air pollutants (Schnelle and Brown, 2002). This strategy effectively helps to reduce the emission of new air pollutants but does not address the pollutants already in the air. Innovative approaches should be adopted to help remove existing air pollutants thereby reducing air pollution concentrations to an acceptable level. One way to reach that goal is the use of urban vegetation which can reduce air pollutants through a dry deposition process and microclimate effects. The high surface area and roughness provided by the branches, twigs, and foliage make vegetation an effective sink for air pollutants (Beckett, Freer-Smith, Taylor, 1998; Hill, 1971). Vegetation also lowers the ambient air temperature by changing the albedos of urban surfaces and evapo-transpiration cooling. The lowered ambient temperature then slows down photochemical reactions and leads to less secondary air pollutants, such as ozone (Akbari, 2002; Rosenfeld, Akbari, Romm, Pomerantz, 1998).

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

i. Planting of trees should be given great priority by the Federal Ministry of Lands, Housing and Urban Development, Federal Ministry of Works, Federal Ministry of Transport and their state counterpart during the construction of urban roads by federal and state government.

ii. The general populace should be educated regularly by the National Environmental Standards and Regulations Enforcement Agency (NESREA) on the air quality of their environment, how it relates to their health and the importance of trees or vegetation in improving the air quality of their environment.

iii. The government and relevant agencies (i.e Federal Road Safety Corp, FRSC) should set up policies that will gradually bring an end to the importation of old vehicles.

iv. To achieve the aim of ameliorating the traffic-pollutants in urban atmosphere, diverse species of plants are recommended to be planted in urban cities and along road sides. This is because every species has its own capability in capturing the airborne particulates at different rates. However, morphological characteristics of trees like having a hairy, broad and rough leaf surface would be the most effective trees to act as a sink in removing the pollutants (Ade-Ademilua and Obalola, 2008; Tuteja, Rout, and Bishnoi, 2011).

v. The urban planners like the Federal and State Ministries of Lands, Housing and Development should equip themselves with the knowledge and related-beneficial information regarding to selection of pollutant-tolerant species because in certain circumstances, there are trees which are intolerant with the airborne pollutants.

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APPENDICES

Appendix 1 Pictorial Representation of Plymonth Road



Appendix 2 Pictorial Representation of Reservation Road



Appendix 3 Pictorial Representation of Sapele Road A



Appendix 4 Pictorial Representation of Sapele Road B



Appendix 5 Calibration Certificate of Carbon Monoxide Sensor Head

aeroQUAL

Aeroqual Limited

109 Valley Road, Mount Eden, Auckland, New Zealand

Phone: +64 -9-623 3013 Fax: +64- 9 -623 3012

www.aeroqual.com

Calibration Certificate No. 3386

Calibration Date: 27 Sep,2013

Model: Carbon Monoxide 0 -100ppm

Serial No: ECN -2709120-020

Environmental Conditions

Temperature	24.8	^{0}C
Relative Humidity	42	%

measurements

Calibration Standards/ppm	0.00	50.00	0.0	0.0
AQL Sensor (Mean)/ppm	0.00	50.8	0.0	0.0
AQL Sensor (Std.Dev) /ppm	0.000	0.034	0.000	0.000

* The Mean and Standard Deviation are calculated from three consecutive readings.

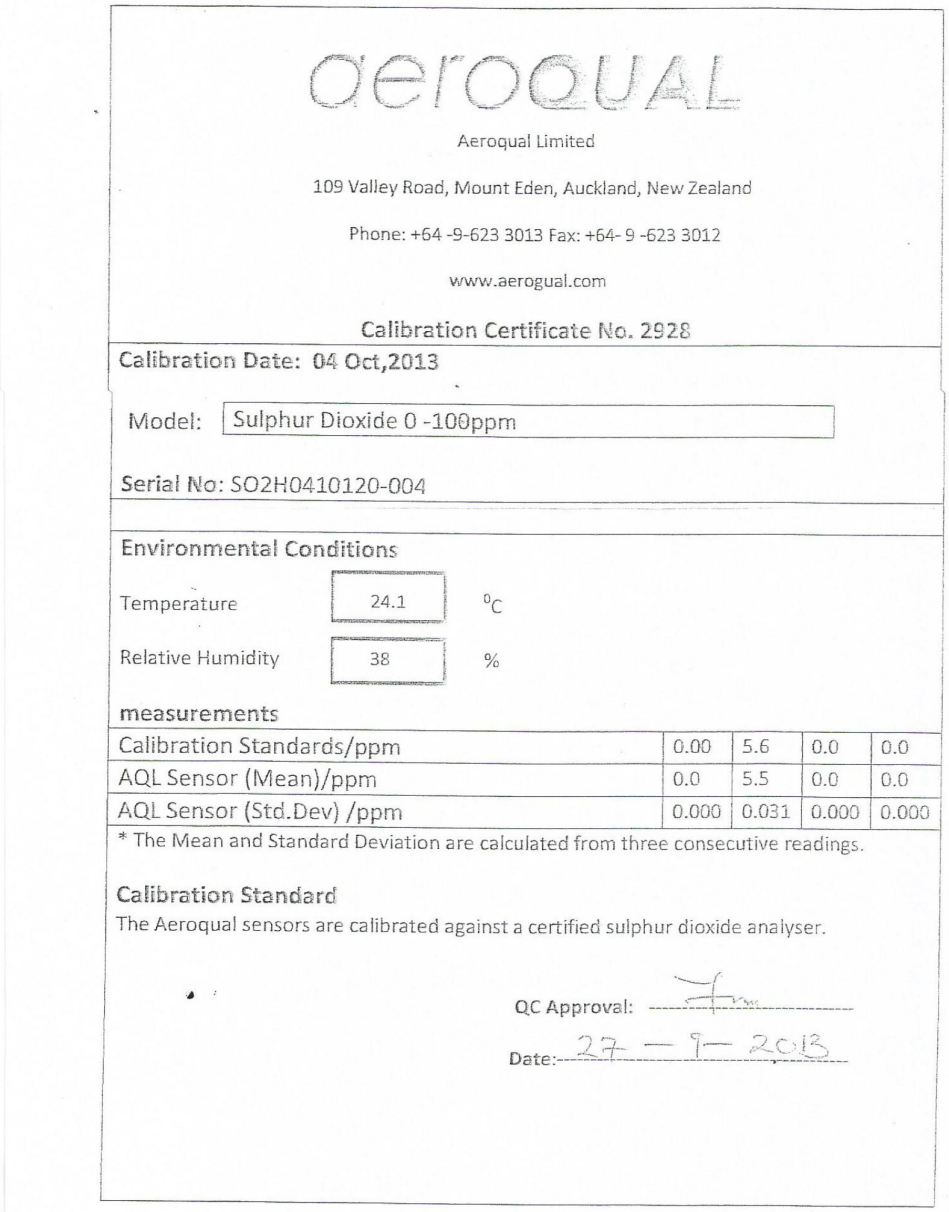
Calibration Standard

The Aeroqual sensors are calibrated against a certified carbon monoxide in air.

QC Approval: ----------

Date: 27 – 9 – 2013

Appendix 6 Calibration Certificate of Sulphur Dioxide Sensor Head



aeroqual

Aeroqual Limited

109 Valley Road, Mount Eden, Auckland, New Zealand

Phone: +64 -9-623 3013 Fax: +64- 9 -623 3012

www.aeroqual.com

Calibration Certificate No. 2928

Calibration Date: 04 Oct,2013

Model: Sulphur Dioxide 0 -100ppm

Serial No: SO2H0410120-004

Environmental Conditions

Temperature	24.1	°C
Relative Humidity	38	%

measurements

Calibration Standards/ppm	0.00	5.6	0.0	0.0
AQL Sensor (Mean)/ppm	0.0	5.5	0.0	0.0
AQL Sensor (Std.Dev) /ppm	0.000	0.031	0.000	0.000

* The Mean and Standard Deviation are calculated from three consecutive readings.

Calibration Standard

The Aeroqual sensors are calibrated against a certified sulphur dioxide analyser.

QC Approval: ----------

Date: 27 – 9 – 2013

Appendix 7 Calibration Certificate of Nitrogen Dioxide Sensor Head

aeroqual

Aeroqual Limited

109 Valley Road, Mount Eden, Auckland, New Zealand

Phone: +64 -9-623 3013 Fax: +64- 9 -623 3012

www.aeroqual.com

Calibration Certificate No. 150

Calibration Date: 06 Jun,2013

Model: Nitrogen Dioxide 0 -1ppm

Serial No: NO2 -0607128-004

Environmental Conditions

Temperature	23.8	^{0}C
Relative Humidity	42.0	%

measurements

Calibration Standards/ppm	0.020	0.048	0.000	0.000
AQL Sensor (Mean)/ppm	0.017	0.408	0.000	0.000
AQL Sensor (Std.Dev) /ppm	0.001	0.002	0.000	0.000

* The Mean and Standard Deviation are calculated from three consecutive readings.

Calibration Standard

The Aeroqual sensors are calibrated against a chemiluminescene NOX analyzer.
The calibration of this analyzer is traceable to primary standards.

QC Approval: ----------