DETERMINATION OF THE QUANTITY OF CARBON DIOXIDE CONTRIBUTED BY AUTOMOBILE EMISSIONS TO THE ENVIRONMENT – CASE STUDIES: KADUNA AND ABUJA

BY

KATO MARY EGIGANYA
99/8222EH

DEPARTMENT OF CHEMICAL ENGINEERING,
SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY,
FEDERAL UNIVERSITY OF TECHNOLOGY,
MINNA, NIGER STATE,
NIGERIA.

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A THESIS SUBMITTED TO:

THE DEPARTMENT OF CHEMICAL ENGINEERING
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IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF ENGINEERING (B. ENG) DEGREE IN CHEMICAL ENGINEERING.

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DECLARATION

I hereby declare that this project was carried out by me in the Department of Chemical Engineering, under the supervision of ENGR. U. G. AKPAN. All information utilized and their sources are duly acknowledged.

13/12/05

KATO MARY EGIGANYA
99/8222EH

DATE

CERTIFICATION

This is to certify that this project titled "Determination of the Quantity of Carbon Dioxide Contributed by Automobile Emissions to the Environment: Case Studies, Kaduna and Abuja Metropolis" carried out by Kato, Mary Egiganya of the Department of Chemical Engineering, Federal University of Technology, Minna, Nigeria meets the requirements for the award of Bachelor of Engineering (B. Eng) Degree in Chemical Engineering.

ENGR U. G. AKPAN PROJECT SUPERVISOR	DATE
DR. F. A. ABERUAGBA HEAD OF DEPARTMENT	DATE
EXTERNAL SUPERVISOR	DATE

DEDICATION

I dedicate this project to my mother, Mrs. C. L. Kato, and sister, Miss Veronica Kato.

ACKNOWLEDGEMENTS

My sincere gratitude goes to the Almighty God for His protection and preservation over my life and for His grace that kept me throughout the entire session.

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I appreciate very sincerely, my family – my mother, Mrs. C. L. Kato, my father, (Rtd.) Maj. J.J. Kato, and my only sister, Miss Veronica Kato, for their love, encouragement and support, every step of the way. You are the best family anyone could hope for.

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Finally, I want to appreciate my friends, and all those who, in one way or another, have been there for me. Thank you.

ABSTRACT

The quantity of carbon dioxide (CO_2) contributed by automobile emissions to the environment was determined at some areas in Kaduna and Abuja. Five census stations were selected in each of the two towns. In Kaduna, Jabi road in Ungwan Rimi, Kawo Motor park, Stadium round-about, Sabo and Kasuwa (Kaduna Main Market), 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 in the project to detect the quantity of CO_2 in the environment at such a time. The results obtained show a variation in the amount of CO_2 in the environment. Areas with relatively heavy congestion show a high concentration of CO_2, while areas with minimal traffic show a lower concentration of CO_2. Sabo in Kaduna has an average concentration of 1840ppm being the highest, while Asokoro (behind ECOWAS), Abuja has the least average concentration of 1160ppm. Review of literature showed that increasing CO_2 levels have adverse effects – such as the Greenhouse Effect, which may lead to Global Warming, as well as a number of other climatic events. It was recommended that to avoid economic disasters, the economy should be diversified away from oil production to other commodities. Also, renewable energy sources could be further developed to reduce the contribution to climate change.

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CHAPTER ONE

1.0 INTRODUCTION

The atmosphere, below 15km, is comprised of 75.5% nitrogen, 23.1% oxygen, and 1.3% other elements (Howland, 1998). The primary pollutants found in the atmosphere are carbon monoxide, carbon dioxide, sulphur oxides, nitrogen oxides, and hydrocarbons and suspended particulate matter. Since the dawn of the Industrial Revolution and the automobile, these pollutants have increased greatly attributing to events such as global warming, ozone layer depletion and acid rain.

One of the most important human impacts on our environment is the relatively rapid increase in atmospheric carbon dioxide caused by our profligate use of fossil fuels, as well as several activities which produce CO_2. The deforestation going on in several places is also a contributor to CO_2 increase in the environment. The rise in carbon dioxide (CO_2) is more rapid than at any time in the past, due to the increase in industrial activities. (Hamburg, 1999).

Although CO_2 is not toxic, its release is of interest as small increase of CO_2 concentration in the atmosphere can result in increase in ambient temperature and consequent climatic changes (Probstein and Hicks, 1985).

CO_2 levels have increased substantially since the Industrial Revolution, and are expected to continue doing so (IPCC Report, 1995). It is reasonable to believe that humans have been responsible for much of this increase, due to an increased dependence on machines and equipment that burn fossil fuels; such as automobiles and generators, as well as enhanced chemical processes carried out in factories and power plants.

Direct effects of CO_2 include the impact on human health and agricultural supply. These include illnesses such as carbon dioxide narcosis, caused by increased levels of CO_2 in the body, and more positively, an increase in crop yields. Indirect effects include those that arise as a result of climate change, such as the way temperature change may influence illness and mortality, and its impact on the incidence of extreme weather events. Ecosystem and agricultural changes (change of plants response to an environment), another indirect effect, can also be related to changes in climate.

CO_2 is an essential ingredient in the cycle of life on earth. Plants directly use CO_2 in the process of photosynthesis, where, combined with water, it is converted into sugars and oxygen. Plants use the sugars to fuel their growth, and animals breathe in the oxygen, consume plant matter, and exhale CO_2. The more CO_2 available, the better plants grow. Carbon dioxide only directly becomes a problem to animal life, including humans, if atmospheric concentrations continue to grow to toxic levels.

CO_2 plays a key role in the atmosphere. It has properties that allow it to sustain and hold in heat in the atmosphere and warm the planet (Howland, 1998).

CO_2 is emitted by natural and human-induced activities. Natural procedures include fire, human respiration, as well as ocean sinks. Fire, though may be caused by several human activities. Fire releases CO_2 when burning organic matter. Fire plays an important role in the contribution of CO_2 to the environment, since it is used in several activities such as bush burning, firewood-cooking, refuse disposal, etc. Respiration occurs when animals take in oxygen and discharge CO_2. CO_2 is also found in the ocean, under the controls of sea surface temperature, currents and photosynthesis and respiration in the ocean (Hamburg and Harris, 1999).

CO_2 emission due to human activities is pinpointed to three major causes: transportation, industry, and power plants. Transportation includes all vehicles that burn fossil fuels. Industrial activities bring about the emission of CO_2. Power plants emit CO_2 from chemical processes and the use of equipment such as generators that entail the combustion of fossil fuels for their operation.

The environment absorbs CO_2 from human and natural activities. These are known as 'sinks'. Sinks are reservoirs that keep a chemical element from another part of its cycle. There are three basic branches of the environment that absorb CO_2, these include; the atmosphere, ocean and land. On land, trees are the main absorbers of CO_2 – through the process of photosynthesis. Also, CO_2 is taken in through the soil through sediments and organic matter. The ocean is a very large sink. Here, photosynthetic organisms that live in the ocean take up the carbon. It is then exported as dissolved oxygen or particulate organic matter. In the deep ocean, bacteria then break down the organic matter produced and forms dissolved inorganic compounds. In the atmosphere, CO_2 is absorbed as well. CO_2 is also a minor component of the atmosphere, about 3 volumes in 10,000. (Pearce, 1999)

CO_2 is used for a variety of industrial applications. These include carbonation for beverages, refrigeration, enhanced oil recovery, the production of urea and methanol, etc. It can also be extracted as a by-product from the production of ammonia, hydrogen, fermentation and limestone calcinations. CO_2 is produced in a variety of ways: by combustion or oxidation of carbon containing compounds such as coal, wood, oil or foods, by fermentation of sugars, and by decomposition of carbonates under the influence of heat or acids. CO_2 is also used in the manufacture of sodium carbonate; $Na_2CO_3.10H_2O$ (washing soda), and sodium hydrogen carbonate, $NaHCO_3$ (baking soda).

1.1 BACKGROUND

CO_2 is a colourless gas having a faint sharp odour and a sour but refreshing taste. CO_2 was recognized as a gas different from others early in the seventeenth century by a Belgian chemist; Jan Baptist van Helmont, who observed it as a product both of fermentation and combustion (Britannica, 1982).

CO_2 liquefies upon compression to 1.071 lb/in^2 at 31°C (87.4°F) or to 230 – 345 lb/in^2 at -23°C to -12°C (-10°F to 10°F). By the mid-twentieth century, most CO_2 was sold in the liquid form. If the liquid is allowed to expand to atmospheric pressure, it cools and partially freezes to a snow like solid called 'Dry Ice', that sublimes at -78.5°C (-109.3°F) (Britannica, 1982).

At ordinary temperatures, CO_2 is quite unreactive. Above 1700°C (3100°F), it partially decomposes into carbon monoxide and oxygen. Hydrogen or carbon also converts it to carbon monoxide at high temperatures. Ammonia reacts with CO_2 under pressure to form ammonium carbonate, and then urea, an important component of fertilizers and plastics. CO_2 is slightly soluble in water (1.79 volumes per volume at 0°C and atmospheric pressure, larger amounts at higher pressures.) forming a weakly acidic solution called carbonic acid. (Britannica, 1982)

CO_2 is widely used as a refrigerant, in fire extinguishers, for inflating life rafts and life jackets, for blasting coal, for foaming rubber and plastics, for promoting the growth of plants in green houses, in mobilizing animals preparatory to slaughter and in carbonated beverages.

Ignited magnesium continues to burn in CO_2 but the gas does not support the combustion of most materials. Because of these properties, it is used for extinguishing fires. The CO_2 extinguisher is a steel cylinder filled with liquid CO_2, which when released, expands suddenly and causes so great a lowering of temperature that it solidifies into dry ice. This dry ice vaporizes on contact with the burning substance, producing a blanket of gas that cools and smothers the flame.

The presence of CO_2 in the blood stimulates breathing. For this reason, CO_2 is added to oxygen or ordinary air in artificial respiration and to the gases used in anaesthesia. But a prolonged exposure of humans to high concentrations of CO_2 may cause unconsciousness and death. (Britannica, 1982) At concentrations of 2500ppm to 5000ppm, CO_2 can cause headaches. At extremely high levels of 100,000ppm people lose consciousness in ten minutes, and at 200,000ppm, CO_2 can cause death. (Greiner, 1995)

CO_2 also acts as a greenhouse gas along with water vapour, ozone, methane, nitrous oxide and the chlorofluorocarbons to cause the phenomenon known as the 'greenhouse effect'. The ***Greenhouse Effect*** occurs when greenhouse gases allow incoming solar radiation to pass through the earth's surface, but prevent part of the outgoing infrared radiation from the earth's surface from escaping into space. It is called the 'Greenhouse Effect' because the differential transmissivity of the atmosphere plays the same role as the glass in a horticultural greenhouse (Probstein and Hicks, 1985). This greenhouse effect causes the gradual 'warming up' of the atmosphere known as '***Global warming***'.

1.2 PROBLEM STATEMENT

In recent years, there has been increasing concern for the quality of the environment. In fact, in most developed countries, adequate laws and implementation procedures have been embarked upon, to reduce levels of toxic pollutants present in the atmosphere. In some developing countries, there is a low level of environmental awareness, creating a lack of stringent measures needed for control of emissions of toxic gases, and the lack of implementation of these measures where they exist.

Motor vehicles are major sources of air pollutants. As industrialization and technological development continue, there will be a corresponding increase in income and hence cities will experience a greater increase in the number of vehicles on the roads. If vehicles continue to increase, it will become imperative that more attention be paid to vehicular pollutants, most especially CO_2 which is a direct product from the combustion of fossil fuels.

1.3 AIM AND OBJECTIVES

The aim of this study is to determine the quantity of CO_2 present in air samples obtained from two different areas – Kaduna and Abuja. The objectives include the following:-

- To determine present levels of CO_2 in air samples from the aforementioned areas.
- To review the possible effects of these levels.
- To examine the contribution of automobiles to the quantity of CO_2 in the environment.
- To raise awareness and promote an understanding of this relationship between vehicle emission and increasing levels of CO_2.

1.4 SCOPE

This project is restricted to studying and measuring the levels of CO_2 present in air samples using Kaduna and Abuja as case studies. This will be carried out with the use of a gas-analyzing sampling pump and tubes which can detect the quantity of CO_2

present in a given sample. Results will be obtained for each area, and the values compared.

1.5 JUSTIFICATION

Some scientists believe that with the rate at which CO_2 is increasing in levels all over the world, it won't be very long before we begin to experience catastrophic events that could cause an end to life as we know it. Others believe there is more scientific evidence to prove that CO_2 does not cause or contribute to adverse effects on public health, welfare or the environment. Some even conclude that an increase in CO_2 levels will confer a net benefit on the society.

It cannot at this stage, be certain of what an increase in CO_2 levels will cause in future, but an awareness of the possible effects is necessary to educate people on likely events, especially extreme weather events such as global warming, which can lead to drastic climate changes. This will either produce a decrease in the extravagant use of fossil fuels, or even a substitute for fossil fuels in the near or far future.

Since the beginning of the Industrial Revolution, the atmospheric concentrations of CO_2 have increased considerably, as well as those of other greenhouse gases. This increase in concentration is likely to accelerate the rate of climate change, i.e. an indirect implication of global warming.

Put simply, global warming may be explained as follows: the earth's climate is driven by a continuous flow of energy from the sun. This energy arrives mainly in the form of visible light. About 30% is immediately scattered back into space, but most of the 70% which is absorbed passes down through the atmosphere to warm the earth's surface. The earth sends this energy back out into space in the form of infrared radiation. Being much cooler than the sun, the earth does not emit energy as visible light. Instead, it emits infrared or thermal radiation. 'Greenhouse gases' in the atmosphere block the infrared radiation from escaping directly from the surface into space (Pearce, 1999). This is known as the 'greenhouse effect'.

The main greenhouse gases are water vapour, carbon dioxide (CO_2), ozone, methane, nitrous oxide and the chlorofluorocarbons. Levels of these gases are rising as a direct result of human activity. Apart from global warming, greenhouse gases are also responsible for the phenomenon known as ozone layer depletion. It is predicted that the global average temperature will rise by about 2°C (3.6°F) by the year 2100 if current emission trends continue (IPCC Report, 1995).

CO_2 is being generated in ever increasing amounts in part due to the increase in the population of the earth, in part due to the clearing of forests (and thus to less use of CO_2 in photosynthesis) and in part to increased combustion of fossil fuels. If this increase becomes severe, it could enhance the greenhouse effect, leading to the global warming trend. This warming might be enough to melt part of the polar ice caps and raise the level of the oceans and turn part of the now temperate zones into deserts. (Kotz and Purcell, 1987)

For these and many other reasons, an understanding of the present situation and the effects are necessary. And for this purpose this research has been carried out.

CHAPTER TWO

LITERATURE REVIEW

2.1 AIR POLLUTION

Air Pollution is the contamination of the atmosphere by gaseous, liquid, or solid wastes or by-products that can endanger human health and the welfare of plants and animals, or can attack materials, reduce visibility, or produce undesirable odours. Air pollution is one of the most pervasive environmental problems because atmospheric currents can carry contaminated air to every part of the globe. Most air pollution comes from motor vehicle emissions and from power plants that burn coal and oil to produce energy for industrial and consumer use.

2.1.1 *Sources of Air Pollutants*

The sources of air pollutants can be classed under two broad categories:

Stationary sources – these include factories, power plants, smelters, volcanic eruptions, etc.

Mobile sources – these include automobiles, buses, trucks, locomotives and air planes.

These emissions adversely affect the health of animals and plants and the chemical nature of the atmosphere.

2.1.2 *Types of Air Pollutants*

These include carbon oxides (CO, CO_2), sulphur oxides (SO_2, SO_3), nitrogen oxides (NO, NO_2, N_2O), hydrocarbons, photochemical oxidants (e.g. ozone, O_3), particulates, inorganic compounds such as hydrogen sulphide (H_2S), hydrogen fluoride (HF), ammonia (NH_3), and other compounds like pesticides, herbicides and radioactive substances. (Garba, 2005)

2.2 THE AUTOMOBILE

The modes of transportation that produce atmospheric pollutants comprise automobiles, buses and trucks with gasoline engines, diesel powered trucks and buses, propeller and jet-powered aircraft, railroad locomotives and marine vessels. By far the most important from an air pollution standpoint is the spark-ignited internal combustion engine (I.C.E.) using gasoline as fuel (Lawrence, 1972).

2.2.1 The Internal Combustion Engine

In the modern spark-ignited internal combustion engine, a sequence of five events takes place;

i. Air and fuel are mixed in predetermined proportions in a carburettor, or by fuel injection.

ii. The mixture of fuel, in vapour and fine droplet form, and air is drawn into a combustion chamber (cylinder) equipped with a movable piston.

iii. The mixture is compressed and then ignited by means of a controlled spark.

iv. Controlled combustion takes place, producing power that is translated mechanically to the drive mechanism (crankshaft).

v. The spent gases are exhausted to the atmosphere.

2.3 FOSSIL FUELS

Energy can be generated from both renewable and non-renewable sources. Renewable sources include solar, wind and hydro power. But most of our energy is still obtained from non-renewable sources i.e. fossil fuels. (Miller, 1999)

Fossil fuels consist of carbon and hydrogen bonds. There are three types of fossil fuels that can be used for energy generation; coal, crude oil and natural gas. (McKinney and Schoch, 2003) Coal is a solid fossil fuel formed by decay of land vegetation. Crude oil is a liquid fossil fuel formed from the remains of marine micro organisms. It is the most widely used fossil fuel. Natural gas is a gaseous fossil fuel formed, like crude oil, from the remains of marine micro organisms. (McKinney and Schoch, 2003)

Energy generated by burning fossil fuels is converted to electricity and heat in commercial power plants. When fossil fuels are burned, carbon and hydrogen react with oxygen in air to give CO_2 and water. This is the basic reaction taking place during the combustion of fossil fuels in vehicles.

Burning fossil fuels is responsible for a great percentage of environmental issues. Currently, crude oil burning is responsible for about 30% of all CO_2 emissions to air. (McKinney and Schoch, 2003)

2.4 AUTOMOBILE FUELS

Internal combustion engines use liquid fuels i.e. crude oil. Crude oil may be processed to obtain gasoline, diesel, kerosene, heating oils, jet fuels, lubricating oils, and asphalt by continuous fractionating in a distillation column. (Lawrence, 1972)

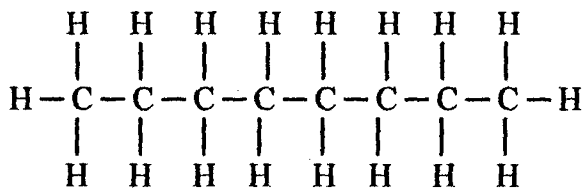
'Detonation or knock' is the name given to an abnormal nature of the combustion of fuel in an engine, when only part of the working mixture after ignition burns normally at the usual rate. In knock regimes, the engine power drops, fuel consumption grows and the operation of the engine becomes rigid and rough. Knock causes burning out and wear of the engine. Accidents are more prone to occur in the regime of intensive engine knock.

Pure isooctane is practically free from knock, while pure heptane knocks worse than almost any known fuel. (Erikh et al, 1984) Mixtures of these two substances can be made to match the knock property of any fuel.

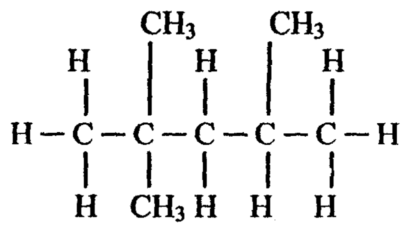
2.4.1 *Structure of Fuel*

Liquid fuels consist mainly of a mixture of hydrocarbons differing in their composition. The principal components of petroleum are the paraffins (alkanes) with the general formula C_nH_{2n+2}, naphthenes (cyclanes) with the formula C_nH_{2n} and aromatic hydrocarbons with the formulae C_nH_{2n-6} and C_nH_{2n-12}. Olefins, diolefins, and acetylenes are contained in petroleum in insignificant quantities. On an average, petroleum contains 84 - 85% carbon and 12 – 14% hydrogen, the remainder being nitrogen, oxygen and sulphur. (Khovakh, 1979)

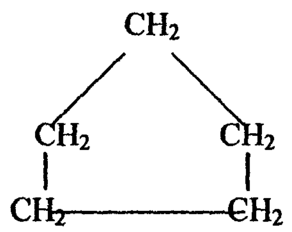
Petroleum contains saturated hydrocarbons, which may have either straight or branched chains of carbon atoms (alkanes and iso-alkanes) or cyclic chains. In these hydrocarbons, the chains of carbon atoms are linked by single bonds and completely saturated with hydrogen atoms. An example is in the structural formulae of octane, iso-octane and cyclopentane shown below.



Octane, C_8H_{18}



Iso-octane, C_8H_{18}

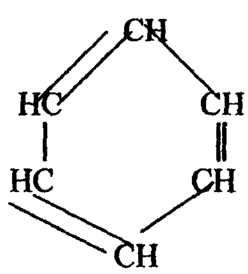


Cyclopentane, C_5H_{10}

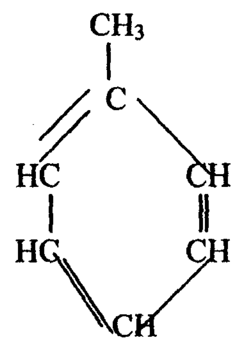
Fig1: Saturated Hydrocarbons

The more compact a hydrocarbon molecule, the better are its antiknock properties, determined by the octane number.

Aromatic hydrocarbons have a cyclic structure of their molecules. The structural formulae of benzene and toluene are given below.



Benzene, C_6H_6



Toluene,$C_6H_5(CH_3)$

Fig 2: Aromatic Hydrocarbons

The presence of aromatic hydrocarbons in petrol improves its antiknock properties. (Khovakh, 1979)

2.4.2 *Properties of Fuel*

a. Volatility: This is the ability of fuel to evaporate when heat is applied. It is determined by heating the fuel in a distillation column and consecutively removing the fractions that boil away within a certain temperature range.

b. Antiknock value: The antiknock properties of petrol are estimated by the octane number, which is numerically equal to the content in percent by volume of the notreadily-detonating isooctane in a mixture also containing easily-detonating n-heptane. (Khovakh, 1979)

c. Flame temperature: This is the temperature of the chemical reaction between fuel and oxidant.

d. Flammability limits: Depending on the concentration of the vapour of a combustible liquid or gas in the air, lower and upper explosive limits are distinguished (Erikh et al, 1984). These are referred to as lean and rich limits of flammability. The lower (lean) limit corresponds to the minimum concentration of fuel vapour in the mixture with air at which it flashes when ignited, while the upper (rich) limit corresponds to the maximum concentration of fuel vapour in the mixture with air above which no flash occurs. The narrower the limit, the safer is a given fuel. (Erikh, 1984)

e. Flame speed: This is the velocity at which a flame moves through a gas mixture (Perry, 2002).

f. Flash point: This is the temperature at which the vapour of a petroleum product ignites in air.

g. Ignition point: This is the temperature at which fuel ignites and burns for at least 5 seconds. It is usually higher than the flash point (Perry, 2002).

h. Self-ignition point: This is the temperature at which fuel in contact with air ignites spontaneously without any external source of flame.

2.5 COMBUSTION

The reaction of alkanes with oxygen to form CO_2, water and heat is the chief reaction occurring in the internal combustion engine. Most motor fuels are combusted by mixing the liquid fuel with stoichiometric amounts of air in an internal combustion chamber. This mixture is pressurized then ignited by either a sparking device or by the cylinder – compression heat.

The amount of air or oxidant just sufficient to burn the carbon, hydrogen and sulphur in a fuel to CO_2, water vapour, and sulphur dioxide is known as theoretical or stoichiometric oxygen or air requirement. The chemical equation for complete combustion of a fuel is

$$C_xH_yO_zS_w + \frac{[4x + y - 2z + 4w]}{4} O_2 = xCO_2 + (y/2)H_2O + wSO_2 \quad \text{------------------2-1}$$

where x, y, z, and w are the number of atoms of carbon, hydrogen, oxygen and sulphur respectively, in the fuel.

More than the theoretical amount of air is necessary in practice to achieve complete combustion. (Perry, 1997) This excess air is expressed as a percentage of the theoretical amount of air. The equivalence ratio is the ratio of the actual air-fuel ratio to the stoichiometric air-fuel ratio. Equivalence ratio values less than 1.0 correspond to fuel-lean mixtures, while values greater than 1.0 correspond to fuel-rich mixtures.

The air-fuel ratio (AFR) is the mass of air per unit mass of fuel. As fuel becomes heavier, i.e. the ratio of moles of hydrogen per mole of carbon decreases, the air-fuel ratio decreases. For instance, at stoichiometric conditions, gasoline (C_8H_{18}) has an AFR of 15, and for pure carbon, it is 11.5. (Lawrence, 1972)

2.5.1 *Exhaust Products of Combustion*

Products of combustion consists of CO_2, water vapour, nitrogen, oxygen, nitrogen oxides, sulphur oxides, particulate matter, carbon monoxide and unburned hydrocarbons.

Carbon dioxide: - For every gallon of oil consumed by a motor vehicle, about 19 pounds of carbon dioxide goes directly into the atmosphere. (Walsh, 1991) In other words, for a typical fill up at the service station (estimated at 15 gallons of petrol) about 300 pounds of carbon dioxide are eventually released into the atmosphere (Walsh, 1991)

At concentration of 2,500ppm to 5,000ppm, CO_2 can cause headaches. At extremely high levels of 100,000ppm, people lose consciousness in ten minutes, and at 200,000ppm, CO_2 can lead to death. (Greiner, 1995)

Carbon monoxide: - Carbon monoxide is formed when there is incomplete combustion of fuels containing carbon. Carbon monoxide combines with atmospheric oxygen in air to form carbon dioxide. It also contributes to smog formation and the build-up of methane. People with coronary artery disease who are exposed to carbon monoxide usually experience chest pain. (Walsh, 1992)

Carbon monoxide is odourless, colourless, and highly toxic. It combines with haemoglobin in the red blood cells to form a stable compound which prevents the transportation of oxygen in the body. It adversely affects human health at only a few parts per million and causes death at 250ppm. (Greiner, 1995)

Nitrogen oxides: - There are three major oxides of nitrogen, known collectively as NO_x. Nitrous oxide, N_2O, is produced naturally. Both nitric oxide, NO, and nitrogen dioxide, NO_2 are emitted anthropogenically. Both result from oxidation of nitrogen present in fossil fuels and, from nitrogen in the air used in the combustion process. Vehicles emit large concentration of nitric oxide (NO), which is rapidly oxidized in the atmosphere to nitrogen dioxide (NO_2), an important reaction in the formation of photochemical smog. (Meethan et al, 1981)

Sulphur oxides: - Sulphur dioxide is a colourless gas with a pungent odour. SO_2 can be oxidized to form sulphur trioxide (SO_3), which dissolves in water to form sulphuric acid. Combustion of sulphur containing fossil fuels, smelting of sulphur–bearing metal ores, industrials processes, natural events such as volcanic eruptions are the principal sources of sulphur dioxide. Health effects of sulphur dioxide are: aggravation of respiratory diseases, including asthma, chronic bronchitis, and emphysema, reduced lung function, irritation of eyes and respiratory tract. (Umeh and Uchegbu, 1997)

Particulate matter: - These may consist of mineral matter derived from ash constituents of fuels, condensed sulphate particles, char, coke and soot.

Unburned hydrocarbons: - These include small molecules that are the intermediate products of combustion, e.g. formaldehyde, and larger molecules that are formed by the pyrosynthesis in fuel-rich zones, e.g. benzene, toluene, xylene, and aromatic hydrocarbons.

2.6 CARBON DIOXIDE

Carbon dioxide is an atmospheric gas composed of one carbon and two oxygen atoms. CO_2, as it is f results from the combustion of organic matter if sufficient amounts of oxygen are present. It is also produced by various micro organisms from fermentation and cellular respiration. Plants utilize CO_2 during photosynthesis using both the carbon and the oxygen to form carbohydrates. It is present in the Earth's atmosphere at a low concentration and acts as a greenhouse gas. It is a major component of the carbon cycle.

2.6.1 *Chemical and Physical Properties of Carbon Dioxide*

Carbon dioxide is a colourless gas. Its density at 25°C is 1.98kgm^{-3}. about 1.5 times that of air. The CO_2 molecule (O=C=O) contains two double bonds and has a linear shape. It has no electrical dipole. As it is fully oxidized, it is not very reactive and in particular not flammable (Wagner et al, 2002).

At temperatures below -78°C, CO_2 condenses into a white solid called 'Dry Ice'. Liquid CO_2 forms only at pressures above 5.1atm. Water will absorb its own volume of CO_2, and more than this under pressure. About 1% of the dissolved CO_2 turns into carbonic acid. This in turn dissociates partly to form bicarbonate and carbonate ions.

2.6.2 *Applications of CO_2*

Liquid and solid CO_2 are important refrigerants, especially in the food industry, where they are employed during the transportation and storage of ice-cream and other frozen foods. CO_2 is used to produce carbonated soft drinks and soda water. The leavening agents used in baking produce CO_2 to cause dough to rise. Baker's yeast produces CO_2 by fermentation within the dough, while chemical leaveners such as baking powder release CO_2 when heated or exposed to acids (Wagner et al, 2002).

CO_2 is often used as an inexpensive, non-flammable pressurized gas. Life jackets often contain canisters of pressurized CO_2 for quick inflation. Rapid vaporization of liquid CO_2 is used for blasting coal in mines. CO_2 extinguishes flames, and some fire extinguishers, especially those designed for electrical fires, contain liquid CO_2 under pressure. CO_2 also finds use as an atmosphere for welding, although in the welding arc, it reacts to oxidize most metals. Weld joints made in this way deteriorate over time due to the formation of carbonic acid. CO_2 is used for welding because it is less expensive than inert gases such as argon or helium (Indermuhle et al, 1999).

Liquid CO_2 is a good solvent for many organic compounds, and it is used to remove caffeine from coffee in a process known as 'super-critical fluid extraction'. CO_2 is used in greenhouses to enhance plant growth. High levels of CO_2 in the greenhouse atmosphere will effectively exterminate pests such as whitefly, spider, mites and others (Smith et al, 1997).

In arts theatres, dry ice is used to produce fog as a special effect; when dry ice is added to water, the evaporating mixture of CO_2 and cold humid air condenses as fog. In medicine, up to 5% of CO_2 is added to pure oxygen, for stimulation of breathing and to stabilize the O_2/CO_2 balance in blood (Smith et al, 1997).

2.6.3 *The Carbon Cycle*

Carbon follows a certain route on earth, which is called the carbon cycle. The carbon cycle is based on CO_2 which can be found in air in the gaseous form and in water in the dissolved state. The carbon cycle therefore consists of two parts; the terrestrial and the aquatic carbon cycle.

Terrestrial plants use carbon dioxide from the atmosphere, to generate oxygen that will sustain animal life. Aquatic plants also generate oxygen, but they use carbon dioxide from water. The process of oxygen generation is called photosynthesis. During photosynthesis, plants and other producers transfer carbon dioxide and water into complex carbohydrates, such as glucose, under the influence of sunlight. The overall reaction of photosynthesis is:

$$\text{carbon dioxide} + \text{water} + \text{solar energy} \rightarrow \text{glucose} + \text{oxygen}$$

$$6CO_2 + 6H_2O + \text{solar energy} \rightarrow C_6H_{12}O_6 + 6O_2$$

Carbon dioxide is released back into the atmosphere during respiration of consumers, which breaks down glucose and other complex organic compounds and converts the carbon back to carbon dioxide for reuse by producers.

Carbon can also be stored as biomass in the roots of trees and other organic matter for many decades. This carbon is released back into the atmosphere by decomposition.

In the aquatic ecosystem carbon dioxide can be stored in rocks and sediments. Carbon dioxide that is stored in water will be present as either carbonate or bicarbonate ions. These ions are an important part of natural buffers that prevent the water from becoming too acidic or too basic. When the sun warms up the water, carbonate and bicarbonate ions will be returned to the atmosphere as carbon dioxide. Schematic representations of the aquatic and terrestrial part of the carbon cycle are shown in figs. 2 and 3.

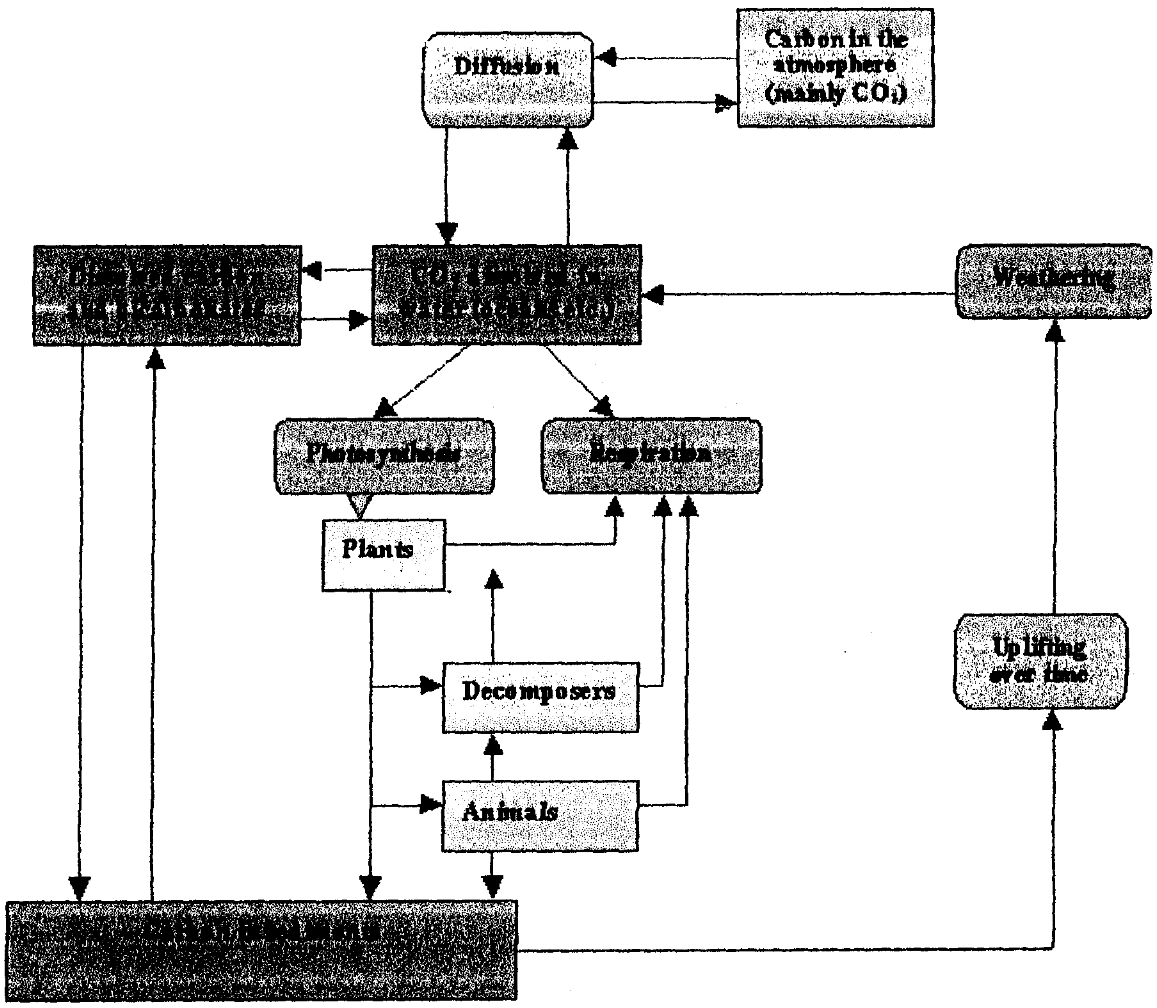


Fig 3: The Aquatic Carbon Cycle

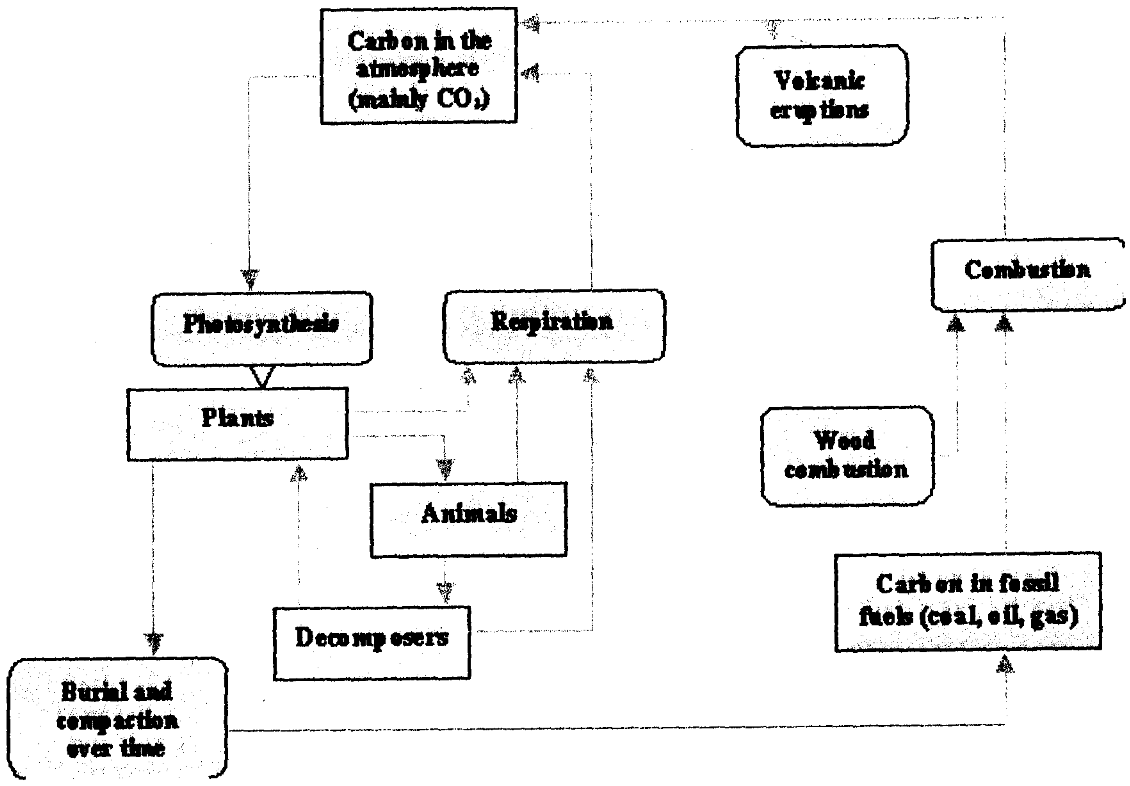


Fig 4: The Terrestrial Carbon Cycle

2.6.4 *Contribution of Automobiles to Elevated CO_2 in Urban Areas*

In Nigeria, there has been rapid increase in population from 3,340,000 in 1950 to 38, 159,000 in 1990 (UNO, 1990) and by 1995, there were about 40 million people living in Nigeria cities and towns. (Koleola, 1997). 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. The various opportunities offered by cities are therefore accompanied by problems of congestion, environmental degradation, unemployment, poverty, violence and all sorts of environmental risks. (Koleola, 1997).

City Centres

The centre of a city is its focal point. It is like the heart in human body, pulsating with life and activity. It will contain most of the public buildings, courts of law, police and fire stations, post office, telephone exchange, commercial offices such as banks, insurance companies, and office of professional consultants, a comprehensive shopping area, and entertainment facilities such as hotels, restaurant, bars, clubs, theatres and cinemas. (Vagale, 1976).

Traffic Congestion in City Centres

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.

In city centres with a high degree of congestion of automobiles and inflation of population, there will most certainly be a high level of atmospheric CO_2 due to combustion of fuels, and other processes that produce CO_2.

2.6.5 Effects of Elevated CO_2

2.6.5.1 Environmental Effects

Greenhouse Effect: - The greenhouse effect refers to the way in which gases in the Earth's atmosphere warm the Earth like the glass roof of a greenhouse—by letting sunlight in but keeping the reflected heat energy trapped inside. These gases, notably carbon dioxide and water vapour, are called greenhouse gases.

The atmosphere is largely transparent to incoming short-wave (or ultraviolet) solar radiation, which is absorbed by the Earth's surface. Much of this radiation is then re-emitted as heat energy at long-wave, infrared wavelengths; some of this energy escapes back into space, but much of it is reflected back by the greenhouse gases – carbon dioxide, methane, nitrous oxide, halocarbons, and ozone in the atmosphere. This heating effect leads to global warming.

Under normal conditions the level of carbon dioxide in the atmosphere remains constant, and trees absorb the same amount of carbon dioxide that is produced. But in recent decades, our planet has supported more people and fewer trees, leaving an excess of carbon dioxide in the atmosphere.

Ozone Layer Depletion: - Another serious problem related to air pollution is the shrinking of the upper atmospheric ozone layer that blocks out dangerous ultraviolet (UV) light. First reported over Antarctica in the 1980s, ozone holes have since been detected over parts of North America and elsewhere. (Bell, 2003). The holes are created when ozone molecules are destroyed by chlorofluorocarbons (CFCs), chemicals that are used in refrigerants and aerosol containers (e.g. CO_2) and can drift into the upper atmosphere if not properly contained.

Acid Rain: - Acid rain occurs when sulphur dioxide and nitrogen oxide emissions from motor vehicles and fossil-fuel burning power plants fall back to Earth as acidic precipitation. The pH level, or relative acidity, of many freshwater lakes has been altered so dramatically by acid rain that entire fish populations have been destroyed. (Bell, 2003)

Global Warming: - The gradual warming of the earth caused by the greenhouse effect has a number of dire consequences. These include;

- Droughts and floods
- Temperature changes
- Sea level rise
- Evaporation of water supplies
- Conducive environment for disease causing organisms

2.6.5.2 Agriculture

Crop yields: - CO_2 acts as a fertilizer, increasing plant growth rate and biomass by increasing photosynthetic capacity. It increases plant water use efficiency and drought tolerance, as well as performance under low light conditions and high temperature conditions. It also increases plants' abilities to grow in the presence of environmental hazards imposed by soil alkalinity, mineral stress, atmospheric pollutants, and UV radiation.

Enhanced Photosynthetic Capacity: - An enhancement of atmospheric CO_2 levels increases the efficiency of photosynthesis, resulting in a marked reduction of plant respiration. This results in increases in total dry weight, root growth, higher root/top ratios, leaf area, weight per unit area, leaf thickness, stem height, branching and seed, and fruit number and weight. (IPCC Report, 1995)

Increased Water-Use Efficiency: - CO_2 improves water use efficiency by closing down the pores through which plants lose moisture. Plants increase their fine root mass – which increases the ability to ingest water – at higher CO_2 concentrations.

2.6.5.3 Health

Internal Respiration: - Internal respiration is a process, by which oxygen is transported to body tissues and carbon dioxide is carried away from them. Carbon dioxide is a guardian of the pH of the blood, which is essential for survival. The buffer system in which carbon dioxide plays an important role is called the carbonate buffer. It is made up of bicarbonate ions and dissolved carbon dioxide, with carbonic acid. The carbonic acid can neutralize hydroxide ions, which would increase the pH of the blood when added. The bicarbonate ion can neutralize hydrogen ions, which would cause a decrease in the pH of the blood when added. Both increasing and decreasing pH is life threatening (Smith et al, 1997).

Asphyxiation: - This is caused by the release of carbon dioxide in a confined or unventilated area. It can lower the concentration of oxygen to a level that is dangerous for human health (Miller, 1999).

Frostbite: - Solid carbon dioxide is always at temperatures below -78°C. Handling this material for more than a second or two without proper protection can cause serious blisters. Carbon dioxide gas released from a steel cylinder, such as a fire extinguisher, causes similar effects (Miller, 1999).

Emphysema: - This is caused by an imbalance between oxygen and CO_2 in the blood. Normal blood oxygen is about 80 – 100mmHg, while normal blood CO_2 is about 40mmHg. An increased concentration of CO_2 or a decreased level of oxygen will lead to the condition known as emphysema. (Bloomfield, 1992)

2.6.6. Nigeria's Contribution to Global CO_2 Emissions

Overview of Carbon Dioxide Emissions in Africa

• Between 1980 and 2001, Africa's energy related carbon dioxide emissions increased by 61% overall - an average of 2.3% annually - from 390 MMT to 630 MMT (www.eia.doe.gov, 2005). During this period, the region's per capita carbon dioxide emissions rate declined 5% overall, from 0.95 metric tons to 0.9 metric tons per person. Both Africa's absolute carbon dioxide emissions and its per capita carbon dioxide emissions rate were the lowest in the world in 2001 (www.eia.doe.gov). This was probably due to the absence of an extremely large transportation sector, combined with relatively low rates of electrification, and industrialization.

• Much of Africa's carbon dioxide emissions growth between 1980 and 2001 came from South Africa. In 2001, South Africa accounted for 61% of Africa's total carbon dioxide emissions. During this period, South African emissions grew from 235 MMT to 386 MMT. The most reason for South Africa's large carbon dioxide emissions is its reliance on coal.

• Despite having a population almost three times larger than South Africa's, Nigeria emitted less than a quarter as much carbon during the past 20 years. This reflects the relative absence of industrial development. Nigeria's carbon dioxide emissions grew modestly, rising an average of 1.0% a year, from 69 MMT to 86 MMT. (www.eia.doe.gov).

Carbon Dioxide Intensity in Africa

• South Africa and Nigeria released the most carbon dioxide per dollar of GDP throughout the 1980s and 1990s, reflecting their status as the most industrialized country and largest energy producer, respectively, in Africa (www.eia.doe.gov).

• Nigeria's carbon dioxide intensity is the lowest of all OPEC members, but it remains significantly higher than the levels of rest of the major African economies', other than South Africa (www.eia.doe.gov).

2.6.7 Carbon dioxide Emission Trends in Nigeria

Carbon Dioxide (CO_2) Emissions	Nigeria	Sub-Saharan Africa	World
(in thousand metric tons of CO_2)			
Total Emissions, 1998	78455	515001	24215376
Emissions as a percent of global CO_2 production	0.3 %	2.1 %	
Emissions in 1998 from:			
solid fuels	172	292852	8654368
liquid fuels	25410	151843	10160272
gaseous fuels	11325	16330	4470080
gas flaring	40202	42110	172208
cement manufacturing	1345	11865	758448
Per capita CO_2 emissions, 1998			
(thousand metric tons of CO_2)	1	1	4
Cumulative CO_2 emissions, 1900-1999			
(in	2162	1688	933686

billion metric tons)	7		
CO2 Emissions by Sector, 1999 (in million metric tons of CO2)			
Public electricity, heat production,	6	-	8693
Other Energy Industries	6	-	1205
Manufacturing Industries and Construction	9	-	4337
Transportation	16	-	5505
Residential	3	-	1802
Other Sectors	2	-	5640
Total Emissions All Sectors:	43	-	27180
CO2 Intensity, 1999			
Emissions per total energy consumption (metric tons CO2 per terajoule energy)	11	32	56
Non-CO2 Air Pollution, thousand metric tons			
Sulphur dioxide emissions, 1995	764	5345	141875
Nitrogen oxide emissions, 1995	835	9309	99271
Carbon monoxide emissions, 1995	21424	177268	852415
Non-methane VOC emissions, 1995	3424	17375	159634

(Source: World Resources Institute, 2005) – See charts in Appendix B.

2.6.8 Impact of Global Warming on Nigeria

Policies adopted globally to mitigate climate change (global warming) will have negative implications for specific sectors, such as the coal, oil and gas industries. Nations relying exclusively on any of these sectors will thus be gravely affected by the climate change abatement process. Few countries stand more threatened by this development than the oil-producing Nigeria. (Ikeme, 2004) Nigeria's economy today remains heavily dependent on the oil sector, which accounts for around 80%of government revenues, 90-95%of export revenues, and over 90%of foreign exchange earnings (Ikeme, 2004).

Currently, the action to stem the emission of greenhouse gases is restricted to the developed countries. This requires them to cut their greenhouse gas emissions by 5%compared to 1990 levels by the period 2008-2012 (Kyoto Protocol). Nigeria is not required to take any action now as it does not fall under this group. The impact of global warming on Nigeria presently therefore, is the threat to Nigeria's economy posed by the response measures being adopted by the international community. Nigeria stands to suffer income losses when the global community begins to substitute renewable energy alternatives for fossil fuels. The Kyoto Protocol, if fully implemented, would lead to a dramatic loss of revenue for oil-exporting countries, as a result of a heavy reduction in demand for petroleum. Independent studies estimate the loss at tens of billions of US dollars per year for OPEC's members of which Nigeria is one, and up to 25%reduction in the OPEC's revenues by 2010. Such a heavy decline in income would strike at the very heart of Nigeria's economic and social infrastructures, causing a radical scaling down of development plans and entailing huge cutbacks in such vital services as education and health care. It would also affect its ability to invest in future production capacity.

Already developed countries are channeling huge resources into research and development of alternative and renewable energy sources that would enable the transition away from fossil fuels, signaling their resolve to transit away from the fossil fuel economy. For instance, Denmark put in place energy tax levies aimed at restructuring the power markets by raising a levy on conventional energy supplies, and refunding it to renewable energy power producers in the private sector. Also, some private developers in Denmark received a capital subsidy of up to 30%for each wind turbine erected in place of the conventional fossil fuel-based power generation facility. Likewise in Netherlands, investment costs for wind power were subsidized by up to

40%and this translated into an increase in capacity to 120 MW of installed wind power in 1996. In the UK, the Non-Fossil Fuel Obligation (NFFO) requires regional electricity companies in England and Wales to secure specified amounts of electricity from renewable energy sources (Street and Miles, 1996).

The above scenario highlights the importance of evolving a development strategy geared towards sowing the income from fossil fuels, in order to achieve sustainable long-term economic development. This should include diversifying the industrial base away from oil dependence, revitalizing the agricultural sectors and developing the infrastructure to accommodate this, in such areas as roads, railways, telecommunications and power-generation. These measures should be supported by investment in education, health and social services.

It is commonly argued that the climate change issue should be paid only minor attention in Africa for the following reasons:

(i)Present greenhouse gas emissions from Africa are negligible on a global scale;

(ii) Climate change is a problem that is largely caused by emissions from industrial countries, and hence, these countries should bear the main responsibility and the major costs of reducing emissions.

While the low contribution of Nigeria to climate change (global warming) might cause one to advocate for indifference on the part of Nigeria, a more sober appraisal of the climate change stands to affect the country's economic, social and environmental landscape.

On the economic front, the projected impact of climate change on electricity generation and hydroelectric dams stands to cause severe disruptions to economic activity. This threat arises because climate change is expected to bring about a shift in climatic belts resulting in greater aridity in the tropics with huge impacts on energy production and supply. This threat is made more important by the fact that Nigeria relies heavily on hydroelectricity which accounts for over 36% share of its electricity energy sources (Ikeme, 2004). The resulting interruptions in power supply due to limitations in available generation capacity in the hydro stations would not only result in waste of national resources, it would also affect other sectors of the economy.

The social implication of climate change for Nigeria suggests a massive environmental refugee migration. For a 1-m rise in sea level, more than 3 million people are at risk, based on the present population. The estimated number of people that would be displaced ranges from 740,000 for a 0.2-m rise to 3.7 million for a 1-m rise and 10 million for a 2-m rise (Awosika et al., 1992). The most vulnerable is the coastal region of the country. A large percentage of Nigeria's urban population live in coastal cities. Estimates put the total population living along the coastal zone to about 20 million people which translates into 22.6%of the national population. Similarly, most of the economic activities that form the backbone of the national economies are located within the coastal zone. Coastal areas also form the food basket of the region. Offshore and inshore areas, as well as estuaries and lagoons, support industrial fisheries accounting for more than 75%of fishery landings in the region. As populations are displaced and climatic and vegetation belts migrate away from the traditional geographical location, a general disruption in food production is expected to be the outcome.

Environmentally, Nigeria's climatic regime stands to be severely disrupted leaving its forests and water resources at risk. Studies show that productivity in Nigeria will decrease in the event of global warming (Ikeme, 2004) with an additional consequence of severe fuel wood shortages. Already Nigeria has experienced definite shift in the long-term rainfall mean towards more arid conditions. These climatic changes have had adverse implications for water resources availability for power generation and agriculture. Likewise, Nigeria's low-lying lagoon coasts stand threatened by sea-level rise, particularly because most of its major and rapidly expanding cities are on the coast. If sea level rises, inundation (flooding) could occur along more than 70%of the Nigerian coastline, placing land at risk many kilometers inland (Awosika et al., 1992). In Nigeria, The advantages of detection tubes over other analytical methods are simplicity of use, rapid response, and low maintenance. Because each batch of tubes is pre-calibrated, the user does not need any calibration equipment.

CHAPTER THREE

MATERIAL AND METHODS

3.1 RESEARCH METHODOLOGY

The aim of this research is to determine the quantity of CO_2 in the environment, using Kaduna and Abuja as case studies. These two locations were chosen to establish a comparison between the levels of CO_2 obtained.

The research was carried out using a sampling pump and tubes that can detect CO_2. Five different stations were used in each location. In each location, one of these five stations was used as control because there were relatively low levels of CO_2 as a result of minimal traffic in these areas.

3.2 DESCRIPTION OF PROJECT AREA

The project areas used, as earlier mentioned are Kaduna and Abuja.

Kaduna – the stations selected in Kaduna include:

1. Jabi road – this is situated in Ungwan Rimi, G.R.A., Kaduna. It was chosen as control because traffic jam is less in the area. It is a residential area and is usually very quiet. The only traffic along this road comes from the residents or visitors to the area.

2. Kawo – this is a motor park with vehicles going to Abuja, Zaria, Jos, Maiduguri, and several other places. It is situated close to a round-about which is connected to roads leading to Mando, Ungwan Sarki, and Zaria. This area is almost always congested with vehicles – buses, motorcycles, cars – as well as with lots of people.

3. Stadium round-about – this is situated on Ahmadu Bello Way, and is usually heavily congested from about 5.00 p.m. to 7.00 p.m. This is because one of the roads leading to this round-about comes from Kaduna south. A lot of people resident on the other side of town work in Kaduna south, and at this hour, they will be returning from work. Also close to this round-about is a place called Station, which houses the Station market. There is also a church – Winners' Fellowship – whose members contribute to very high congestion on certain days. Another road leads to, and from Barnawa, while another leads to and from Sabo. This really creates a very busy traffic area.

4. Sabo – this is the area that houses a part of the industrial region of Kaduna state. Here, there are roads that lead to NNPC, KRPC, Oando Plc, and emissions from these industries increase the CO_2 levels in this area. Also, there are roads leading straight to Kudendan Industrial Layout where companies such as Ideal Flour Mills, IBBI, Chellco, Sunglasses, and others are situated.

5. Kasuwa – this area houses two markets: the central market and Chechenya market. It is usually busy because by the road side, there are always buses leading to and from Kaduna south, Kawo, Ungwan Rimi, Ungwan Sarki, Barnawa and so many other places in Kaduna. It is the meeting point of most of these vehicles and contains several shops and supermarkets along the way. The congestion from Kasuwa usually contributes to that of Stadium, especially around 6.00 p.m. when the market closes.

Abuja – the stations used in Abuja include:

1. Asokoro – this is a part of Asokoro situated behind ECOWAS. It was chosen as control because of very low degree of congestion at any given time. Various embassies are located here. It is usually very quiet and traffic is minimal.

2. A.Y.A. Junction – this junction is usually heavily congested at most times. It is connected to roads leading to and from Karu, Nyanya, Keffi, Mararaba, and also from Asokoro. There are four filling stations located within the area. There are also shops, confectionaries and restaurants such as Mr Biggs at this junction.

3. Mabushi round-about – this round-about is connected to four different express-ways. These lead to and from Wuse, Maitama, and Kado. There is also a bus stop with buses to Suleja and Karu. Some offices such as the Federal Ministry of Works & Housing is situated here, so worker coming to work in the mornings and leaving in the late afternoons will create heavy traffic along this area.

4. Area One junction – this area is always occupied with vehicles going towards Area One, from Berger round-about, also from Apo, Garki 2, Wuse, Durumi and Old Secretariat. Around area one, there is the secretariat containing several offices, so workers and commuters will create high congestion around this area. Also various eateries are situated along the way.

5. Wuse market – this has roads leading to and coming from Wuse 2, Zone 4, Zone 6. Zone 4 contains some offices which can cause increased traffic when the workers are going to and from their offices. There are a lot of residential areas along the roads that lead to Wuse market, and the market itself is usually a beehive of activity. There is also the Wuse market bus stop where buses leading to the market from various places in town stop to drop or pick passengers.

3.3 DESCRIPTION OF PROJECT EQUIPMENT

The experiment was carried out using gas detection tubes and sampling pump manufactured by RAE Systems Inc. This section describes the use and performance of this equipment.

3.3.1 Hand Pump Description

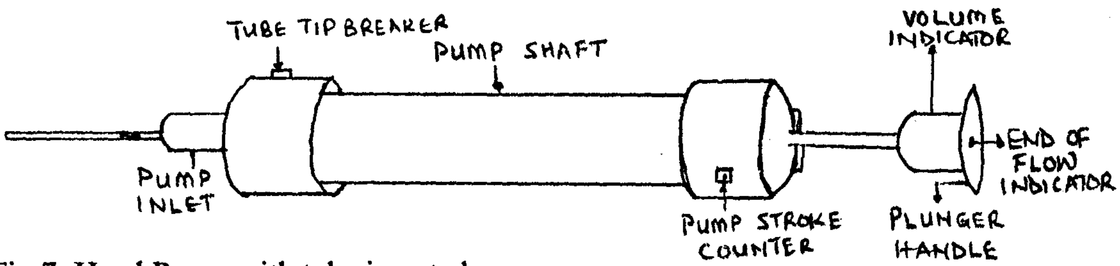


Fig 7: Hand Pump with tube inserted.

This is a piston type hand pump that draws a fixed volume of gas, selectable at either 50ml or 100ml, by rotating the handle. A tight vacuum seal is formed by a greased plunger gasket. The tapered rubber inlet accommodates a range of tube diameters for different types of tubes. The inlet filter prevents glass pieces and dust from entering the shaft. An end-of-flow indicator in the handle turns white when the gas sampling is complete. A pump stroke counter is rotated to keep track of the number of strokes completed.

3.3.2. Tube Description

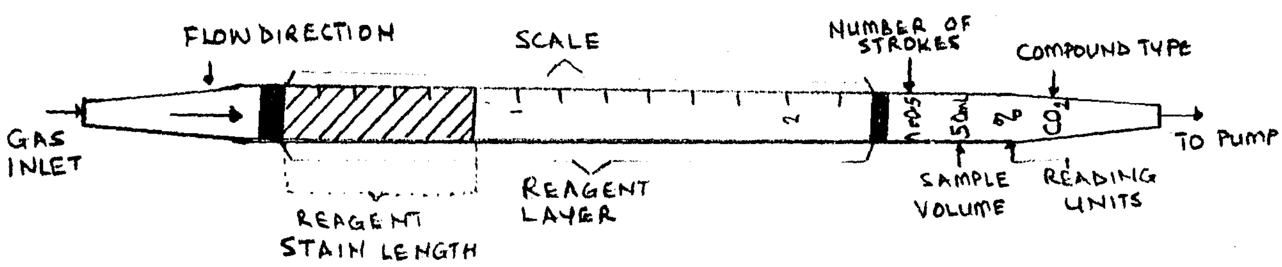


Fig 8: Gas detection tube parts description.

The figure above shows the key components of a gas detection tube. The tubes are typically packaged in a box of 10 tubes. Each box contains instructions on how the tubes should be used. The concentration scale is printed on the tube such that the gas must enter in the direction of the arrow. The standard number of 100ml strokes is indicated on one side along with the total sample volume, the unit of measure, and the gas type.

3.3.3. Data Sheets

Each box is packaged with a data sheet that provides detailed information on the tube performance. The data sheet contains information such as part number, sampling volume and time, and cross-sensitivity.

- Part Number – The 7-digit part number is indicated on the top right of the data sheet. The second 3 digits indicate the tube chemical type and the last 2 digits indicate the approximate range of the tube. For CO_2, the 7-digit part number is 10-104-50.

- Sampling volume and time – Using the standard number of pump strokes, the concentration of the gas is read from the stain length directly from the printed scale after the listed sampling time has elapsed. However, the range of the tube may be extended by using a smaller or larger sample volume. In such cases, the scale reading must be multiplied by a correction factor to adjust for the different sample size.

- Cross-sensitivity – Gas detection tubes are generally quite selective, but some compounds interfere in the measurements. The data sheet lists possible interfering compounds and in most cases, these compounds may increase or decrease the stain length.

An excerpt of a typical data sheet is provided in Appendix A.

3.4. EXPERIMENTAL PROCEDURE

The experimental procedure carried out in each location involved first preparing the tubes and then taking readings over the duration of one hour. 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 and the red dot on the plunger was aligned with the red dot on the pump shaft. Then the handle was pulled quickly until it stopped at ½ stroke, which indicated 50ml. This was left for about 1 minute sampling time 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.

CHAPTER FOUR

RESULTS AND DISCUSSION OF RESULTS

4.1 RESULTS

4.1.1 TABLE 4-1: CO_2 CONCENTRATION IN KADUNA

S/NO	TIME (min)	A (%) 10-11 am	A (ppm)	B (%) 4-5 pm	B (ppm)	C (%) 5-6 pm	C (ppm)	D (%) 4-5 pm	D (ppm)	E (%) 3-4 pm	E (ppm)
1	0	0.100	1000	0.185	1850	0.174	1740	0.191	1910	0.160	1600
2	5	0.100	1000	0.181	1810	0.182	1820	0.180	1800	0.165	1650
3	10	0.120	1200	0.175	1750	0.191	1910	0.200	2000	0.175	1750
4	15	0.100	1000	0.168	1680	0.180	1800	0.190	1900	0.150	1500
5	20	0.125	1250	0.150	1500	0.165	1650	0.185	1850	0.154	1540
6	25	0.128	1280	0.150	1500	0.160	1600	0.178	1780	0.148	1480
7	30	0.100	1000	0.180	1800	0.180	1800	0.190	1900	0.150	1500
8	35	0.125	1250	0.175	1750	0.170	1700	0.180	1800	0.160	1600
9	40	0.130	1300	0.164	1640	0.175	1750	0.165	1650	0.169	1690
10	45	0.136	1360	0.180	1800	0.190	1900	0.170	1700	0.172	1720
11	50	0.120	1200	0.170	1700	0.185	1850	0.185	1850	0.175	1750
12	55	0.120	1200	0.175	1750	0.184	1840	0.190	1900	0.173	1730

A –STATION 1 – JABI ROAD, KADUNA

B – STATION 2 – KAWO MOTOR PARK, KADUNA

C – STATION 3 – STADIUM ROUND-ABOUT

D – STATION 4 – SABO, KADUNA

E – STATION 5 – KASUWA, KADUNA

4.1.2 TABLE 4-2: CO_2 CONCENTRATION IN ABUJA

S/NO	TIME (min)	F (%) 11-12 am	F (ppm)	G (%) 4-5 pm	G (ppm)	H (%) 12-1 pm	H (ppm)	I (%) 3-4 pm	I (ppm)	J (%) 4-5 pm	J (ppm)
1	0	0.100	1000	0.120	1200	0.160	1600	0.140	1400	0.162	1620
2	5	0.110	1100	0.124	1240	0.170	1700	0.148	1480	0.174	1740
3	10	0.110	1100	0.126	1260	0.175	1750	0.128	1280	0.164	1640
4	15	0.114	1140	0.130	1300	0.140	1400	0.136	1360	0.148	1480
5	20	0.116	1160	0.138	1380	0.152	1520	0.154	1540	0.155	1550
6	25	0.120	1200	0.148	1480	0.137	1370	0.150	1500	0.167	1670
7	30	0.125	1250	0.152	1520	0.141	1410	0.150	1500	0.148	1480
8	35	0.115	1150	0.146	1460	0.148	1480	0.122	1220	0.140	1400
9	40	0.118	1180	0.125	1250	0.136	1360	0.130	1300	0.133	1330
10	45	0.120	1200	0.138	1380	0.139	1390	0.125	1250	0.129	1290
11	50	0.120	1200	0.140	1400	0.167	1670	0.127	1270	0.141	1410
12	55	0.125	1250	0.150	1500	0.172	1720	0.142	1420	0.160	1600

F – STATION 1 – ASOKORO, BEHIND ECOWAS, ABUJA

G – STATION 2 – AREA ONE JUNCTION, ABUJA

H – STATION 3 – A.Y.A. JUNCTION, ABUJA

I – STATION 4 – WUSE MARKET BUS-STOP, ABUJA

J – STATION 5 – MABUSHI ROUND-ABOUT, ABUJA

4.1.3 TABLE 4-3: AVERAGE CO_2 CONCENTRATIONS OVER ONE HOUR PER STATION

SAMPLE STATION	AVERAGE TUBE CONCENTRATIONS (%)	AVERAGE TUBE CONCENTRATIONS (ppm)
JABI ROAD	0.117	1170
KAWO	0.171	1710
STADIUM R/ABOUT	0.178	1780
SABO	0.184	1840
KASUWA	0.163	1630
ASOKORO	0.116	1160
AREA 1 JUNCTION	0.136	1360
A.Y.A. JUNCTION	0.153	1530
WUSE MARKET	0.138	1380
MABUSHI R/ABOUT	0.152	1520

4.1.4 CALCULATIONS FOR CONVERSION OF UNITS FROM VOLUME % TO PPM

VOL % × 1,000,000 = VOL PPM

VOL % × 1×10^6 = VOL PPM

FOR TABLE 4-1:

1. 0.100% × 1×10^6 = 1000ppm
2. 0.100% × 1×10^6 = 1000ppm
3. 0.120% × 1×10^6 = 1200ppm
4. 0.100% × 1×10^6 = 1000ppm
5. 0.125% × 1×10^6 = 1250ppm
6. 0.128% × 1×10^6 = 1280ppm
7. 0.100% × 1×10^6 = 1000ppm
8. 0.125% × 1×10^6 = 1250ppm
9. 0.130% × 1×10^6 = 1300ppm
10. 0.136% × 1×10^6 = 1360ppm

11. $0.120\% \times 1 \times 10^{o} = 1200$ppm

12. $0.120\% \times 1 \times 10^{o} = 1200$ppm

FOR TABLE 4-2:

1. $0.185\% \times 1 \times 10^{6} = 1850$ppm
2. $0.181\% \times 1 \times 10^{6} = 1810$ppm
3. $0.175\% \times 1 \times 10^{6} = 1750$ppm
4. $0.168\% \times 1 \times 10^{6} = 1680$ppm
5. $0.150\% \times 1 \times 10^{6} = 1500$ppm
6. $0.150\% \times 1 \times 10^{6} = 1500$ppm
7. $0.180\% \times 1 \times 10^{6} = 1800$ppm
8. $0.175\% \times 1 \times 10^{6} = 1750$ppm
9. $0.164\% \times 1 \times 10^{6} = 1640$ppm
10. $0.180\% \times 1 \times 10^{6} = 1800$ppm
11. $0.170\% \times 1 \times 10^{6} = 1700$ppm
12. $0.175\% \times 1 \times 10^{6} = 1750$ppm

FOR TABLE 4-3:

1. $0.117\% \times 1 \times 10^{6} = 1170$ppm
2. $0.171\% \times 1 \times 10^{6} = 1710$ppm
3. $0.178\% \times 1 \times 10^{6} = 1780$ppm
4. $0.184\% \times 1 \times 10^{6} = 1840$ppm
5. $0.163\% \times 1 \times 10^{6} = 1630$ppm
6. $0.116\% \times 1 \times 10^{6} = 1160$ppm
7. $0.136\% \times 1 \times 10^{6} = 1360$ppm
8. $0.153\% \times 1 \times 10^{6} = 1530$ppm
9. $0.138\% \times 1 \times 10^{6} = 1380$ppm
10. $0.152\% \times 1 \times 10^{6} = 1520$ppm

FIG 11: AVERAGE CONCENTRATION OF CO2 IN EACH STATION

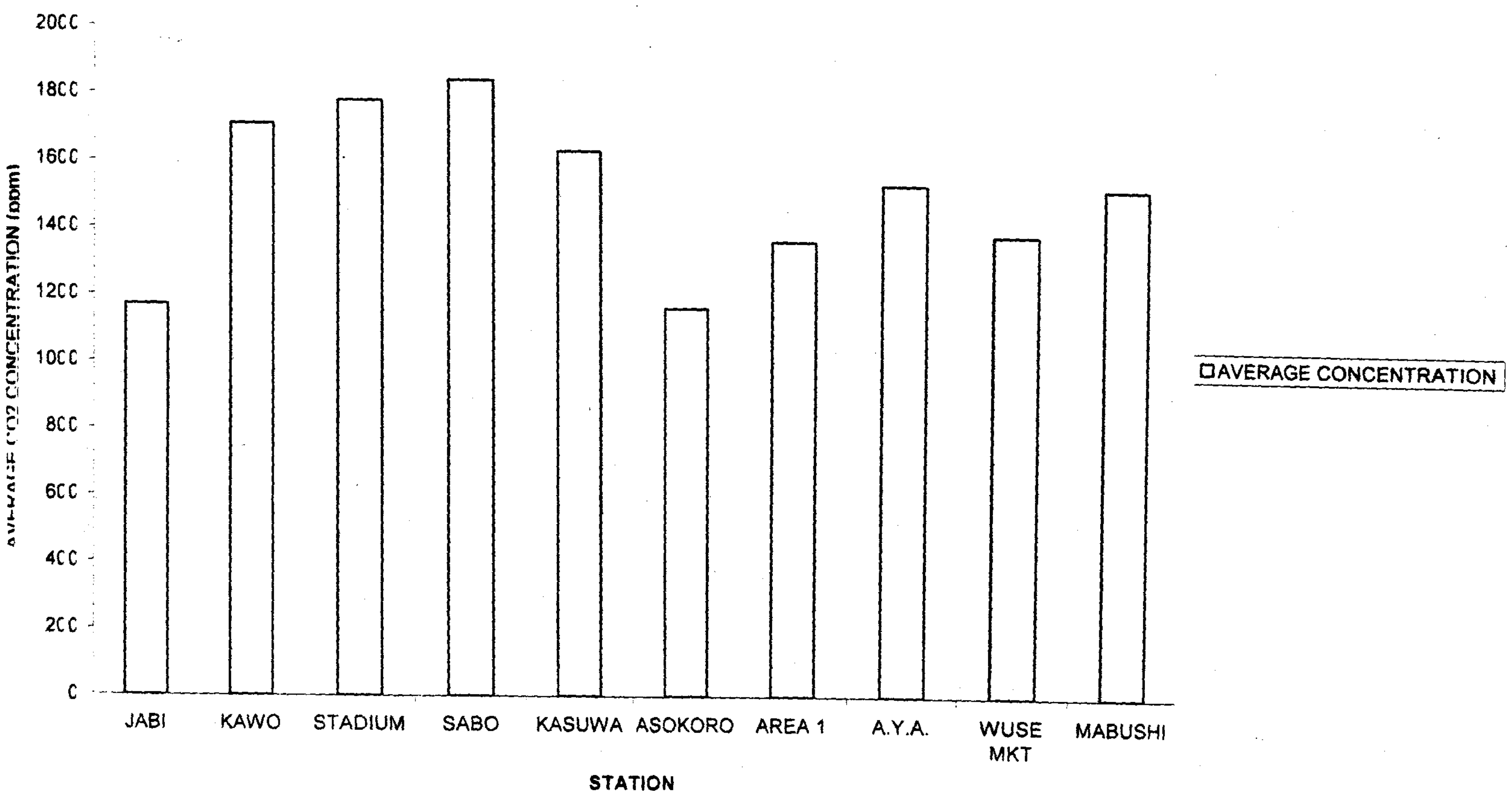


FIG 10: CO2 CONCENTRATION VS TIME (ABUJA)

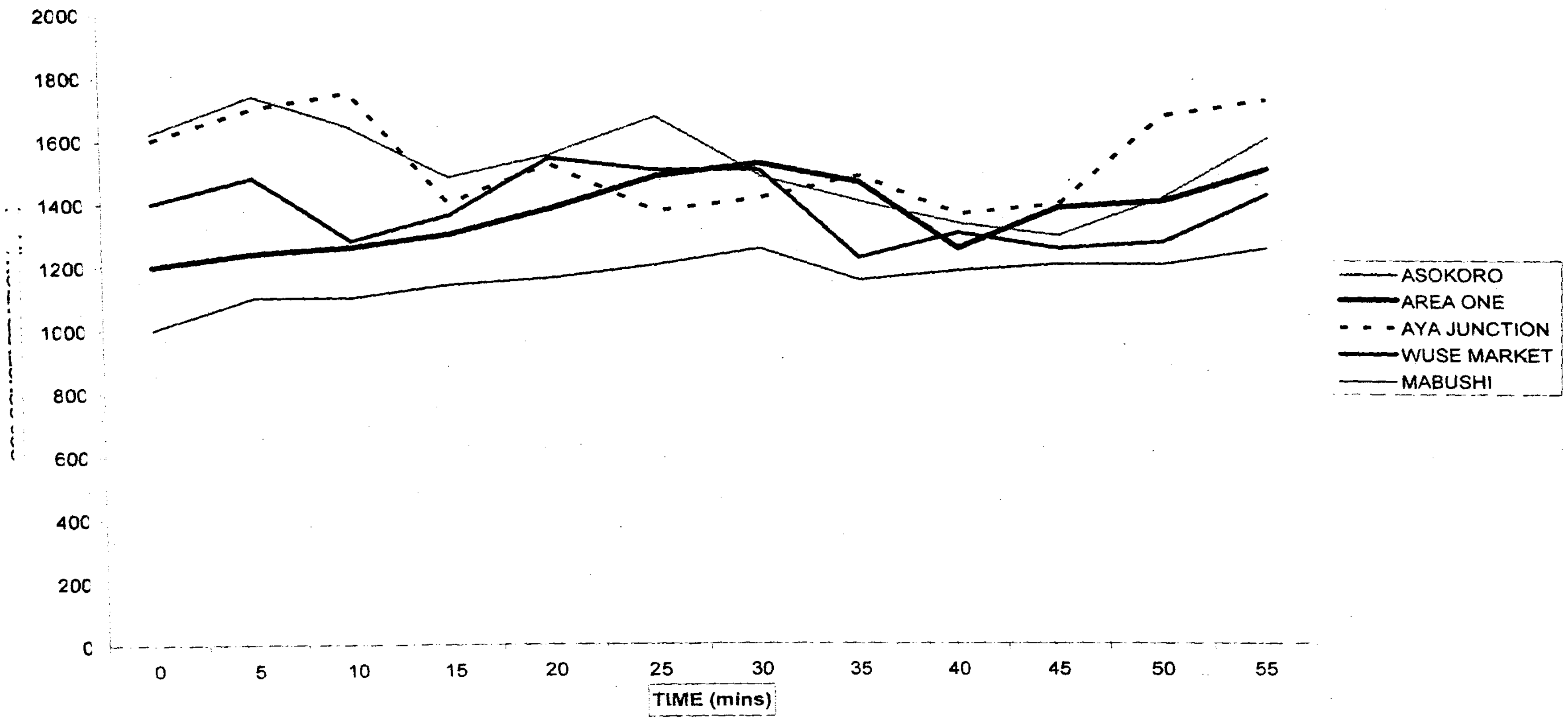
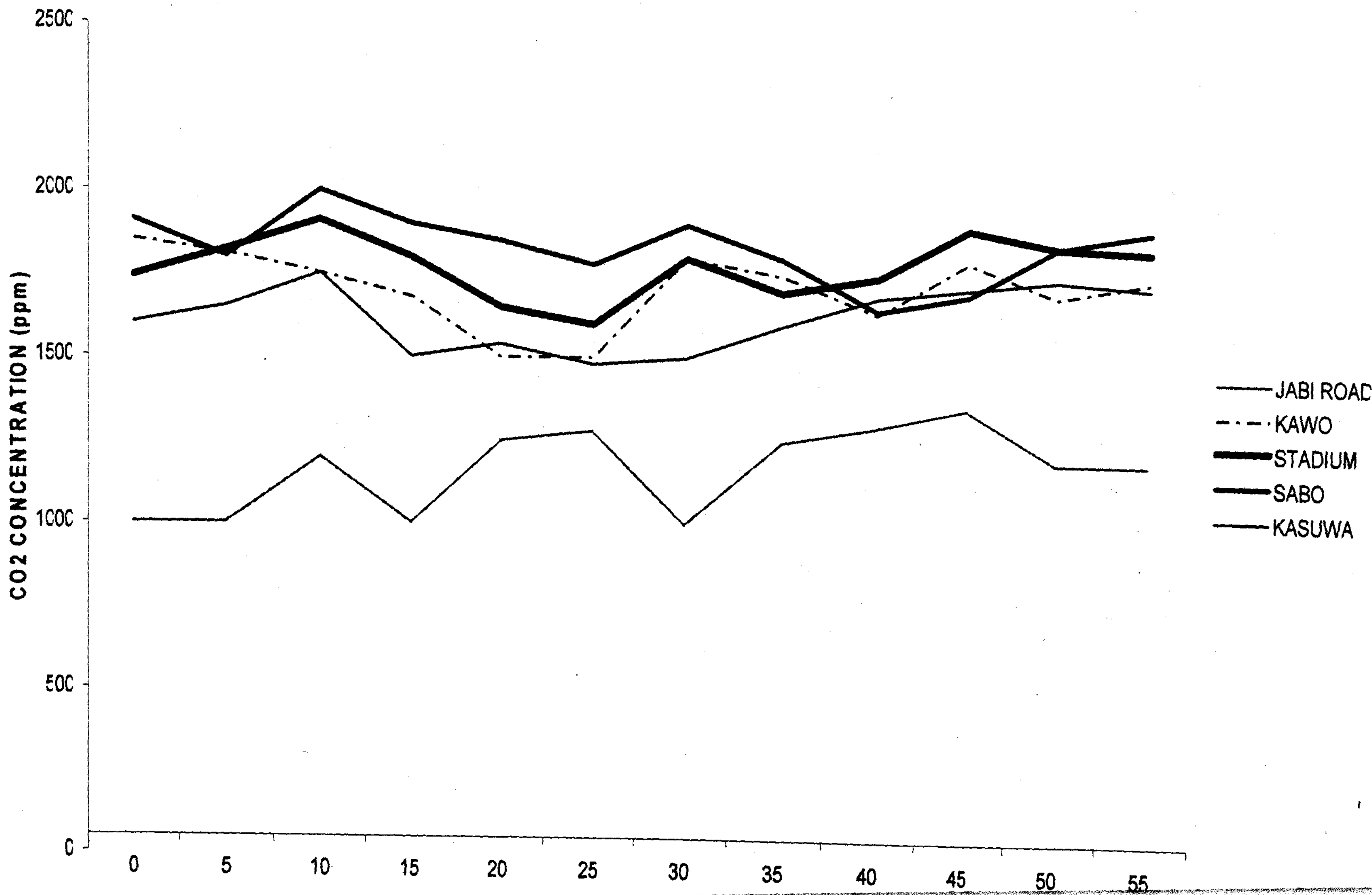


FIG 9: CO2 CONCENTRATION VS TIME (KADUNA)



4.2 DISCUSSION OF RESULTS

4.2.1 Comparison with Standard Values

The Nigerian Ambient Air Quality Standard does not provide limits for CO_2. However, a table showing the composition of clean, dry air near sea level gives the concentration of CO_2 in mole percent as 0.0350. The atmosphere contains carbon dioxide in variable amounts, usually 3 to 4 parts per 10,000. (Bell, 2003)

4.2.2 Analysis of Data based on Results

The results obtained for the selected project areas – Kaduna and Abuja – show a higher concentration of CO_2 in Kaduna, compared to values obtained in Abuja. This is because Kaduna is a more industrialized area than Abuja. Industries located in Kaduna include; NNPC, Ideal Flour Mills, Sunglasses, United Nigerian Textiles Ltd., Nigerian Breweries Plc, International Beer & Beverages Industry, etc.

The results obtained in each area give a remarkable relationship between congestion and concentration of CO_2 in that area. The control areas used are areas which are relatively quiet with minimal vehicular activity. Therefore, the values obtained here are far less than those obtained at heavily congested areas. These values, for the congested areas, were obtained at high peak periods, between the hours of 3.00 – 6.00 p.m. when the areas were considerably busy. The high values indicate that with increase in vehicular concentration, there will also be a high level of CO_2 emitted in the atmosphere due to the combustion of petroleum products.

4.2.3 Relationship between Variables

Figures 4-1 and 4-2 show the concentration of CO_2 against time for Kaduna and Abuja respectively. A separate curve exists for all five census stations in each area. The curves obtained show a fluctuation in the values. This is because every vehicle has an individual contribution to the CO_2 concentration level in the atmosphere, and this in turn is affected by meteorological conditions, such as wind speed, wind direction, and precipitation, which can cause dispersion of air pollutants; and topographic factors, which include valleys, oceans, lakes, foliages, and even man-made elements like bridges and roads. This just means that the concentration of CO_2 at any given time is never constant.

A chart showing the average concentration obtained in each sample station is given in Figure 4-3. It shows the comparison of the level of CO_2 obtained in each area. The tallest bar on the chart (representing Sabo in Kaduna, a highly industrialized area) gives the highest CO_2 concentration obtained. The shortest bar on the chart (representing Asokoro in Abuja) gives the least CO_2 concentration obtained. This reveals the earlier anticipated factor that the concentration level of carbon dioxide is dependent on the automobile congestion in an area. The more congested areas have the highest carbon dioxide level in the atmosphere, and vice versa.

4.2.4 Basis for Conclusion

From the analysis carried out and the results obtained, a conclusion can be drawn based on the fact that CO_2 levels are increasing. This is because the values obtained are quite high. Though these values are not high enough to cause any catastrophes presently, there will probably be a time in the near future when the accumulation of CO_2 will be high enough to exert a negative influence on the atmosphere. Therefore, increasing CO_2 levels should be checked.

4.2.6. Sources of Error

These include prevailing environmental conditions causing the dispersion of air pollutants. Also, errors due to parallax may have been incurred while taking readings from the tubes. Useful data pertaining to CO_2 emissions in individual states in Nigeria, for the past few years could not be obtained as the analysis have not been properly carried out in the country. In addition, the data collection was not adequate due to difficulties experienced in obtaining the project equipment.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

The quantity of carbon dioxide in the environment presently is not only due to automobile emissions. It is affected by other factors such as electricity consumption, manufacturing and construction industries, petroleum refining as well as other chemical-based industries, and even residential areas. But the bulk of the entire quantity is contributed by the transportation sector.

From data obtained during this research, it is clear that there is more carbon dioxide emitted in areas with a greater congestion of vehicles compared to areas with minimal traffic. These high levels of carbon dioxide concentrations obtained show that with increase in congestion and number of vehicles passing a given area at any time, there would be an increase in the quantity of carbon dioxide emitted, due to the combustion of fossil fuels, i.e. petroleum products.

On the average, the data show higher values of carbon dioxide concentration for heavily congested areas – 1840ppm for Sabo, Kaduna, 1780ppm for Stadium round-about, Kaduna, and 1530ppm for A.Y.A. Junction, Abuja – and lower values of carbon dioxide concentration for areas with minimal traffic – 1170ppm for Jabi road, Kaduna, and 1160ppm for Asokoro (behind ECOWAS), Abuja.

To conclude, it has been demonstrated that Nigeria can not afford to continue ignoring the potential impacts of the global climate change response measures on its oil-based economy. It was also made clear that though Nigeria should capitalize on the emission allowance afforded for its low historical contribution to the climate change problem, it is in its interest to begin to introduce measures to reduce its greenhouse gas emissions, due to the negative impacts of climate change on its economic, social and environmental resources. It is imperative that full attention is paid to ways through which the Nigerian economy can be diversified and steered away from fossil fuels both in terms of production and consumption. Only such a strategy will save the country's economy from certain collapse in the event of implementation of climate change abatement measures.

5.2 RECOMMENDATIONS

In terms of policies for remedying the situation, one way is the diversification of the economy away from oil production. This will ensure that the global switch away from fossil fuels and the consequent reduction in fossil fuel demand have little impact on the Nigerian economy and foreign exchange earnings. Also research on climate change and the socio-economic implications for Nigeria is necessary for developing adequate response strategies. Further, study of the science of climate change and its potential impacts on Nigeria is very important for creating awareness and providing the background information for targeting policies adequately. This point is made in view of the recognition that the major constraint to adequate forecasting and formulation of adaptation policies is the scarcity of climate data in Nigeria. Long term studies on national and regional climate change in Nigeria should be embarked upon and vigorously pursued. The findings of such studies will be crucial for the formulation of adequate response and adaptation policies such as adequate resettlement programmes for those that may be displaced by climate change.

For reducing its contribution to climate change, the mandate for Nigerian energy planners is to institutionalize its development of energy efficiency and renewable energy with appropriate goals for increasing the use of renewable energy resources in areas where opportunities for the use of renewables is economically warranted. This should be accompanied by an inbuilt mechanism for stock taking and reassessment of progress towards the objective. In addition to building institutional framework, Nigeria should also adopt specific regulatory measures. Establishment of comprehensive air quality standards and creation of national energy efficiency codes can furnish the driving force for rapid development of the country's energy efficiency and renewable energy opportunities. Likewise, market transformation mechanisms similar to that adopted in the developed countries which will encourage more rapid development of its energy efficiency and renewable energy potential should be explored. This objective will obviously benefit from an increase in government-industry collaboration, a key avenue for development rarely explored in Nigeria's development initiatives.

Finally, increased government participation in the global climate change deliberation in order to negotiate a better deal for Nigeria and Africa is necessary. Nigeria can only be sure that its interest is protected in the emergent global abatement strategy if it increases its level of participation. Its participatory capacity in turn will be enhanced by findings from studies and research into various ramifications and dimensions of the climate change issue as suggested above.

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APPENDIX A

CARBON DIOXIDE DETECTION TUBE DATA SHEET

Carbon Dioxide CO_2 — No. 10-104-50

	Extended Range	Extended Range	Standard Range
Range (ppmv)	0.25 – 5%	0.5 -10%	1 – 20%
No of pump strokes	2	1	0.5
Sample volume (ml)	200	100	50
Sample time (min)	2 x 1.5	1.5	1
Correction factor	0.25	0.5	1

Precision: $\leq \pm$ 10%

Linearity with No of pump strokes: $r^2 \geq 0.999$

Humidity: No effect, 5 – 100% RH

Temperature Range: No effect, 0 – 40°C

Storage life: 2 years in darkness at 5 – 25°C. Refrigeration preferred.

Colour change: White ⟶ Purple

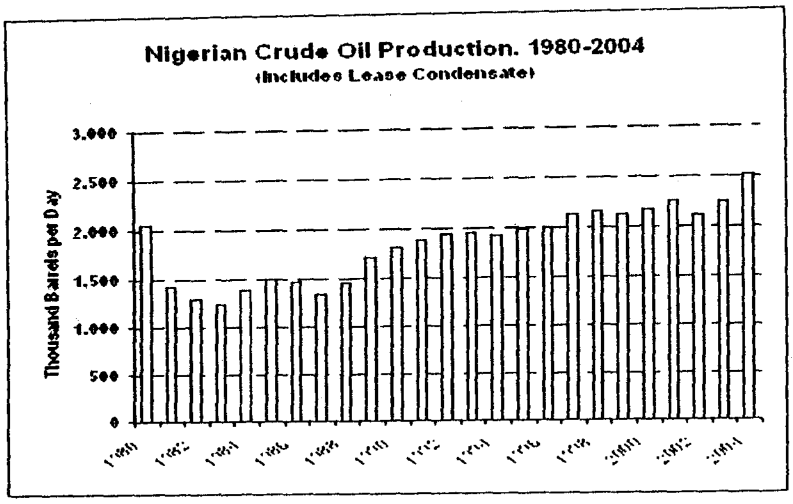
Reaction principle: CO_2 + H_2NNH_2 ⟶ H_2NNHCO_2H (pH indicator change)

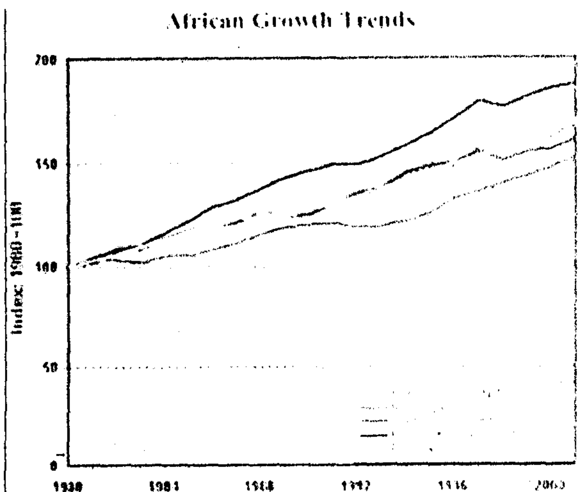
Cross-sensitivity: Substance	Concentration (ppmv)	Apparent Reading
CO	3000	0
SO_2	200	0
NO	100	0
NH_3	300	0
CH_4	25000	0
H_2S	100	0
Hexane	1200	0
Isobutylene	100	0
Toluene	100	0

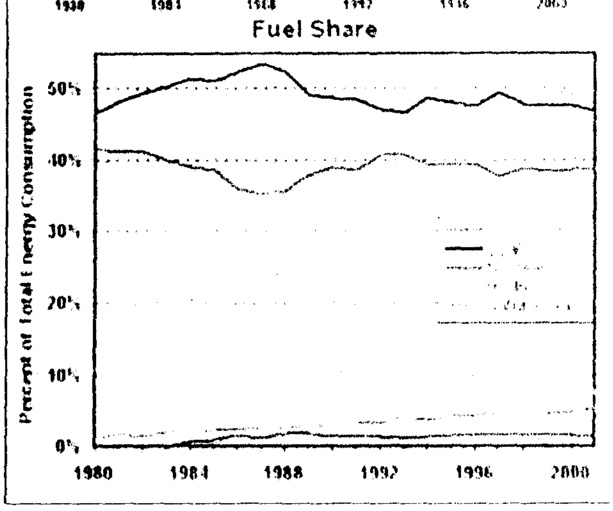
Other possible interferences: Acid gases

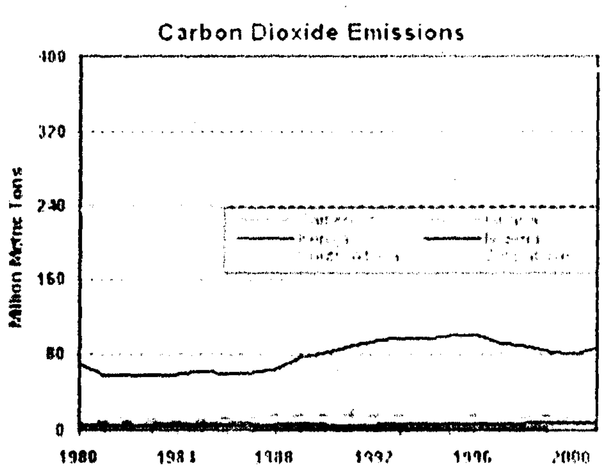
$TWA_{(TLV)}$: 5000 ppm $STEL_{(TLV)}$: 30,000 ppm   Flammability Limits: NA

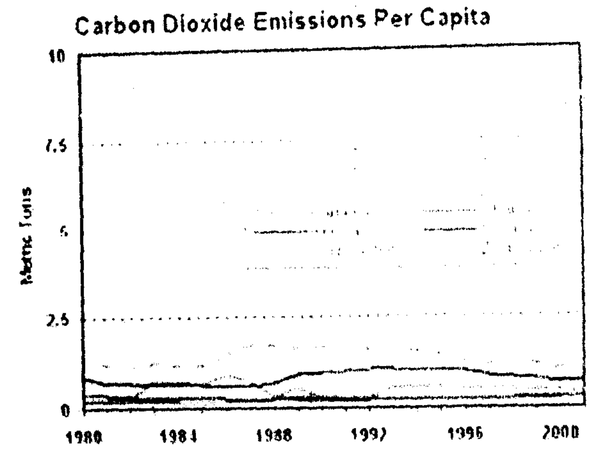
APPENDIX B
CHARTS

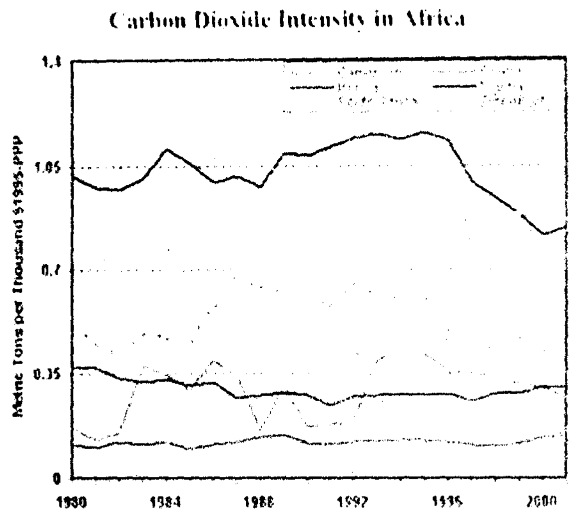


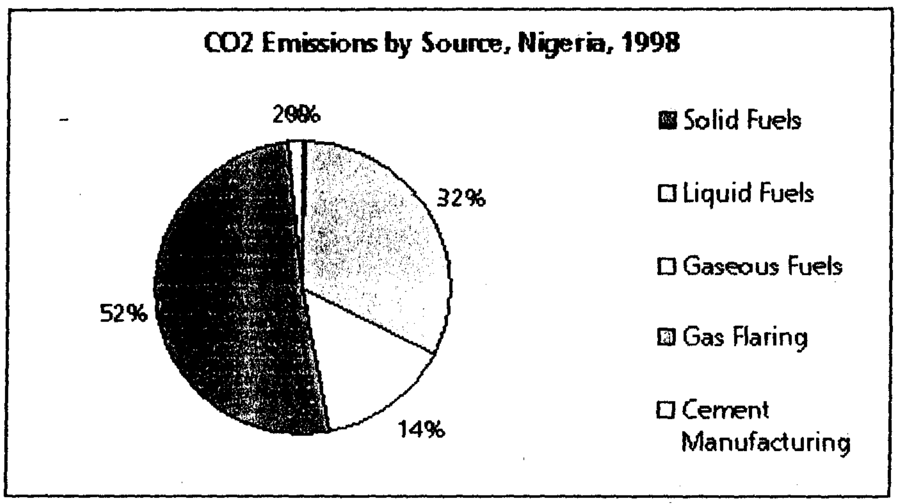


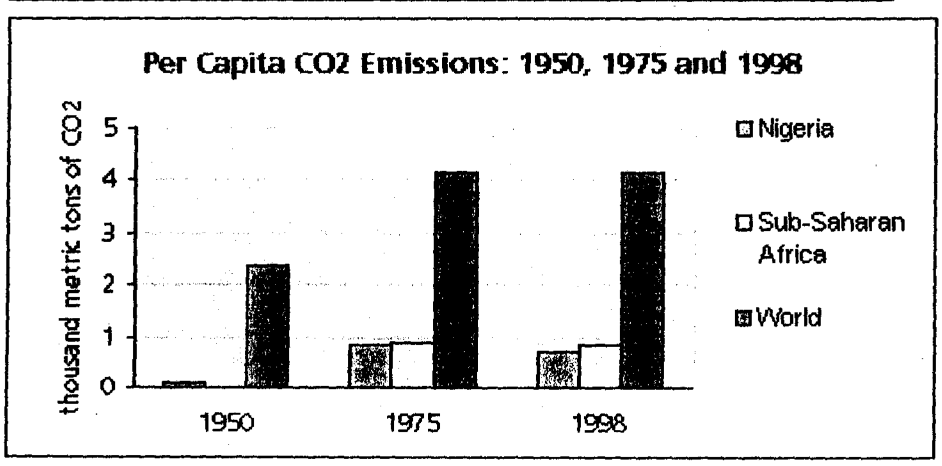


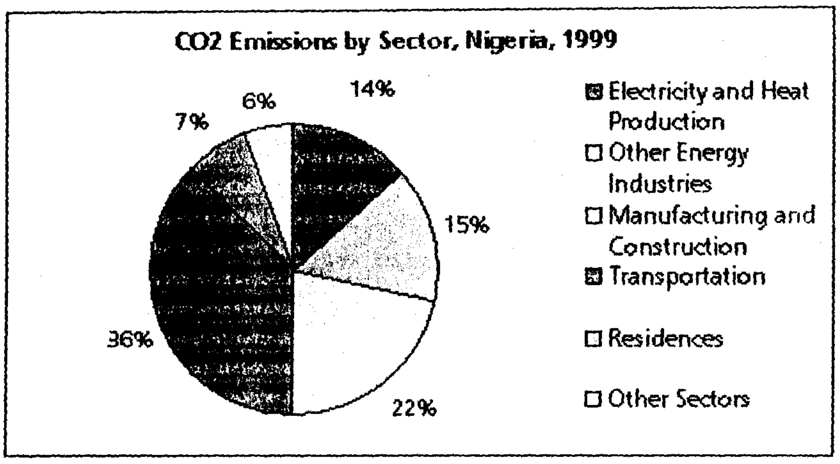


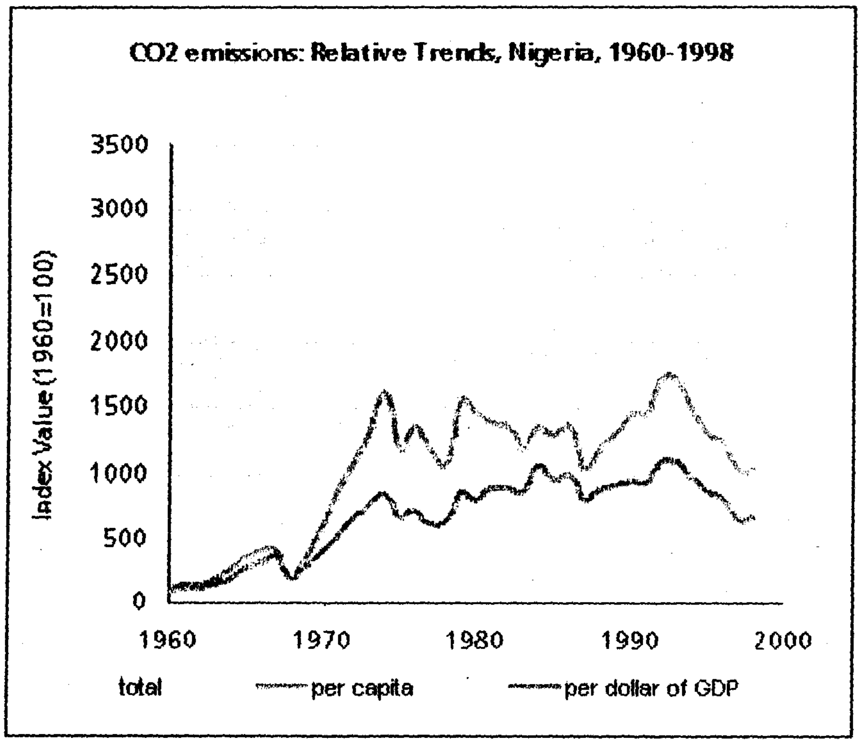

Carbon Dioxide Emissions Per Capita
Metric Tons
10
7.5
5
2.5
0
1980
1984
1988
1992
1996
2000

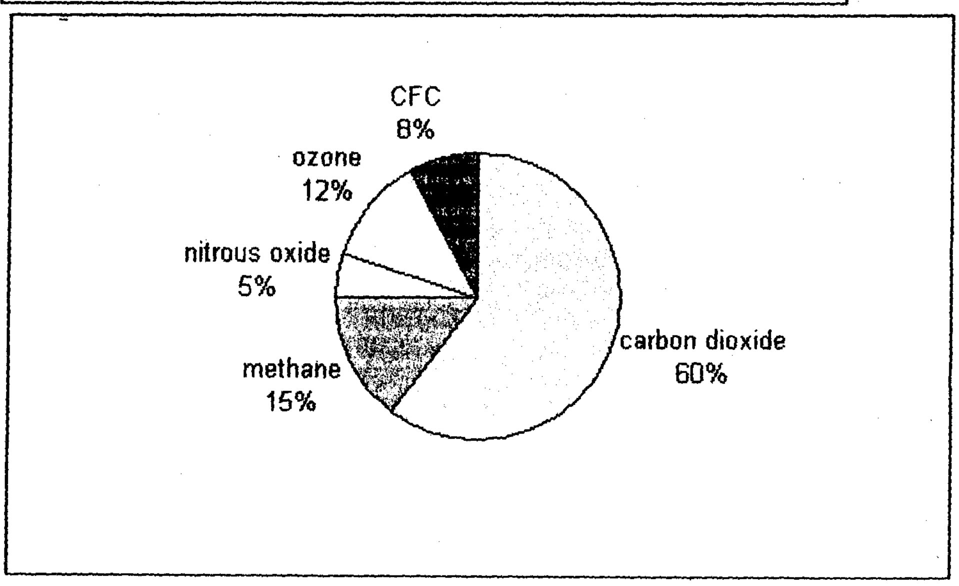

Carbon Dioxide Intensity in Africa
1.4
1.05
0.7
0.35
0
1980
1984
1988
1992
1996
2000


CO2 Emissions by Source, Nigeria, 1998
32%
52%
14%
Solid Fuels
Liquid Fuels
Gaseous Fuels
Gas Flaring
Cement Manufacturing


Per Capita CO2 Emissions: 1950, 1975 and 1998
thousand metric tons of CO2
5
4
3
2
1
0
1950
1975
1998
Nigeria
Sub-Saharan Africa
World







Relative contribution of greenhouse gases to the greenhouse effect (2004)

APPENDIX C

- NIGERIAN AMBIENT AIR QUALITY STANDARDS

Pollutants	Time	Limit
particulates	Daily average of daily 1 hour	250 μg /m3 *600μg/m3
sulphur oxides (sulphur dioxide)	Daily average of hourly values1 hour	0.1ppm(26μg /m^3) 0.1ppm(260μg/m^3)
Non – methane Hydrocarbon	daily average of 3 hourly values	160μg/m^3
Carbon monoxide	daily average of hourly values 8 hourly average	10ppm(11.4μg/m^3) 20ppm(22.8μg/m^3)
Nitrogen oxides (Nitrogen dioxide)	Daily average of hourly values (range)	0.04ppm-0.06ppm (75.0μg/m^3 - 113μg/m^3)
Photochemical Oxidant	Hourly values	0.06ppm

* Concentration not to be exceeded once in a year.

Source: FEPA, 1991.