# ASSESSMENT OF CARBON MONOXIDE (CO) LEVEL IN ENUGU METROPOLIS MONITORING INDUSTRIAL AND RESIDENTIAL AREA

**BY**

**ADIKE JOSEPH .N.**

**CHE/2007/123**

**PROJECT REPORT SUBMITTED TO THE DEPARTMENT OF CHEMICAL ENGINEERING**

**FACULTY OF ENGINEERING**

**CARITAS UNIVERSITY, AMORJI-NIKE**

**ENUGU STATE**

**AUGUST, 2012**

# TITLE PAGE

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IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR OF ENGINEERING, DEGREE IN CHEMICAL

CARITAS UNIVERSITY

AMORJI-NIKE

ENUGU STATE

AUGUST, 2012

## CERTIFICATION

This is to certify that this work was down under the supervision of Supervisor's name Engr Ken Ezeh

Signature---------- ---------- date ----------

Head of Department ----------

Signature ---------- Date ----------

External supervisor ----------

Signature ---------- Date ----------

Department of Chemical Engineering

Caritas University Amorji-Nike Enugu

## DEDICATION

This project was dedicated to Jesus the Saviour for all his marvelous deeds in my life, more especially for seeing me through all my university years and to my dearly parents Mr. and Mrs. Adike, N. Joseph, for all their contributions, encouragement, love, understanding and care for me and the family.

## ACKNOWLEDGEMENT

To Jesus the Saviour be the glory to whom I depend on I wish to thank the Almighty God for giving me the opportunity, knowledge and wisdom to under take my university task successfully. My profound gratitude goes to my supervisor, Engr. (Mr.) Ken Ezeh for is invaluable supervision and unremitting attention. I wish also to acknowledge my lecturers in the person of Engr. Prof. J.I. Umeh, Engr. (Mr.) Odilinye, Engr. (Mrs.) Otegulu and Engr. Buny Ugwu for their encouragement.

I also wish to express my profound appreciation and gratitude to my parents Lydia Mrs. Nkechi Asa Adike and my father Adike. N. Joseph for their support, love and care throughout my educational pursuit.

I also wish to express my heartfelt appreciation to my family members, friends and well wishers for their support both spiritually and otherwise during my stay in the university. They include: Anthony, Mary joy, Christian, George.

My special thinks goes to my lecturers for the knowledge impact on my and my course mates and friends, Ezinne, Jennifer, finals, John, George, confidence, victor, Rosarian, Legion of Mary, Precious , divine Mercy, Tochi, bright, Chika, Precious and onyinye

I thank you all for your support may Almighty God bless you all.

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## ABSTRACT

Air pollutions pollutant showed that the extent of spreading depends on the motor vehicle traffic population of the area. This pollution strongly generated through combustion of fossil fuels presents difficult environmental challenge to societies as it could degrade the environment and affect human health and quality of life. Vehicular emissions are major contributors to air pollution in urban areas as they contain harmful gases. The levels of carbon monoxide has been investigated in two locations of Enugu metropolis (high traffic 'old park' and low traffic 'caritas university'), in order to determine its pollution status with regards to air. EL-USB-CO analyzer used for the analysis indicated variations in the levels of CO for the period of study. The results obtained revealed that the concentrations of CO in high traffic (HT) area is higher than that of low traffic (LT) and is unacceptable compared with the Federal Environmental Protection agency (FEPA) Nigeria set limit. The dispersion pattern of the suggests that vehicular emission contributes to the levels of carbon monoxide in the environment.

# CHAPTER ONE

## 1.0 INTRODUCTION

Air pollution is associated with increasing cases of many adverse health effects, e.g. mortality, respiratory diseases and cancer. The chemical composition of ambient air is very complex and depends on many different factors, traffic generated air pollution being a major source in large cities. This is especially true in the developing world, mainly due to the high proportion of old, poorly maintained vehicles, the abundance of two stroke vehicles and the poor fuel quality (Baumbach *et al*., 1995; Gwilliam 2003). All these factors contribute to one of the major air pollutant in urban areas; carbon monoxide (CO).

CO is a poisonous, colorless, inevitable gas that has neither taste nor smell. It is formed when carbon burns with too little air (incomplete combustion) (Smith and Scott, 2002). Carbon monoxide (CO), also called Carbonious oxide or Carbon (II) Oxide and is slightly lighter than air. CO is a deadly, colorless, odorless, poisonous gas, produced by the incomplete burning of various fuels, including coal, wood, charcoal, oil, kerosene, propane, and natural gas. Products and equipments and machines powered by internal combustion engines such as portable generators, cars, lawn mowers, and power washers also produce CO. It has a high affinity for hemoglobin in blood and displaces O2 to form carboxyl hemoglobin (COHb). This can cause dizziness, headaches and eventually death. Tobacco smoke, gas

fires, burning candles are also common sources of CO in indoor air. Internal combustion engines are responsible for most of the CO in outdoor air (Smith and Scott, 2002). The ambient concentration of CO is measured in parts per million (ppm). Most of the studies on air pollution and exposure to air pollutants have been conducted in developed countries, i.e. Western Europe and the USA (Šišvić and Fugaš, 1987, Cernuschi *et. al.*, 1998; and Chiara *et. al.*, 2005). There is limited information on exposure to air pollutants in developing tropical countries, but some studies have been carried out in sub-Saharan Africa (Baumbach *et. al.*, 1995; Fanou *et. al.*, 2005; Lindèn *e.t al.*, 2007).

The population in Enugu city, the economic and administrative capital of Enugu state, has increased rapidly in the last decade (about one million inhabitants), and in since there is no reliable public transport system, air pollution has worsened because of an increasing number of old second-hand cars and of taxi motorbikes (Keke-NAPEP). Petroleum products used are also of poor quality, due to the importation of sub-standard products into the country. No data on health effect of air pollution in Enugu city is available to the researcher, but it is anticipated that air pollution could become a major public health problem if adequate mitigation measures are not taken at this time. Exposure to air pollution is normally assessed by environmental monitoring; using either fixed monitoring stations or personal air collecting instruments.

## 1.1STATEMENT OF PROBLEM

The world is presently confronted with the twin crises of environmental degradation and fossil fuel depletion. The uncontrolled use and overexploitation of our natural resources have also triggered other environmental issues, which hitherto were non-existent. Some of these environmental issues include global warming (climate change) and air pollution. The aforementioned have been shown to have very serious health implications. Presently, fossil fuel powered engines are noted to account for over sixty percent of the hydrocarbon and nitrogen oxide pollution which have very serious environmental and health implications, especially in our urban areas and their surrounding communities. It is thus very timely and pertinent within the Enugu city due to the growing use of automobiles and diesel powered generators within the city.

CO is one of those gases that are released from these combustion processes and its effect on our environment range from its contribution to the photochemical smog, ground level ozone and depletion of available oxygen within the area. Its effect on human health when its accepted threshold is exceeded include headache, irritation, fatigue, loss of muscular coordination, loss of memory and in severe cases, death.

The effects of CO on health are most dangerous because it is both colorless and odorless, and as such cannot be easily detected. But since these factors; that

contribute to its formation and possible increment in its concentration within the city is present, it is necessary that a monitoring system of stations be set up to help in the establishment and eventual monitoring of the gas so as to ensure the safety and wellbeing of the lives of the people in the city.

## 1.2 AIM AND OBJECTIVES

### 1.2.1 Aim:

The aim of this project is to monitor CO levels within Enugu city using two cities as our basis.

### 1.2.2 Objectives:

i. Identify possible 'hotspots' for generation of CO gas within the city.

ii. Determine the distribution of CO gas within high traffic and low traffic areas of the city.

iii. Determine the daily differences in the various sample stations.

## 1.3 RESEARCH HYPOTHESIS

$H_O$: There is a significant difference between the carbon monoxide levels within high traffic areas and low traffic areas.

## 1.4 SCOPE OF STUDY

The scope of this project covers studies of CO concentrations and distribution within Enugu city comprising of such districts as Old Park (high traffic) and Caritas University (low traffic). The project will examine the distribution of air pollution situation within these areas of the city. Data will be collected and analyzed for its relevance to the question of how CO disperses in the environment. To this end, two stations are chosen, one a high traffic (Old Park) and a low traffic area that is primarily residential and have low traffic flow (Caritas University). The essence of choosing these stations is to give a general overview of what the air quality is like within the city, with one station showing the residential profile while the other shows the commercial profile. The study will focus on only Carbon Monoxide (CO) gas. The gas will be measured for a nine hour period for one week at a five minutes interval using carbon monoxide sensors.

## 1.5 SIGNIFICANCE OF THE STUDY

This study helps in the understanding and also the monitoring of carbon monoxide in Enugu metropolis and this will help in knowing the level of carbon monoxide being emitted in this area.

This study will also help in minimizing the level of carbon monoxide in the environment and also provide a means of solving the problems since motor bikes and vehicles serves as the case study and the major contributor of carbon-monoxide in outdoor activities.

# CHAPTER TWO

## 2.0 LITERATURE REVIEW

Carbon monoxide is a chemical compound of carbon and oxygen with the formula CO (Redmond, 2008). It is a colorless, odorless gas, about 3 percent lighter than air, and is poisonous to all warm-blooded animals and to many other forms of life. Carbon monoxide is formed whenever carbon or substances containing carbon are burned with an insufficient air supply. When inhaled it combines with hemoglobin in the blood, preventing absorption of oxygen and resulting in asphyxiation. Even when the amount of air is theoretically sufficient, the reaction is not always complete, so that the combustion gases contain some free oxygen and some carbon monoxide.

An incomplete reaction is especially probable when it takes place quickly, as in an automobile engine; for this reason, automobile-exhaust gases contain harmful quantities of carbon monoxide, sometimes several percent, although antipollution devices are intended to keep the level below 1 percent. As little as 1/1000 of 1 percent of carbon monoxide in air may produce symptoms of poisoning, and as little as $^{1}/_{5}$of 1 percent may prove fatal in less than 30 min. Carbon monoxide is a major component of air pollution in urban areas. In addition to being present in automobile exhaust, carbon monoxide also occurs in cigarette smoke.

Carbon monoxide has been used by humans since prehistoric times, for the smelting of iron and other metallic ores (Roberts, 1983). The gas was used for executions by the Greek and Romans in Classical Antiquity (Blumenthal, 2001), and was first described by the Spanish doctor Arnaldus de Villa Nova in the 11th century (McVough, 1970). In 1776, the French chemist de Lassone produced CO by heating zinc oxide with coke, but mistakenly concluded that the gaseous product was hydrogen, as it burned with a blue flame. The gas was identified as a compound containing carbon and oxygen by the Scottish chemist William Cumberland Cruikshank in the year 1800. Its toxic properties on dogs were thoroughly investigated by Claude Bernard around 1846 (Waring *et. al.*, 2007).

A gas mixture that included carbon monoxide has been used for different purposes in the past. For instance, During World War II, such mixture was used to keep motor vehicles running in parts of the world where gasoline and diesel fuel was scarce. Another gas mixture produced when external (with few exceptions) charcoal or wood gas generators were fitted, and the mixture of atmospheric nitrogen, carbon monoxide, and smaller amounts of other gases produced by gasification was piped to a gas mixer. This gas mixture was known as wood gas. Kitchen (2006) also reported that Carbon monoxide was also used on a small scale during the Holocaust at some Nazi extermination camps.

Carbon monoxide, chemical compound of carbon and oxygen with the formula co. it is a colorless, odorless gas, about 3 percent light than air, and is poisonous to all warm-blooded animals and to many other forms of life. When inhaled it combines with hemoglobin in the blood, preventing absorption of oxygen and resulting in asphyxiation.

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Carbon (11) oxide, co, is produced by incomplete combustion of carbon compounds, such as the octane,

$C_8H_{18}$, found in petrol.

$2C_8H_{18}(1)+17O_2cg) \longrightarrow 16Co(g) +18H_2)(1)$

Carbon(11) oxide occurs in traces as an impurity in the atmosphere. The percentage present any be higher in cities where the gas is released in the exhaust fumes of motor cars, and in industrial areas due to the combustion of fuels.

Carbon (11) oxide occurs in traces as an impurity in the atmosphere. The percentage present may be high in cities where the gas is released in the exhaust fumes of motor cars, and in industrial areas due to the combustion of fuels.

Carbon(11) oxide is a poisonous gas. As little as 0.055 of it in air may cause a person to die. Since the gas has no color, or odor, its presence is difficult to detect, so it is very dangerous.

An incomplete reaction is especially probable when it takes place quickly, as in an automobile engine, for this reason, automobile exhaust gases contain harmful substances, or quantities of carbon monoxide, sometimes several percent, although anti-pollution devices are intended to keep the level below 1 percent. As little as 1/1000 of 1 percent of carbon monoxide in air may produce symptoms of poisoning, and as little as 1/5 of 1 percent may prove fatal in less than 30mins.

Carbon monoxide is a major component of air pollution in urban areas. In addition of being present in automobile exhaust, carbon monoxide also occurs in cigarette smoke.

Because it is odorless, carbon monoxide is an insidious poison it produces only mild symptoms of headache, nausea, or fatigue followed by unconsciousness.

An automobile engine running in a closed garage can make the air noxious within a few minutes, a leaking furnace flue may fill a house with unsuspected

poison fuel gas, which may contain as much as 50 percent carbon monoxide, often has small quantities of unpleasant-smelling sulfur compounds purposely added to make leaks noticeable.

Carbon monoxide is an important industrial fuel because it contains more than two-thirds of the hearting value of he carbon form which it was formed. It is a constituent of water gas, producer gas, blast furnace gas and coal gas. In smelting iron ore carbon monoxide formed from coke used in the process acts as a reducing agent, that is, it removes oxygen from the ore.

Carbon monoxide combines actively with chlorine to form carbonyl chloride, or phosgene and it combines with hydrogen, when heated in the presence of a catalyst to form methyl alcohol.

The direct combination of carbon monoxide with certain metals, forming gaseous compounds, is used in refining those metals, particularly nickel. Carbon monoxide metals at – 205oc (-337of) and boils at – 191.5oc (-312of).

PHYSICAL PROPERTIES

1). Carbon (11) oxide is a colorless tasteless and odorless gas.

2). It is insoluble in water, but dissolves in a solution of ammonical copper

(1) chloride.

3). It is slightly less dense than air.

4). It is neutral to litmus.

## CHEMICAL PROPERTIES

### AS A REDUCING AGENT

Carbon(11)oxide is a strong reducing agent. It reduces some metallic oxides to metals and is itself oxidized to carbon (iv) oxide.

$Pbo(s) + Cocg) \longrightarrow Pb(s) + Co_2cg)$

Carbon (11) oxide also reduces iodine (v) oxide to iodine, and steam to hydrogen.

$I_2O5(s) + 5Co\ (g) \longrightarrow I_2(s) + Co_2(g)$

$H_2Ocg) + Cocg) \longrightarrow H_2cg) + Co_2(g)$

### COMBINATION REACTIONS

With oxygen carbon(11) oxide burns in air with a faint blue flame forming carbon (iv) oxide.

$2CO(g) + O_2(g) \longrightarrow 2Co_2(g)$

With hemoglobin carbon (11) oxide is a poisonous gas since it combines with the hemoglobin in the red blood cells to form a stable compound.

This stable compound prevents the hemoglobin from transporting oxygen in our body. A person will die from back of oxygen when one-third of the hemoglobin in the body is combined with carbon (11) oxide.

TEST FOR CARBON (11) OXIDE

Bubble some of the unknown gas through ha test-tube containing lime water. Next, apply a lighted splint to a test-tube containing the unknown gas. Not what happens? Then add some lime water to the test tube and shake.

Burning of carbon (11)oxide

If the gas is carbon(11) oxide, it will burn with a blue flame and turn lime water milky after burning but not before burning.

## 2.1 MEASUREMENT AND MONITORING OF CO

Natural sources of CO are so variable from year to year, it is extremely difficult to accurately measure natural emissions of the gas. CO is a deadly colorless, odorless

gas and it is difficult to detect carbon monoxide without the use of special equipment. CO levels can be measured in two ways; by purchasing of CO monitors or detectors. These detectors/monitors are either fixed or portable sensors. The fixed being the ones that are fastened to the walls of the buildings for indoor or any standing object within the vicinity for outdoor measurements. The portable sensors are those that can be carried around and the current level of the gas within that vicinity read off from the sensor. The portable gives instantaneous reading of an area while the fixed can be used for the continuous detection/monitoring and logging of the concentration of the place. The fixed sensors are also used as warning systems, which are installed in homes and industries that are in the risk of CO exposure.

Another method of CO measurement is done indirectly by determining the level of CO in the blood at a hospital with the appropriate equipments and personnel. Tests will measure the amount of carboxyl hemoglobin --- a combination of carbon monoxide and hemoglobin which carries oxygen through the blood stream --- in the blood. These tests are best administered by a professional.

PREPARATION

Carbon(11) oxide is prepared from carbon (iv) oxide by passing the latter through red-hot carbon as shown in fig 7.13. most of the carbon(iv) oxide gets reduced to

carbon (11)oxide. Unchanged carbon (iv) oxide is removed when the mixture of gases passes through concentrated sodium hydroxide.

The pure carbon(11) oxide is collected over water.

$Co_2(g) + C(s) \longrightarrow 2\ Co(g)$

Carbon (11) oxide can also be prepared by dehydrating methanioc (formic) acid or ethanedoic (oxalic) acid using concentrated tetraoxosulphate (vi) acid. The latter serves as a dehydrating agent.

$$\begin{array}{l} H \\ | \\ CO\ OH(1) \end{array} \xrightarrow[-H2o]{Conch_2so4} CO(g)$$

methanioc acid

$$\begin{array}{l} CO\quad OH \\ | \\ COO\quad H\ (s) \end{array} \xrightarrow[-H_2O]{Conc.\ H_2SO4} CO_2(g) + CO(g)$$

ethanedioic acid

Fig 7.14 shows how carbon (11) oxide is prepared from ethanedioic acid. The reactants in the flask are warmed gently.

Effervescence occurs and equal volumes of carbon (11) oxide and carbon (iv) oxide are evolved.

The gaseous mixture is passed through concentrated sodium hydroxide to remove the carbon(iv) oxide. Must be done in a fume cupboard as the gas is poisonous.

USES

Carbon(11) oxide is used in the extraction of metals from their ores. It is also an important constituent of gaseous fuels like producer gas and water gas.

PRODUCER GAS

Producer gas is a mixture of nitrogen and carbon (11) oxide, prepared by passing a stream of air through red-hot coke. The oxygen in the air oxidizes the coke to carbon (11) oxide, with the nitrogen is unchanged. Some carbon(iv) oxide may be formed but this is usually reduced by the hot coke to carbon (11) oxide.

$2C(s) + O_2 9g)$ $2CO(g)$

Producer gas has a low heating power because it contains about 67% non-combustible nitrogen and 33% carbon(11) oxide. However, it is inexpensive and is widely used to heat furnaces retorts (in the manufacture of zinc and coal gas) and limekilns. It is also a source of nitrogen for the manufacture of ammonia (Haber process).

WATER GAS

Water gas is a mixture containing equal volumes of hydrogen and carbon(11)oxide, prepared by passing steam over white-hot coke at $1000^{o}C$

$C(s) + H_2o(g) \longrightarrow Co(g) + H_2(g)$

During the process the coke quickly cools to a temperature too low for reaction if heat is not supplied externally. Industrially, producer gas and water gas are made in the same plant, known as the producer, by passing air and steam alternately through the heated coke. The heat produced when producer gas is formed is sufficient for water gas formation.

Both the hydrogen and the carbon (11) oxide in water gas burn in air releasing a lot of heat. This makes water gas an important industrial fuel. However, it has too high a carbon(11) oxide content for domestic use. Water gas is also an industrial sources of hydrogen and other organic compounds e.g. Methanol and butanol.

***CO IN THE AIR***

CO is one of the most common air pollutants. It has no color, odor or taste, it has a low reactivity and low water solubility. It is mainly emitted into the atmosphere as a product of incomplete combustion. Annually, a large number of individuals die as a result of exposure to very high indoor CO levels, far above ambient outdoor

levels. In Flanders, for example, in 1987-1988 about 100 people died, mostly as a result of accidental exposure3. For ambient outdoor air, CO is one of the "classical" air pollutants, for which many countries have set air quality limit values. At the EU level no air quality threshold exist currently.

In terms of absolute concentrations CO is the most prevalent of the toxic air pollutants. Its concentrations are expressed in mg/m3, in contrast to all other pollutants, which are measured in g/m3 or even smaller units.

Fortunately the risk thresholds are also in the range of mg/m3, which is higher than thresholds for other toxic air pollutants of concern.

CO is not only directly emitted into the air, but can also be formed by chemical reactions from organic air pollutants, such as methane. CO has a residence time in the atmosphere of about three months. At moderate latitudes the time for air to travel around the world is also of the order of months. Since CO formation from organic air pollutants takes place everywhere in the atmosphere, a global background level of CO exists, ranging between 0.05 and 0.15 ppm (0.06 and 0.17 mg/m3)4. At EU latitudes the global background level is at the high end of this range.

## 2.2 SOURCES OF CO

### WORLD-WIDE EMISSIONS

CO is brought into the atmosphere by two different mechanisms: emission of CO and chemical formation from other pollutants. Table 1 gives an overview of the global anthropogenic emissions of CO5. From the table it appears that burning of forest, savannah and agricultural waste accounts for half the global CO emissions. The chemical formation of CO is due to the oxidation of hydrocarbons, and it adds 600 - 1600 M tonnes to the atmosphere6. Two-third of it stems from methane. It is a slow process, and does not give rise to local peak concentrations. However, being a source of the same magnitude of the direct emission, CO formation contributes considerably to the global background level. It is estimated that about one-third of CO results from natural sources, including that derived from hydrocarbon oxidation.

### EU EMISSIONS

Data on CO emissions in the EU are available in the CORINAIR emissions inventory for 1990and 1994. By far the largest source is road transport, which accounts for two-thirds of the emissions of the EU. The contribution from traffic is seen to vary considerably between the Member States (from 30 to 89%). Also for other source sectors the relative contributions deviate from the EU pattern, *H_J_* there is no emission from production processes in the UK. Such deviations may

reflect the real emission deviations, but it cannot be excluded that differences in emission registration method cause part of the discrepancies.

Not all sectors in Table 1 and Table 2 can be directly compared, but EU emissions by road transport, combustion and production processes are, on a per capita basis, larger than global emissions by road transport, industry and power generation. Conversely, residential emissions, deforestation, savannah burning and agricultural waste burning are more important sources on the global scale. Again, some of the differences may be due to differences in estimation methods.

Figure 2 compares the 1994 emissions with those of 1990. The trend in emissions is downward, though not in all Member States. The emissions in the most important source category, road transport, have gone down as a result of emission reduction measures, such as Inspection and Maintenance and the introduction of the 3-way catalyst, although the effect was partly offset by the growth of the number of vehicle-kilometers.

## 2.3 PROPERTIES OF CO

Carbon monoxide is the simplest oxocarbon. It consists of one carbon atom and one oxygen atom, connected by a triple bond that consists of two covalent bonds as well as one dative covalent bond. In coordination complexes the carbon monoxide ligand is called carbonyl.

CO has a molar mass of 28.0, and this makes it slightly lighter than air, whose average molar mass is 28.8. CO is therefore less dense than air when you compare their molar masses based on the ideal gas laws. But since neither gas is "ideal", the exact densities and other comparative values depend upon temperature and pressure.

The ground electronic state of carbon monoxide is a singlet state (http://www.mpe.mpg.de/lab/CO/co.html) since there are no unpaired electrons. The bond length between the carbon atom and the oxygen atom is 112.8 pm. This bond length is consistent with a triple bond, as in molecular nitrogen ($N_2$), which has a similar bond length and nearly the same molecular mass. Carbon-oxygen double bonds are significantly longer, 120.8 pm in formaldehyde, for example (Gilliam et al, 1950 and Hayes, 2010). Furthermore, the boiling point (82°K) and melting point (68°K) of CO are very similar to those of $N_2$ (77°K and 63°K, respectively). Its bond dissociation energy of 1072 kJ/mol is stronger than that of $N_2$ (942 kJ/mol) and represents the strongest chemical bond known (Hayes, 2010).

CO is produced in the environment from the partial oxidation of carbon-containing compounds; it forms when there is not enough oxygen to produce carbon dioxide ($CO_2$), this is obtainable when operating a stove or an internal combustion engine

in an enclosed space. It also burns with a blue flame in the presence of oxygen to produce $CO_2$.

## 2.4 PRODUCTION OF CO

Generally speaking, carbon monoxide is produced from the partial oxidation of carbon-containing compounds; and it forms when there is not enough oxygen to produce carbon dioxide ($CO_2$), such as when operating a stove or an internal combustion engine in an enclosed space. It can also be produced by some processes in modern technology, such as iron smelting, which still releases carbon monoxide as a byproduct. Carbon monoxide is also a minor constituent of tobacco smoke.

In biology, carbon monoxide is naturally produced in man and other vertebrates by the action of *heme oxygenase* 1 and 2 on the *heme* from hemoglobin breakdown. This process produces a certain amount of carboxyl hemoglobin in normal persons, even if they do not breathe any carbon monoxide. For lower organisms such as bacteria, carbon monoxide is produced via the reduction of carbon dioxide by the enzyme carbon monoxide dehydrogenase, an Fe-Ni-S-containing protein (Jaouen, 2006).

## 2.5 IMPORTANCE OF CO

Carbon monoxide is an important industrial fuel because it contains more than two-thirds of the heating value of the carbon from which it was formed. It is a constituent of water gas, producer gas, blast furnace gas, and coal gas. In smelting iron ore carbon monoxide formed from coke used in the process acts as a reducing agent, that is, it removes oxygen from the ore. Carbon monoxide combines actively with chlorine to form carbonyl chloride, or phosgene, and it combines with hydrogen, when heated in the presence of a catalyst, to form methyl alcohol. The direct combination of carbon monoxide with certain metals, forming gaseous compounds, is used in refining those metals, particularly nickel (Redmond, 2008).

CO as a very important industrial gas has many applications in bulk chemicals manufacturing (Elschenbroich and Salzer, 2006). It is used in the manufacture of aldehydes by the hydroformylation reaction of alkenes, carbon monoxide, and $H_2$. Methanol is also produced by the hydrogenation of carbon monoxide. In a related reaction, the hydrogenation of carbon monoxide is coupled to C-C bond formation, as in the Fischer-Tropsch process where carbon monoxide is hydrogenated to liquid hydrocarbon fuels. This technology allows coal or biomass to be converted to diesel. More so, an industrial scale use for pure carbon monoxide is purifying nickel in the Mond process.

Since New York Times first reported that carbon monoxide is a normal neurotransmitter in 1993 (New York Times, 2010), as well as one of three gases that naturally modulate inflammatory responses in the body (the other two being nitric oxide and hydrogen sulfide), carbon monoxide has received a great deal of clinical attention as a biological regulator. In many tissues, all three gases are known to act as anti-inflammatories, vasodilators, and promoters of neovascular growth (Li et al, 2009). Johnson (2009) stated that clinical trials of small amounts of carbon monoxide as a drug are on-going. He further stated that studies involving carbon monoxide have been conducted in many laboratories throughout the world for its anti-inflammatory and cytoprotective properties. These properties, he pointed out have potential to be used to prevent the development of a series of pathological conditions including ischemia reperfusion injury, transplant rejection, atherosclerosis, severe sepsis, severe malaria, or autoimmunity. Clinical tests involving humans have been performed; however the results have not yet been released.

Carbon monoxide is used in modified atmosphere packaging systems in the US, mainly with fresh meat products such as beef, pork, and fish to keep them looking fresh. The carbon monoxide combines with myoglobin to form carboxyl myoglobin, a bright-cherry-red pigment. Carboxyl myoglobin is more stable than the oxygenated form of myoglobin, oxymyoglobin, which can become oxidized to

the brown pigment metmyoglobin. This stable red color can persist much longer than in normally packaged meat (Sorheim et al, 1999). Typical levels of carbon monoxide used in the facilities that use this process are between 0.4% to 0.5%.

CO functions as a nutrient for methanogenic bacteria (Thauer, 1998), a building-block for *acetylcoenzyme* A. This is the theme for the emerging field of bioorganometallic chemistry. Extremophile micro-organisms can, thus, metabolize carbon monoxide in such locations as the thermal vents of volcanoes (Hogan, 2010).

## 2.6 EFFECTS OF CARBON MONOXIDE ON HUMAN HEALTH

(a) ASPHYXIATION

Medical examiners are also called upon to investigate cases of asphyxiation that is death from lack of oxygen in the blood.

Asphyxiation may be caused in a number of different ways such as hanging which may be an accident, suicide or homicide or strangulation which is homicide obstruction of the victim's compression of the victim's chest by a person or an object can also result in asphyxiation. Finally asphyxiation can be caused by the replacement of oxygen in the red blood cell by another gas as in carbon (11) oxide poisoning, which can be the result of suicide, homicide or accident.

In death involving carbon (11) oxide poisoning, a closed garage door and no marks on the body are usually taken as an indication of suicide where as the presence of tools around the cars and grease on the victim's hand points to accidental death.

The presence of wound caused by a blow to the head of the absence of carbon monoxide in the blood of the victim would indicate an attempt to make a homicide look like a suicide.

b) PARKINSON DISEASE

Scientists have get to identify a particular drugs or toxin that causes Parkinson diseases.

It is the disorder of the nervous system that affects muscle control marked by trembling of arms and legs muscular rigidity and poor balance.

## 2.7 EPIDEMIOLOGICAL EFFECTS OF CO

CO poisoning is one of the most common type of fatal air poisoning in many countries (Omaye, 2002). Carbon monoxide is colorless, odorless, and tasteless, but highly toxic. It affects the blood's ability to carry oxygen to body tissues including vital organs such as the heart and brain. When CO is inhaled, it combines

with the oxygen carrying hemoglobin of the blood to form carboxyl hemoglobin (COHb). Once combined with the hemoglobin, that hemoglobin is no longer available for transporting oxygen very quickly the carboxyl hemoglobin builds up is a factor of the concentration of the gas being inhaled (measured in parts per million or PPM) and the duration of the exposure (Tiknisis et al, 1992).

Because it is odorless, carbon monoxide is an insidious poison. It produces only mild symptoms of headache, nausea, or fatigue, followed by unconsciousness. An automobile engine running in a closed garage can make the air noxious within a few minutes; a leaking furnace flue may fill a house with unsuspected poison. Fuel gas, which may contain as much as 50 percent carbon monoxide, often has small quantities of unpleasant-smelling sulfur compounds purposely added to make leaks noticeable (Redmond, 2008).

Carbon monoxide (CO) poisoning is responsible for up to 40,000 emergency department visits and 5000 to 6000 deaths per year, making it one of the leading causes of poisoning death in the United States (Ernst and Zibrak, 1998; Weaver, 1999). Inadvertent CO poisoning likely causes around 500 deaths annually; the number of intentional CO poisonings is perhaps 10 times higher (Ernst and Zibrak, 1998; CDC, 2005). The overall case-fatality rate for CO poisoning ranges from 0 to 31 percent (Tibbles and Perrotta, 1994, Hampson and Hauff, 2008).

Unlike intentional poisoning, unintended poisoning demonstrates both seasonal and regional variation, and it is most common during the winter months in cold climates (CDC, 1995). Morbidity, which is primarily related to late neurocognitive impairment, persists beyond initial stabilization in up to 40 percent of victims (Hardy and Thom, 1994).Smoke inhalation is responsible for most inadvertent cases of CO poisoning.

Carbon monoxide binds to other molecules such as myoglobin and mitochondrial cytochrome oxidize. Exposures to carbon monoxide may cause significant damage to the heart and central nervous system, especially to the globus pallidus (Prockop and Chichkora, 2002), often with long-term sequel. Carbon monoxide may have severe adverse effects on the fetus of a pregnant woman (Blackburn, 2007).

One of the major concerns following acute carbon monoxide poisoning is the severe delayed neurological manifestations that may occur. Problems may include difficulty with higher intellectual functions, short-term memory loss, dementia, amnesia, psychosis, irritability, a strange gait, speech disturbances, Parkinson's disease-like syndromes, cortical blindness, and a depressed mood (Lupinetti et al, 1997 and Blackburn, 2002). Depression may even occur in those who did not have pre-existing depression (Wu and Wang, 2005). These delayed neurological squeal

may occur in up to 50% of poisoned patients after 2 to 40 days (Lupinetti et al, 1997). It is difficult to predict who will develop delayed sequel; however, advancing age, loss of consciousness while poisoned, and initial neurological abnormalities may increase the chance of developing delayed symptoms (Thauer, 1998).

## 2.8 IMPACTS OF CO TO THE ENVIRONMENT

CO has an indirect radioactive forcing effect by elevating concentrations of methane and tropospheric ozone through chemical reactions with other atmospheric constituents (e.g., the hydroxyl radical, OH.) that would otherwise destroy them (White et al, 1989). Through natural processes in the atmosphere, it is eventually oxidized to carbon dioxide. Carbon monoxide concentrations are both short-lived in the atmosphere and spatially variable.

Carbon monoxide is a major atmospheric pollutant in some urban areas, chiefly from the exhaust of internal combustion engines (including vehicles, portable and back-up generators, lawn mowers, power washers, etc.), but also from incomplete combustion of various other fuels (including wood, coal, charcoal, oil, paraffin, propane, natural gas, and trash).Other potential sources of CO in the environment include poorly functioning heating systems, improperly vented fuel-burning devices (eg, kerosene heaters, charcoal grills, camping stoves (Thomassen et al.,

2004), gasoline-powered electrical generators (CDC, 2004)), and motor vehicles operating in poorly ventilated areas (eg, ice rinks, warehouses, parking garages). CO poisonings following open air exposure to motorboat exhaust have also been reported. In addition, underground electrical cable fires produce large amounts of CO, which can seep into adjacent buildings and homes (CDC, 2004b).

CO is part of the series of cycles of chemical reactions that form Photochemical smog. Along with aldehydes, it reacts photo chemically to produce proxy radicals. Proxy radicals subsequently oxidize nitrogen oxide (NO) to nitrogen dioxide ($NO_2$) (Sigel and Sigel, 2009). Although this creation of $NO_2$ is the critical step leading to low level ozone formation, it also increases this ozone in another, somewhat mutually exclusive way, by reducing the quantity of NO that is available to react with ozone (Sigel and Sigel, 2009). Simplified, the net effect of the ozone cycle is:

$$CO + 2O_2 \rightarrow CO_2 + O_3$$

In closed environments, the concentration of carbon monoxide can easily rise to lethal levels. An increase in carbon monoxide exposures has been reported to occur in the immediate aftermath of hurricanes (CDC, 2006; Cukor and Restuccia, 2007).

## 2.9 LOCAL STUDIES

There have been a number of studies designed to determine the levels of human exposure to CO. These studies have included personal monitoring studies in which occupants wore personal exposure monitors for 24 hours or more and recorded their activities and locations in diaries (Akland et al. 1985; Nagda and Koontz 1985). These studies have provided information on CO exposure as a function of activity and microenvironment, such as parking garages, motor vehicles, outdoors, and residential buildings. Some studies have focused on CO exposure in buildings, and in some cases on exposure in specific locations within buildings. One of these studies focused on men with ischemic heart disease, in which they wore personal CO monitors that recorded one- minute average CO concentrations (Colome et al. 1992). The study participants also maintained written diaries of their activities, locations and symptoms. In addition to information on health symptoms, the results of this study include information on CO exposure as a function of occupant activity and location. The highest personal exposures were associated with driving automobiles and using small gasoline appliances for lawn care or cutting wood, and CO concentrations are reported for a number of indoor spaces including residential buildings by room type, e.g., kitchen, living room, and bedroom. In residential buildings, mean one-minute CO exposures ranged from 4 mg/m3 to 4.6 mg/m3 (3.5 ppm and 4.0 ppm) in family rooms, kitchens, dining rooms and living

rooms, from 2.4 mg/m3 to 3.4 mg/m3 (2.1 ppm and 3.0 ppm) in bedrooms, bathrooms and laundry rooms, and 4.5 mg/m3 (3.9 ppm) in garages or enclosed carports. However, maximum concentrations were above 100 mg/m3 (87 ppm) in family rooms, kitchens and garages/carports, laundry rooms, and 4.5 mg/m3 (3.9 ppm) in garages or enclosed carports. However, maximum concentrations were above 100 mg/m3 (87 ppm) in family rooms, kitchens and garages/carports.

UNDP (2005) report shows that the majority of the urban dwellers are in the developing and developed countries. Studies have been done in the past in some of these places such as Chile (Rubio et al, 2007), Rome (Chiara et al, 1995), and so on. Studies have also been done in some sub-Saharan African cities such as Cotonou (Fanou et al, 2006) and Ouagadougou (Lindèn et al, 2008). Previous studies that have been done in Nigeria concerning CO include Banjoko et al (2007) and Baumbach et al (1995).

In the previous Nigerian CO studies, Banjoko et al (2007) in a more recent study determined the ambient CO within Ibadan and the level of exposure of CO and Methyl chloride among cabinet makers and non-cabinet makers. The result indicated a distribution of 4 – 52 ppm with a mean of 20ppm. Cabinet makers were found to have higher COHb than the non-cabinet makers, and tobacco smoking did not significantly affect the COHb levels within the two groups.

Moreso, Baumbach et al (1995) studied the air pollution in Lagos. In their study, they observed that air pollution within the city was caused by traffic that is characterized by many strong emitting vehicles and frequent traffic jams. They measured the air pollution within the city using a fixed air monitor and other portable sampling units. Their results show that CO levels exceed WHO guidelines in many centers; as such, drastic measures are necessary to protect the population and the environment against this pollutant. It is view of these studies and many more, which this project wants to examine the difference between the heavy traffic centre and a light traffic within Enugu City.

# CHAPTER THREE

## 3.0 MATERIALS AND METHOD

In this research, a high traffic (HT) and a low traffic (LT) area were identified for sampling. El-USB-CO data logger, a carbon monoxide data logger was used in this study. This data logger measures and stores up to 32,500 Carbon Monoxide (CO) readings over a 0 to 1000 ppm measurement range and -10 to +40°C (14 to +104°F) operating temperature range. The logger was set to record data at five minutes interval and was placed at each sampling location at a height of 3m above the ground. The sampling was conducted for six days (Monday to Saturday), the data were later transferred to a personal computer (PC's) by plugging the module of the logger straight into the PC's USB port and running the purpose designed software under Windows operating system.

# CHAPTER FOUR

## 4.0 RESULT AND DISCUSSION

There is a Significant Difference between the Carbon Oxide levels within high traffic areas and low traffic areas and low traffic areas

## 4.1 LIST OF TABLES

**Table 1: Calculation for the Concentration of Co on 14th May, 2012**

| | Time 1hr | Ht(ppm) Concentrations | Lt (ppm) |
|---|---|---|---|
| 1 | 9.00 | 11 | 0.1 |
| 2 | 10.00 | 10 | 0.1 |
| 3 | 11.00 | 15 | - |
| 4 | 12.00 | 10 | - |
| 5 | 13.00 | 10 | - |
| 6 | 14.00 | 11 | - |
| 7 | 15.00 | 13 | - |
| 8 | 16.00 | 35.1 | - |
| 9 | 17.00 | 9 | 0.5 |
| 10 | 18.00 | 5 | - |

**Table 2: Calculation of the Concentration of Co on 15th May, 2012**

| | Time 1hr | Ht(ppm) Concentrations | Lt conc (ppm) |
|---|---|---|---|
| 1 | 9.00 | 8 | 1.00 |
| 2 | 10.00 | 10 | - |
| 3 | 11.00 | 4 | - |
| 4 | 12.00 | 15 | - |
| 5 | 13.00 | 14 | 0.8 |
| 6 | 14.00 | 12 | - |
| 7 | 15.00 | 13 | - |
| 8 | 16.00 | 1.1 | - |
| 9 | 17.00 | 14 | 0.1 |
| 10 | 18.00 | 0.1 | 0.1 |

**Table 3: Calculation of the concentration of Co on 16th May, 2012**

| | Time 1hr | Ht(ppm)<br><br>Concentrations | Lt (ppm) |
|---|---|---|---|
| 1 | 9.00 | 17 | 2.0 |
| 2 | 10.00 | 10 | 0.05 |
| 3 | 11.00 | 14 | - |
| 4 | 12.00 | 13 | - |
| 5 | 13.00 | 8 | - |
| 6 | 14.00 | 7 | - |
| 7 | 15.00 | 6 | - |
| 8 | 16.00 | 6 | 1.1 |
| 9 | 17.00 | 20 | 0.1 |
| 10 | 18.00 | 7 | - |

**Table 4:Calculation of the concentration of Co on17th May, 2012**

| | Time 1hr | Ht(ppm)<br><br>Concentrations | Lt (ppm) |
|---|---|---|---|
| 1 | 9.00 | 9 | 0.2 |
| 2 | 10.00 | 10 | - |
| 3 | 11.00 | 11 | 0 |
| 4 | 12.00 | 15 | - |
| 5 | 13.00 | 11 | - |
| 6 | 14.00 | 9 | - |
| 7 | 15.00 | 9 | 0.1 |
| 8 | 16.00 | 10 | - |
| 9 | 17.00 | 18 | - |
| 10 | 18.00 | 4 | 0.1 |

**Table 5: Calculation of the concentration of Co on 18th May, 2012**

| | Time 1hr | Ht(ppm)<br><br>Concentrations | Lt (ppm) |
|---|---|---|---|
| 1 | 9.00 | 30 | 0 |
| 2 | 10.00 | 15 | - |
| 3 | 11.00 | 9 | - |
| 4 | 12.00 | 5 | - |
| 5 | 13.00 | 18 | - |
| 6 | 14.00 | 25 | - |
| 7 | 15.00 | 18 | 0.2 |
| 8 | 16.00 | 10 | 0.1 |
| 9 | 17.00 | 5 | 3.0 |
| 10 | 8.00 | 5 | - |

**Table 6: Calculation of concentration of Co on 19th May, 2012**

| | Time 1hr | Ht(ppm)<br><br>Concentrations | Lt (ppm) |
|---|---|---|---|
| 1 | 9.00 | 12 | .0 |
| 2 | 10.00 | 28 | - |
| 3 | 11.00 | 9 | - |
| 4 | 12.00 | 9 | - |
| 5 | 13.00 | 9 | 0 |
| 6 | 14.00 | 13 | - |
| 7 | 15.00 | 8 | - |
| 8 | 16.00 | 9 | 1.0 |
| 9 | 17.00 | 6 | 0.1 |
| 10 | 18.00 | 5 | 0.8 |

**Table 7: Daily Summary**

| | Ht(ppm) Concentrations | Lt (ppm) |
|---|---|---|
| 14/05/2012 | 13 | 0.1 |
| 15/05/2012 | 10 | 0.2 |
| 16/05/2012 | 11 | 0.3 |
| 17/05/2012 | 11 | 0.1 |
| 18/05/2012 | 14 | 1.0 |
| 19/05/2012 | 11 | 0.3 |

**DAILY SUMMARY OF CO FOR THE 6 DAYS OF STUDY**

## 4.2 TEST OF HYPOTHESIS

In this section, the formulated hypotheses of the study were tested and the data were already presented and analyzed. The chi-square ($x^2$) statistics was used to determine if there existed significance difference between the frequencies and research variables.

The formula for chi-square (x2) given below

$$X^2 = \frac{\Sigma (O-E)}{E}$$

Where $X^2$ = chi-square

O = observed frequency

E = Expected frequency

Σ = summation

**HYPOTHESIS**

Ho: There is a significant difference between the carbon monoxide levels with high traffic areas and lord traffic areas.

| Monitored days of Co | 14/5/12 | 15/5/12 | 16/5/12 | 17/5/12 | 18/5/12 | 19/5/12 | Total |
|---|---|---|---|---|---|---|---|
| High traffic | 13 | 11 | 11.99 | 11.99 | 14 | 11.99 | 73.97 |
| Low traffic | 0.1 | 0.2 | 0.3 | 0.1 | 1.0 | 0.3 | 2.00 |
| Total | 13.1 | 11.2 | 12.29 | 12.09 | 14 | 12.29 | 75.97 |

**SOLUTION**

Under the hypothesis Ho that there is a significant difference between the carbon monoxide levels with high traffic areas and low traffic areas.

73.97/75.97 = 97% is an estimate of the percentage of high traffic and 3% is an estimate of the percentage of low traffic. The frequencies expected under the Ho are shown in Table 12

Thus are calculated as follows:

For 14/5/12

High traffic 97% of 13.1 = 12.71

Low traffic 3% of 13.1 = 0.39

Total = 13.1

For 15/5/12

High traffic 97% of 11.2 = 10.9

Low traffic 3% of 11.2 = 0.3

Total = 11.2

For 16/5/12

High traffic 97% of 12.29 = 11.92

Low traffic 3% of 12.29 = 0.37

Total = 12.29

For 17/5/12

High traffic 97% of 12.09 = 11.72

Low traffic 3% of 12.09 = 0.37

Total = 12.09

For 18/5/12

High traffic 97% of 15 = 14.55

Low traffic 3% of 15 = 0.45

Total = 15

For 19/5/12

High traffic 97% of 12.29 = 11.92

Low traffic 3% of 12.29 = 0.37

Total = 12.29

Therefore table 1.2 is shown as

**Table 1.2**

| Monitored days of Co | 14/5/12 | 15/5/12 | 16/5/12 | 17/5/12 | 18/5/12 | 19/5/12 | Total |
|---|---|---|---|---|---|---|---|
| High traffic | 12.7 | 10.9 | 11.9 | 11.7 | 14.55 | 11..9 | 73.97 |
| Low traffic | 0.39 | 0.3 | 0.37 | 0.36 | 0.45 | 0.37 | 2.0 |
| Total | 13.1 | 11.2 | 12.29 | 12.09 | 15 | 12.29 | 75.97 |

**Table 1.3 Chi Square Calculations for the Test of Hypothesis**

| Row, column | O | E | (0-e) | (0-e)2 | $(0-e)^2/e$ |
|---|---|---|---|---|---|
| 1,1 | 13.00 | 12.71 | 0.290 | 0.0841 | 0.0066 |
| 1,2 | 11.00 | 10.90 | 0.100 | 0.01 | 0.00092 |
| 1,3 | 11.99 | 11.92 | 0.070 | 0.0049 | 0.00041 |
| 1,4 | 11.99 | 11.72 | 0.270 | 0.0729 | 0.0062 |
| 1,5 | 14.00 | 14,55 | -0.55 | 0.3025 | 0.421 |
| 1,6 | 11.99 | 11.92 | 0.07 | 0.0049 | 0.00041 |
| 2,1 | 0.100 | 0.390 | -0.29 | 0.0841 | 0.22 |
| 2,2 | 0.200 | 0.300 | -01 | 0.01 | 0.03 |
| 2,3 | 0.300 | 0.370 | -0.07 | 0.0049 | 0.01 |
| 2,4 | 0.100 | 0.450 | 0.55 | 0.0729 | 0.20 |
| 2,5 | 1.00 | 0.450 | 0.55 | 0.3025 | 0.67 |
| 2,6 | 0.300 | 0.370 | -0.07 | 0.0049 | 0.01 |
| Sum | 75.97 | 75.97 | 0 | | 1.176 |

The degree of freedom for the chi-square distribution is

$V = (h-1)(K-1) = (2-1)(6-1) = 5$

Where h = No of Row

K = No of column

P = level of significance = 0.05

$x^2$ 95 = 11.070 and ($x^2$) = 1.176

Since $x^2$ 95 = 11.070 and 1.176 is lesser than 11.070, we accept the hypothesis at 0.05 significance level. Thus we conclude that the results are probably significant and that there is high increase of carbon monoxide level in high traffic than low traffic areas.

## 4.3 LISTS OF FIGURES

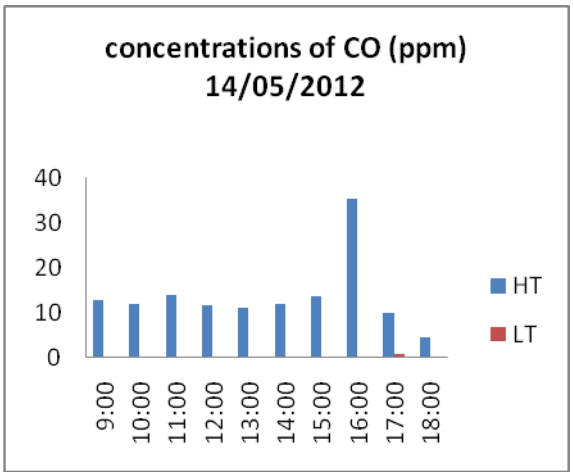


FIG 1: CONCENTRATIONS OF CO ON 14/05/2012

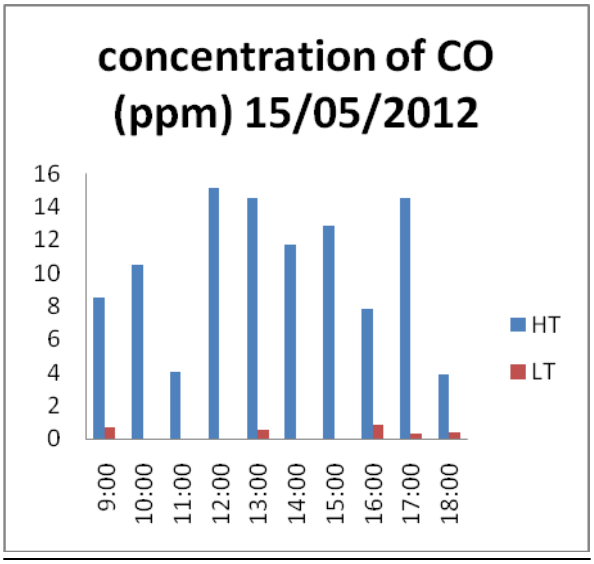


FIG 2:CONCENTATIONS OF CO ON 15/05/2012

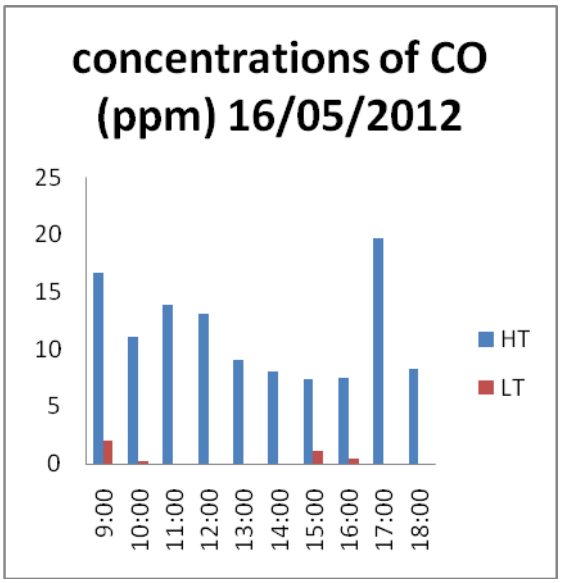


FIG 3: CONCENTRATIONS OF CO 16/05/2012

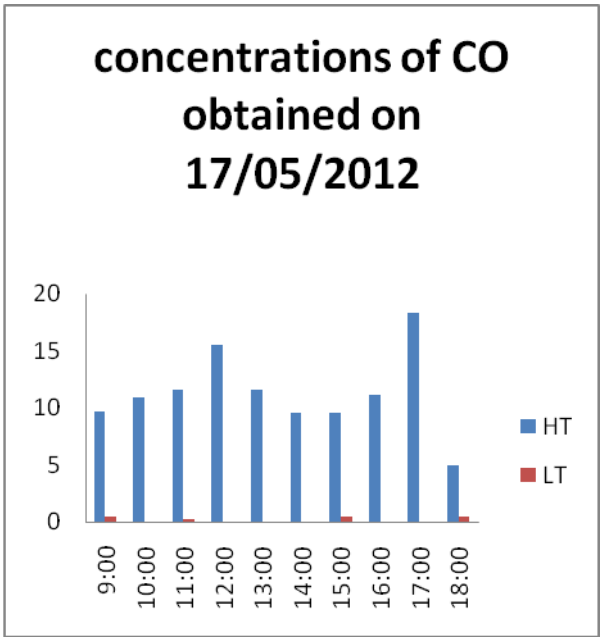


FIG 4: CONCENTRATIONS OF CO 16/05/2012

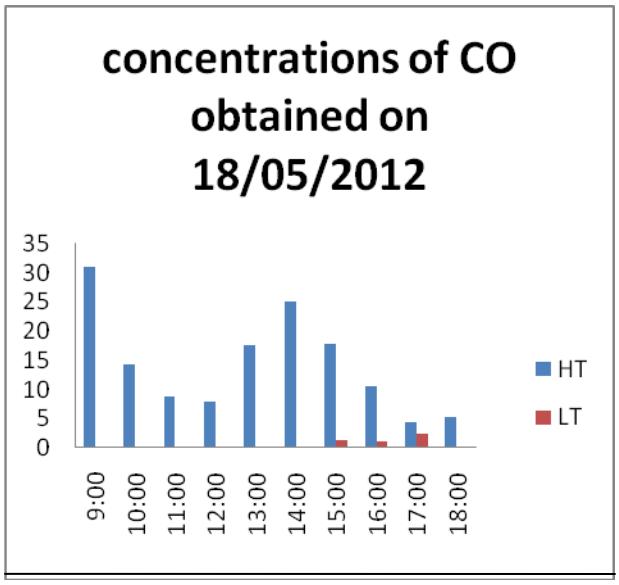


FIG 5: CONCENTRATIONS OF CO ON 18/05/2012

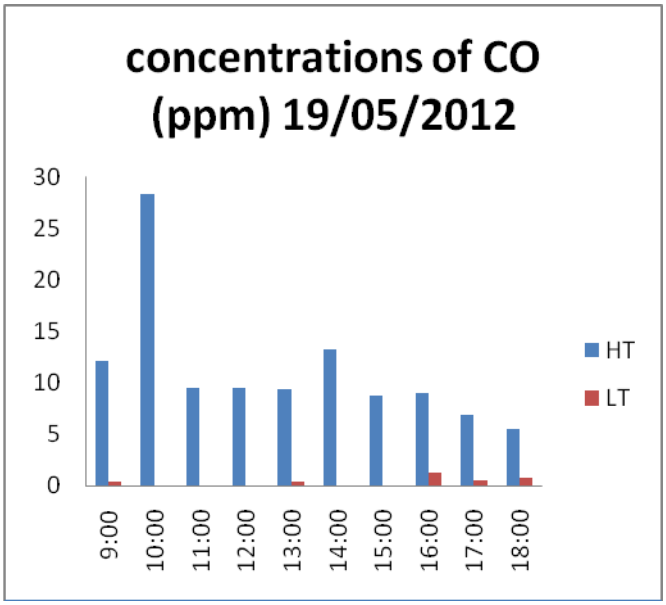


FIG 6: CONCENTRATIONS OF CO ON 19/05/2012

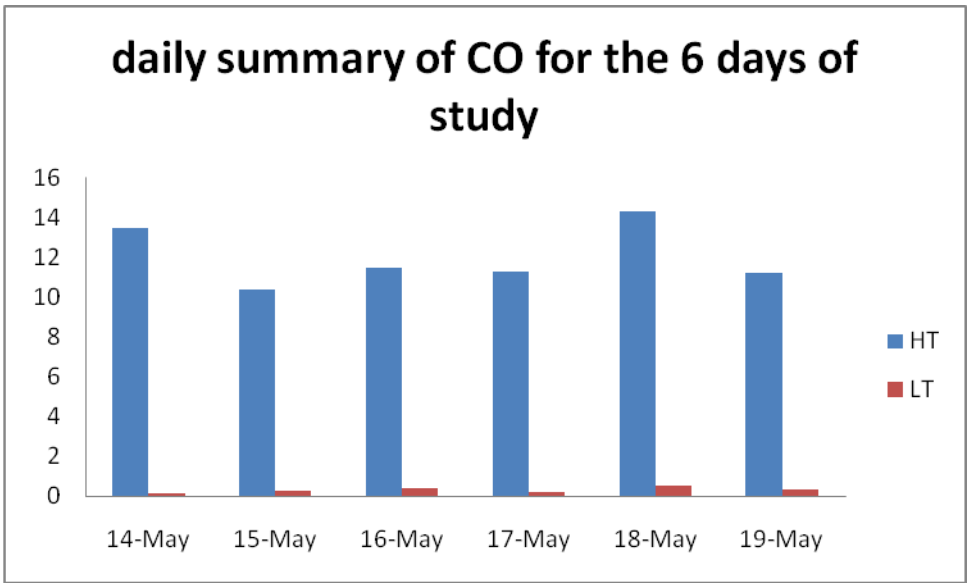


FIG 7: DAILY SUMMARY OF CO FOR THE 6 DAYS OF STUDY

Mans activities have reached a level at which the natural system are disturbed i.e. the atmosphere, land, sea as well as plants and human beings. This has contributed to increase in traces of CO in the last century. This is as a result of continued industrial growth and development of urban areas. It has become necessary to seriously consider environmental management as a project of high importance if improved quality of life is to be guaranteed. The hourly mean concentrations of carbon monoxide presented in figure 1-6 indicated variations between the periods studied. Figure 1-6 showed the levels of CO at a high traffic (HT) and a low traffic (LT) in Enugu metropolis. Generally there was a high CO level in HT than LT in all the periods of study. HT and LT presented the highest hourly mean CO level of 35.1ppm at 16:00hrs of 14/05 and 1.1ppm at 15:00hrs of 16/05 respectively. On the whole, an average of 11.99ppm and 0.30ppm were recorded at HT and LT

areas respectively. An increase in concentration was noticed between 12:00-17:00 in HT, this may be attributed to incomplete combustion of gases and high level of traffic jam observed in the area as a result of commercial activities going on in the area (Abdulkareem and Kovo 2006).

The FEPA (Federal Environmental Protection Agency) allowed daily average limit for CO is presently 10ppm. The levels of CO obtained in HT ranged from 8.6-35.1ppm and are slightly higher than the national standards. These observed levels of CO may be as a result of heavy traffic around the location, since vehicular emissions are major sources of CO levels in the atmosphere. The results of this study are in line with the findings of de Rosa (2003), that traffic pollutants like CO are higher in concentration at road sides or high traffic areas. De Rosa (2003) also reported that young men and middle aged men serving as motorway tollgates attendants in Italy, subjected to exposure to traffic pollution have their fertility impaired. The levels of CO in this study is above the safe limit and brings to mind that road side vendors are under severe threats of health hazards associated with CO exposure. Greiner (1999) also reported that CO is a slow poison that kills by reducing the oxygen supply in the blood. LT which are remote from vehicular traffic gave very low concentrations of CO. Temporal variations were observed in all the sampling areas, this may be attributed to high and low traffic jam.

# CHAPTER FIVE

## 5.0 CONCLUSION

The results from this study showed that concentrations of CO are higher in high traffic area than the low traffic area. High traffic area showed concentrations higher than the regulatory standards, this calls for urgent need for policy readjustments, continuous monitoring and control of source point emission as well as legislative and enforcement supports from stakeholders and government agencies and proper awareness for the citizenry for health hazards associated with air pollution.

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# APPENDIX

CDC-Center for Disease control

CO-Carbon monoxide

CO2-Carbon dioxide

E/-USB-Co-Data Logger

PC’s – Personal computer

HT – High Traffic

LT- Low Traffic

PPM – Part Per Million