POLLUTANTS IN AIR AND HEAVY METALS IN STREET DUST OF SOME SELECTED LOCATIONS IN ZARIA

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DECLARATION

I declare that the work in the thesis entitled "**Pollutants in Air and Heavy Metals in Street Dust of Some Selected Locations in Zaria**" has been performed by me in the Department of Chemistry under the supervision of Prof. V.O. Ajibola and Dr. P. A. Ekwumemgbo

The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously presented for another degree or diploma at any university.

Ochigbo, Victor

| --- | --- | --- |
| Name of Student | Signature | Date |

CERTIFICATION

This Thesis entitled "**Pollutants in Air and Heavy Metals in Street Dust of Some Selected Locations in Zaria**" by Ochigbo, Victor meets the regulations governing the award of the degree of Master of Science of Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This work is dedicated to my parents; Mr. and Mrs. Eje Ochigbo M.C.

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ABSTRACT

Carbon-monoxide (CO), Hydrogen sulphide (H_2S) and sulphurdioxide (SO_2) concentrations were determined in the morning, afternoon and evening hours at the Sabon-Gari Market, Zaria and Aliyu Mustapha Social Centre, Ahmadu Bello University Zaria, using an automatic gas sampling system. The concentrations of these gases have been attributed to the burning of solid and fossil fuels and bacterial decomposition of organic matter from dump sites and gutters. The distribution of the gaseous pollutants showed either a platykurtic (flat) or leptokurtic (peaked) distribution. Analysis of variance using Friedman test showed no significant difference at ($P<0.05$) within the study sites. Hierarchical cluster analysis carried out showed more agglomeration between site B and D during the morning and afternoon hours respectively and between site A and D for the evening hour for all the Sites at location1 while at location 2, their is more agglomeration between site A and C during the morning hour and site A and B for afternoon and evening hours respectively. The concentration of Cd, Cr, Fe, Ni and Pb were determined in the street dust of the Sabon – Gari market Zaria using AAS. The concentration of these metals are within the range of 0.40 – 1.45μgg^{-1}, 16.92 – 33.82μgg^{-1}, 240 – 315.61μgg^{-1}, 3.05 – 6.04 μgg^{-1} and 25.79 – 121.35μgg^{-1} respectively. This indicated the order of relative abundance as Fe> Pb> Cr> Ni> Cd for all the sites. Correlation analysis between metals indicated significant positive correlation at ($P<0.05$) for Pb and Cd and at ($P < 0.01$) for Cd and Cr, Pb and Cr, Fe and Cr and Fe and Ni. Metal pollution in street dust are of anthropogenic origin mainly vehicular, generator and other gasoline powered equipment emissions.

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CHAPTER ONE

INTRODUCTION

1.1 Background of the study

In the earlier days, the impact of man's activity on the earth's environment was rather little and nature could resist and compensate for it. At the end of the 19th century, environmental problems arose due to the growing cities and industrialization.

Pollution of air and water channels in the bigger cities became severe. In the 20th century, the increase in intensity of agricultural and cattle rearing, changes and growth in industrial processing and in the nature of compounds used from natural and synthetic compounds made environmental problems even greater. Nature could no longer resist and compensate for them.

Pollution is the undesirable changes in the physical, chemical or biological characteristics of air, water or land that can harmfully affect the health, survival or activities of human or other living organism (Albert, 1992). It is the existence of substances in the environment that prevents the functioning of natural processes producing undesirable environmental and health effects due to their chemical composition or quality.

The substances that cause pollution are referred to as pollutants, therefore pollutants can be defined as substance not normally present or that are present in large concentration than normal with harmful effects especially on living organism. In other words, pollution is the undesirable modification of air, water or food by substance that are toxic or with diverse effects on health, offensive though not necessarily harmful to health with the risk of damaging human health, the well being, the artificial and the natural environment (Ross, 1972; John, 1983; Albert, 1992). It is an act of discharging accidentally or deliberately that in any way damages or threatens the environment (Howard, 1985)

1.2 Air Pollution

Air pollution is a contamination of air by the discharge of harmful substance (Thursten *et al*., 2006). A broader definition of air pollution is the presence in the atmosphere of contaminants such as dust, fumes, gas, mist, odour, smoke or vapour in quantities and of such characteristics and duration such as to be injurious to human, plant or animal life or to properly or to interfere unreasonably with the comfortable enjoyment of life and property (Bishop, 2003). Some of these particles are directly emitted into the air from a variety of sources such as cars, trucks, factories, construction sites, tilled fields and burning of woods.

Pollutants in the atmosphere may be of natural origin such as smoke, fumes, ash and gases from volcanoes, forest fires, sand and dust from windstorms in arid regions, fog in humid low-lying areas and natural terpene haze from pine trees in mountainous region long before human induced or anthropogenic problems came on the scene (Howard, 1985). Pollutant sources are varied and may be categorized into mobile (transportations), stationary combustion, industrial process and solid waste disposal (US-EPA, 1975). Regulated air pollutants are of two groups, the criteria and the hazardous air pollutants. Criteria pollutants include particulate matter, Nitrogen oxides, sulphur oxides, carbon monoxide, ozone and lead while hazardous air pollutants includes asbestos, beryllium, mercury, vinyl chloride, arsenic, radio nuclides, benzene and coke oven emission. (Hermann,1991). Depending on their origin, pollutants are considered either primary or secondary contaminants. Primary pollutants such as hydrogen sulphide, hydrocarbon (HC) are emitted directly to the atmosphere in the form in which they were emitted. Secondary pollutants such as ozone and peroxyacetylnitrate (PAN) are those in the atmosphere by photochemical hydrolysis or oxidation reaction. (Lee, 1978; Howard,1985).

1.3 Ambient Air Quality

Ambient air is the outside air that is free to move, it is the open air around us. Ambient air pollution is also referred to as tropospheric or ground level air pollution (Hill, 2004). Air pollution was a major nuisance for many and a serious concern for some in the industrializing cities of the 19th century, but concerted efforts to address ambient pollution only began in the 20th century (Hassan *et al*.; 2003). There is considerable variation in exposure to air pollution between and within urban centres, depending on geographical factors as well as the type of activities undertaken in and around the urban centres (Hassan *et al*., 2003). Ambient air pollution is usually worse in urban centres; however, overall exposure to air pollution (indoor and ambient) is higher in rural areas because most biofuel users are rural (Colls, 2002). Air pollutants are blown across state and national boarders sometimes in significant amounts (Colls, 2002). Ambient air pollution has reached excessively high levels in many large cities in Asia, Africa and Latin America (Hassan *et al*.; 2003). However, as a result of higher emission standard and closer monitoring levels, certain types of air pollutants have declined in many developed countries. On the other hand, the ambient air pollution levels are a growing problem in urban cities in many developing countries. Several factors contribute to the worsening air pollution level in developing country cities including rapid growth in urban population, increasing industrialization and rising demand for energy and motor vehicles. Other factors such as poor environmental regulation, less efficient technology of production, congested roads, age and poor maintenance of vehicles; also add to the problem. (Starkman, 1975).

1.4 Effects of Air Pollution on Animals

Air pollution is a major environmental health problem affecting both developed and developing countries (WHO, 2003). That air pollution causes ill health and death is well documented (Starkman,1975). Recent estimates of the global burden of disease suggests that approximately 5% of trachea, bronchus and lung cancer, 2% of cardio-respiratory mortality and about 1% respiratory infections are attributed to outdoor air pollution (WHO, 2002; Ezzati *et al*.; 2002). Air pollution from outdoor sources, such as motor vehicles, industry and neighborhood level, solid waste burning is associated with increased morbidity and mortality from respiratory infection in children and adults (Hauser and Shy, 1972).

Air pollution is estimated to cause approximately two (2) million premature deaths worldwide per year. More than half of this burden is borne by people in developing countries (Cohen, 2007). Air pollution has both acute and chronic effects on human health. Health effects range anywhere from minor irritation of eyes and the upper respiratory system to chronic respiratory and heart disease. It has been shown to cause acute respiratory infections in children and chronic bronchitis in adults. It has also been shown to worsen the condition of people with pre-existing heart or lung disease (WHO, 2003). Individual reaction to air pollution depends on the type of pollutants a person is exposed to, the degree of exposure and the individual's health status (Wikipedia, 2007). A person who exercises in outdoors on hot, smoggy days increases their exposure to pollutants in the air (Wikipedia, 2007). The WHO estimated that 500,000 people die prematurely each year because of exposure to ambient concentrations of airborne particulate matters (Colls, 2002).

1.5 Other Effects of Air Pollution

Plants and animals are harmed by air pollution. Acid rain kills trees and can harm animals, fish and other wild life. (Gardiner, 2006). Some gases that can harm aquatic fresh water life are gasses such as chlorine, ammonia and methane (Thurston, 2006). Ammonia even at dilute concentration is highly toxic to aquatic animals and for this reason is classified as dangerous for the environment (Wikipedia, 2007). Damage to vegetation by air pollution is of many kinds. Sulphur dioxide may damage field crops such as alfalfa and trees such as pines especially during the growing season. Both hydrogen fluoride and Nitrogen dioxide in high concentration have been shown to be harmful to citrus trees and ornamental plants (Thurston, 2006). Oxides of Nitrogen can injure vegetation at certain concentrations. Effects include bleaching or killing plant tissue, causing leaves to fall and reducing growth rate. (Nyasula and Mottola,1987).

1.6 Indoor Air Pollution

Indoor air pollution is the presence of chemical or biological contaminants in the air of confined environments, which are not naturally present in high quantities in the external air of the ecological system (Labowitz *et al*., 1984). Many people spend large portion of time indoor as much as 80 – 90% of their lives. We work, study, eat, drink and sleep in enclosed environment where air circulation may be resisted. Therefore, more people suffer from the effect of indoor than outdoor pollution. Pollution exposure at home and work is greater than the outdoors. It has been estimated that indoor air pollutant levels are 25 – 62% greater than outside levels and can pose serious health problems. (Benson *et al*.,1972).

1.7 Sources of Indoor Air Pollution

There are many sources of indoor pollution which include tobacco smoke, vapour from building materials, paints, floors and furniture. Others include maintenance and clearing products (detergents, pesticides), Heating, Air conditioning devices and Cooking apparatus (coal, gas, etc). Also, smoke from nearby houses, burning of household wastes, forest use or kerosene lamps (Smith and Liu, 1993; Ayodele *et al*.; 2007a & b).

1.8 Effects of Indoor Air Pollution

Indoor air pollution from kitchen or household fires is a silent killer in poor countries causing more death (Geneva, 2004). Impoverished families had little choice but to favour fires fueled by cheap and readily available fuels like wood, coal or animal dung. Yet inhaling the smoke produced by those fires is equivalent to consuming two packets of cigarettes a day (WHO, 2004). Women, who spend hours in the home tending the fires, pay the highest price along with young children who suffer from chronic bronchitis or pneumonia (Albalak, 1997). WHO has estimated that about two thousand, five hundred people in the world are exposed to excess level of indoor pollution due to burning biomass and coal indoors in ovens that are poorly designed and lacking proper chimneys? Some millions of additional deaths each year are blamed on rural indoor pollution through suspended particulate matter and another four hundred and fifty thousand deaths are attributed to urban indoor air pollution. These figures are over and above the five hundred thousand excess death world wide due to concentrations of suspended particulate matter and sulphur dioxide (WHO, 1972). There are many health problems potentially linked to indoor air pollution; for instance, studies in China reported that coal smoke was a strong risk

factor for lung cancer among non-smoking women while another study in Japan has related lung cancer to the past use of biofuel in cooking (Deckoning *et al*., 1985).

In the Gambia children under the age of five carried on their mother's back during cooking, has a six times higher risk of acute respiratory infections – a substantially higher risks factor than their parent smoked. The source of health problems associated with indoor air pollution include acute and chronic respiratory infections, tuberculosis, pneumonia, asthma, eye diseases (cataract), lower birth rate, high infant mortality rate, malignancies of the digestive tract and lungs, dermal and mucosa irritation (Dawson, 1983). However, these can be attributed to short and long term effects. The extent to which the harm is affected depends on total exposure and concentration of the air pollution (World Resources Institute WRI, 1998). Apart from the enormous detrimental health effects, environmental impacts cannot be over looked. Demands for traditional fuel also place significant pressures on local forests and woodlands, contributing to deforestation, soil erosion and desertification. Frequently, the need for wood is so great that afforestation attempts of badly degraded regions proves impossible because even young trees are rapidly harvested for cooking fuel or charcoal production. The severely affected regions, the poorest fuel sources, animal manures, grasses, crops residues, roots and shrubs are also harvested. This increasingly common practice in parts of Africa and South Asia lead to a spiraling loss of soil fertility as natural fertilizers is not returned to the ground. (Donna,1999).

1.9 Street Dust

Dust kicked up by vehicles traveling on roads may make up 33% of air pollution. Street dust consists of deposition of vehicle exhausts and industrial exhausts, tire and brake wears, dust from paved roads or potholes, and dust from construction sites. Street dust represents a

significant source contributing to the generation and release of particulate matter into the atmosphere. Control of street dust is a significant challenge in urban areas, and also in other spheres with high levels of vehicular traffic upon unsealed roads such as mines and garbage dumps. The component and quantity of street dusts is an environmental pollution indicator in big cities as a source of outdoor air pollutant. (Yeung *et al*.,2003; Sezgin *et al*., 2004). The urban environment is composed of varying concentrations of trace elements from a vast array of anthropogenic sources (Hodel and Chang, 2004) as well as from natural geochemical processes (Shakourn and El-Talib, 1995). Street dust particles can be grouped into: Elements geochemically associated in nature as related to resuspension of soil particles as their main source are building construction, renovation and weathering of building materials, Elements of anthropogenic origin, that is, traffic, petrol and diesel operated generating machines, coal combustion or domestic heating and Elements related to industrial activity in an area. (Loredo *et al*., 2003).

Street dust, particles deposited on road, originates from the interaction of solid, liquid and gaseous materials produced from different sources (Banerjee, 2003).

1.10 Heavy Metals

Heavy metals are natural constituents in nature, usually occurring in low concentration under normal conditions. Anthropogenic activities can cause elevated levels of these metals in various parts of the ecosystem. Environmental pollution by heavy metals may occur via various diffuse and point sources. Heavy metal scattering by traffic is an example of diffuse spread, while the emission of heavy metals by industrial establishments like metal smelters and iron works represents point sources. Traffic activities on roads can contribute to elevated levels of heavy

metals in these environments through fossil fuel combustion, wear and tear of many parts of the automobile, in addition to natural sources, as they might exist in the rocks of the surrounding areas.

Heavy metals have been widely used in other research projects and therefore comparative data are readily available. Many studies have examined the contribution of individual components of the urban hydrological cycle to the transport and storage of heavy metals (Lees, 1994; Xanthopolous and Hahn, 1993; Morrison *et al.*, 1988; Gibson and Farmer, 1984; Hamilton *et al.*, 1984). Heavy metals may come from many different sources in urbanized areas, including vehicle emissions, industrial discharges and other activities (Harrison *et al*., 1981). Atmospheric pollution is one of the major sources of heavy metal contamination. Heavy metals can accumulate in topsoil from atmospheric deposition by sedimentation, impaction and interception. Top-soils and roadside dusts in urban area are indicators of heavy metal contamination from atmospheric deposition. It has been noted that roadside soils near heavy traffic are polluted by Pb and other metals (Wong and Mak, 1997).

Heavy metal pollutant in urban street dust has become a growing concern in recent years. In Nigeria, Street dust is one major way through which heavy metals may find their way into soils and subsequently living tissues of plants and human beings. In monitoring urban pollution, there is need to consider the materials that cause the occurrence of pollutants. Chemical and biological indicators are of interest when they provide information on the concentration and accumulation in the ecosystem.

A range of metals and chemical compounds found in the street dust environment are harmful. Pollutants can attack specific sites or organs of the body and disease can develop as a consequence to such exposure (Archer and Barratt, 1976; Ayodele and Gaya, 1998). Although

there have been considerable number of studies on the concentration of heavy metals in street dust, the vast majority have been carried out in developed countries with long histories of industrialization (Jaradat and Momani, 1999). Very few studies have been carried out in developing countries like Nigeria. Little interest has been focused on the contamination of street dust by other heavy metals in Nigeria. Such data on pollutant metal concentration of street dust in such areas are extremely scarce.

Humans and other living organisms are exposed to a variety of heavy metals that are released into the environment. The uptake of these metals occurs through three main routes: dermal absorption, inhalation and ingestion of contaminated dusts and soils, It has been noted that children of age 1-8 are of specific concern for this pathway via their hands or mouths (Watt *et al*., 1993).

Most trace elements especially the heavy metals remain in the soil nearly indefinitely. These metals remain bound to organic matter unless they are remobilized mechanically as wind blown dust (Turer *et al.*, 2001). Human exposure to metals and their compounds in the environment is through food, drinks and water. Other forms of uptake are via skin contact. (Ewers and Schlipkőter, 1991a). However, over a period of time, adverse toxic effects may occur as a result of long-term low-level exposure (Ewers and Schlipkőter, 1991). Motivations for controlling heavy metal concentrations in gas streams are diverse. Some of them are dangerous to health or to the environment (e.g. Hg, Cd, As, Pb, Cr), some may cause corrosion (e.g. Zn, Pb), some are harmful in other ways (e.g. Arsenic may pollute catalysts). Within the European community the 13 elements of highest concern are As, Cd, Co, Cr, Cu, Hg, Mn, Ni, Pb, Sn, and Tl, the emissions of which are regulated in waste incinerators. Some of these elements are actually necessary for humans in minute amounts (Co, Cu, Cr, Mn, Ni) while others are carcinogenic or toxic,

affecting, among others, the central nervous system (Mn, Hg, Pb, As), the kidneys or liver (Hg, Pb, Cd, Cu) or skin, bones, or teeth (Ni, Cd, Cu, Cr) (Banerjee A. 2003; Charlesworth *et al*.,2003 and Lu X *et al*., 2010). Heavy metal pollution can arise from many sources but most commonly arises from the purification of metals, e.g., the smelting of copper and the preparation of nuclear fuels. Electroplating is the primary source of chromium and cadmium through precipitation of their compounds or by ion exchange into soils and muds, can be localize and lay dormant. Unlike organic pollutants, heavy metals do not decay and thus pose a different kind of challenge for remediation.

As an indicator of environmental pollution, the following metals were chosen for analysis: cadmium (Cd), nickel (Ni), iron (Fe), chromium (Cr), and lead (Pb). Wood (1974) indicated that these metals have known pollutant properties, are toxic and readily available to the environment. The purpose of this paper is to assess the environmental impact of traffic by investigating the distribution of heavy metal concentrations in street dust of major roads in the sabon-gari market, zaria.

1.11 Toxic effects of heavy metals

Many heavy metals act as biological poisons even at parts of per billion (ppb) levels. The toxic elements accumulated in organic matter in soils are taken up by growing plants (Alloway and Ayres 1997). The metals are not toxic as the condensed free elements but are dangerous in the forms of cations and when bonded to short chains of carbon atoms (Lees, 1994). Many metals with important commercial uses are toxic and hence undesirable for indiscriminate release into the environment (Bouce et al., 1990).

The uncontrolled input of heavy metals in soils is undesirable because once accumulated into the soil, the metals are generally very difficult to remove (Walt *et al*., 1993). Subsequent problems may be toxicity to the plant growing on the contaminated soils and uptake by the plants resulting in high metal levels in plant tissues.

Generally, at the biochemical levels, the toxic effect caused by excess concentrations of heavy metals include competition for sites with essential metabolites, replacement of essential ions, reactions with SH groups, damage to cell membranes and reactions with the phosphate groups (Alloway and Ayres, 1997).

1.12 Justification

This research is timely because:

- of the rising incidence of poor air quality which is a major nuisance for many and a serious concern for some in the industrializing cities and confined environments which concerted efforts to addressing it only began in the 20th Century (Hassan *et. al*., 2003).

- Air pollution is a major environmental health problem affecting both developed and developing countries; that air pollution causes ill health and death is well documented (WHO, 2003).

- While air quality remains a principal environmental concern affecting the health and quality of life of the residents and people in urban areas across the world, little or no

studies have been conducted on air quality in Zaria, thus the need to embark on such studies.

1.13 Aim and Objectives

The aim of this research is to determine the presence and concentrations of some gaseous pollutants in ambient air and some trace metals in street dust at the Sabon-Gari Market Zaria and Aliyu Mustapha Social Centre, Ahmadu Bello University, Zaria, thus, serving as the base data for gaseous pollution level in these locations in Zaria. This aim would be achieved through the following objectives:

- To ascertain the presence and concentration of some gaseous pollutants such as CO, H_2S and SO_2 at the Sabon-Gari Market Zaria and Aliyu Mustapha Social Centre, Ahmadu Bello University Zaria.
- To determine how the concentration of these gases varies daily from morning through afternoon to evening.
- To determine the levels of heavy metals such as Cr, Cd, Ni, Pb and Fe in street dust from Sabon-gari market in Zaria.

CHAPTER TWO

LITERATURE REVIEW

2.1 Carbon Monoxide (CO)

Ever since man learned how to break stone by heat or to burn wood with resisted flow of air to produce charcoal, he has been affected by carbon monoxide (Wellbum, 1988). Whilst smoking is the major source of carbon monoxide for humans, most of the hazards at work connected with gas come from motor vehicles. During their repairs, testing, raising or servicing (Cuddenback *et al*., 1976, Wellbum, 1988). Blasting, fire-fighting, methanol production, wood distillation and cooking over charcoal have similar hazards (Goldsmith 1968, Wright *et al*., 1975, Deckoning *et al*., 19852, Albalak *et al*., 1999).

Carbon monoxide unlike many toxic gases is a colourless, odourless and life threatening gas, can be breathed without giving any warning to the victim. It is a poisonous gas produce by the partial combustion of wood, coal, tobacco, car emission, gas water heater, leaking chimney and furnaces, generators and other gasoline powered equipment (Deckoning *et al*., 1985). Carbon monoxide is the next most abundant atmospheric pollutants in the troposphere. Emission of carbon monoxide caused by man far exceeds those of other pollutants (Thompson *et al*., 1973). Sources of air pollutants are diverse and are often impossible to discriminate between them. Domestic sources often surround industrial sources and power or heat generation by particular activities without making distinction between industrial and domestic apportionment.

In areas away from major sources, the atmospheric level of carbon monoxide is fairly constant which meant that significant natural sinks exist to remove this vast excess of gas. The natural sinks and their relative importance are the oxidation to carbon dioxide in the troposphere by hydroxyl radicals. Oxidation in the stratosphere or absorption by soil microbes, the ocean, or

plant and animals. (Wellbum 1988, Abbey *et al*., 1993).Wood, stubble, dunk and grass are use daily in about half of the world's household as energy for cooking. In most part of the third world, they are burnt in open fire or inefficient stoves in poorly ventilated kitchen. (Hayes,1989; Engel *et al*., 1998, Bouce *et al*., 2002a). The result is toll in death and ill health far greater than the outdoor air pollution. The first of severe poisoning is loss of consciousness and further inhalation of high concentrations readily lead to death (Raub *et al*., 2000). During normal combustion each atom of carbon in the burning fuel joins with two atoms of oxygen forming a harmless gas called carbon dioxide. When there is lack of oxygen to ensure complete combustion of the fuel, each atom of carbon links up with only one atom of oxygen forming carbon monoxide gas.

Carbon monoxide inhibits the blood capacity to carry oxygen in our lungs. Carbon monoxide quickly passes into our blood stream and attaches itself to haemoglobin (oxygen carrying pigment in red blood cell). Haemoglobin readily accepts carbon monoxide even over the life giving oxygen atom (as 210 times as readily as oxygen), forming a toxic compound known as carboxyhaemoglobin (COHb); consequently, disrupting oxygen transport to the tissues (Raub, 2000). Depending on the amount inhaled, CO impedes coordination, worsen cardiovascular conditions and produce fatigue, (Cuddenback *et al*., 1976, Hayes 1989, Lippmann 1989, Bruce., *et al* 2002a & b). The elderly, the fetus and persons with cardiovascular and pulmonary diseases are particularly sensitive to elevated CO level (Raub *et al*., 1989). Methylene chloride found in some common household products such as paint strippers can be metabolized to form carbon monoxide which combines with the haemoglobin to form carbonyl haemoglobin. Carbonyl haemoglobin levels of the order 60% COHb saturation are normally fatal. Lower concentration of 40% saturation can also be lethal for young or elderly people. (Behera *et al*., 1988). The health

effects associated with exposure to carbon monoxide at low concentration include fatigue and chest pain in people with heart diseases (WHO, 2004). At higher concentration impaired vision and coordination, heart aches, permanent damage to central nervous System, dizziness, confusion, nausea and death may occur (Goldsmith, 1968). At moderate concentration, impaired vision and reduced brain function in pregnancy result in low birth weight and prenatal death (US-EPA 1997; Raub *et al*., 2000; WHO, 2004). The health effect of exposure is depended upon the carbon monoxide content of the blood, the air breathed, the duration of exposure of temperature, the working rate or the general fitness (Ellegard, 1997).

2.2 Hydrogen Sulphide (H_2S)

Hydrogen Sulphide is a colourless, toxic and flammable gas. Small amount of Hydrogen Sulphide occur in crude petroleum but natural gas can contain up to 28%. Volcanoes and hot spring emit some H_2S about 10% of the total emissions of H_2S are due to human activities (Wikipedia, 2007). By far the largest industrial route to H_2S occurs in petroleum refineries. Other anthropogenic sources of Hydrogen Sulphide include coke, ovens, paper mills (using the sulphate method) and tanneries. H_2S arises from virtually anywhere elemental sulfur come into contact with organic material especially at high temperature, H_2S can be present naturally in well water, in such cases, ozone is often used for its removal (Wikipedia, 2007). Appreciable quantity of Hydrogen Sulphide and other reduced sulfur compounds are formed during treatment of sewage by the anaerobic bacteria decomposition of organic matter in the presence of the sulphate (SO_4^{2-}) ion (Environmental Agency, 2001).

Hydrogen Sulphide has offensive that is detectable at low concentration below 8ug/m^3 at a concentration of 50 – 150ug/m^3. It has a deceptively sweet smell, above this range, it deadens

the sense of smell (Patwardhan, 1988). Its concentration varies from 0.1 – 1.0ug/m^3 in ambient air, although concentration above 100ug/m^3 has been reported in industrial plants (Sienko and Plane, 1974). Hydrogen Sulphide is considered a broad spectrum poison - meaning that it can poison several different systems in the body, although the nervous system is most affected. It forms a complex bond with iron in the blood, thereby blocking oxygen from binding and stopping cellular respiration. However, since Hydrogen Sulphide occurs naturally in the environment and the gut, enzymes exist in the body capable of detoxifying it by oxidation to harmless sulphate (Wikipedia, 2007). Chronic exposure to low level H_2S (about 2ppm) has been implicated in increased miscarriage and reproductive health tissues amongst Russian and Finish wood pulp workers (Myers, 1986).

Different methods have been employed for the determination of hydrogen sulphide gas in the environment. A sensitive spectrophotometric method has been use for the determination of H_2S in environmental sample after its fixation as zinc sulphide. The suitability of the method for monitoring H_2S in atmosphere air in the vicinity of possible sources such as a sewage treatment plant and in waste water has been evaluated (Selvapathy *et al*., 1988). Colourimetric, stain length, personal dosimeters, operating by gas diffusion has been developed by (Meconnaughey *et al*., 1985). To determine worker exposure for up to an 8 hour period for several inorganic air borne contaminants in the range of their threshold limit values. H_2S in air was measured. Pandurangappa and Balasubraalial (1996), employed extractive spectrophotometric method for the determination of trace amount of H_2S after fixing the gas triethanolamine (TEA)-zinc acetate sodium hydroxide solution. This method has been employed for the determination of hydrogen sulphide in air (Wood, 1988).

2.3 Sulphur Dioxide (SO_2)

Sulphur dioxide has long been recognized as an important parameter in the determination and control of ambient air quality (McDermott *et al*., 1979). SO_2 gas is the main product from the combustion of sulphur compounds and is of significant environmental concern (Wikipedia, 2007). SO_2 is produced in volcanoes and in various industrial processes. Since coal and petroleum contain various amounts of sulphur compounds, their combustion generates sulphur dioxide. Further oxidation of SO_2 usually in the presence of a catalyst, Such as NO_2 forms H_2SO_4 and thus acid rain (Wikipedia, 2007). Sulphur dioxide is a colourless, non-flammable gas with a strong suffocating odour (Goldberg, 1954). It has a taste threshold of 784ug/m^3 (0.3ppm) and an odour threshold of 1306ug/m^3 (0.5ppm). Its high solubility in water causes it to be irritating to the eyes and upper respiratory tract. It may oxidize to sulphur trioxide (SO_3) which then dissolves in water to produce sulphuric acid (Goldberg, 1954).

The United States has witnessed a 33% decrease in emission between 1983 and 2002. This improvement resulted from glue gas desulphurization, a technology that enables SO_2 to be chemically bound in power plants burning sulphur containing coal or oil. New fuel additive catalyst such as ferox, are being used in gasoline and diesel engines in order to lower the emission of sulphur dioxide gas into the atmosphere (Wikipedia, 2007). Epidemiology studies indicate that chronic exposure to SO_2 is associated with increased respiratory symptoms and decrease in pulmonary function. Clinical studies have shown that some asthmatics respond with bronchus constriction to brief exposure of SO_2 levels as low as 0.4ppt (part per trillion). Its concentration in air may range from 0.01 to several parts per million, and it is responsible for the decay of building and monuments, acid rains and human discomfort and disability (Frank 1964; Ross, 1972; Wolff *et al*., 1975; John, 1983; Albert, 1992).

Different methods have been employed to determine the concentration of sulphur oxides in the atmosphere (McDermott *et al*., 1979) collected and determined sulphur dioxide by permeation of the gas through a membrane into a catalytic oxidizing solution, which stabilizes the sulphur dioxide as sulphate, which is then analysed turbidmetrically by precipitation. Liu et al (1997) employed gas permeation continuous flow coulometric analysis for determining high of sulphur dioxide. Neves *et al*, (1994) determined sulphur dioxide in air on the basis of the catalysed autoxidation of CO (II) in azide medium. The method provides result comparable with those obtained with a coulometric monitor based on the I_2/I-System. Ayodele and Mohammed (2001) reported the ambient concentration of SO_2 over Kano municipality as in the range 14 – 22ug/m^3 with a co-efficient of variation of 12.74% by bubbling air through dilute H_2O_2 Solution.

2.4 Cadmium

Cadmium is produced as an inevitable by-product of zinc (or occasionally) refining, since these metals may occur naturally within the raw ore, the most significant use of cadmium is in nickel/cadmium batteries, as rechargeable of secondary power source exhibiting high output, long life, low maintenance and high tolerance to physical and electrical stress. Cadmium coatings provide good corrosion resistance, particularly in high stress environment such as marine and aerospace applications where high safety and reliability is required. Other uses of cadmium are as pigments, stabilizers for polyvinyl chloride, in alloys and electronic compounds; cadmium is also present as an impurity in several products and refined petroleum products.

Cadmium derives its toxicological properties from its chemical similarity with zinc, an essential micronutrient for plants, animals and humans. Cadmium is biopersistant and once absorbed by an organism, remains resident for many years, although it is eventually excreted.

Uptake of cadmium by plants is greatest from soils and varies with soil properties especially those that control adsorption and also with the plant species and the source of cadmium. The average daily intake for humans is estimated as 0.15ug from air and 1ug from water. Smoking a packet of cigarette can lead to the inhalation of around 2-4ug of cadmium. Airborne cadmium comes primarily from steel industry and waste incineration, followed by volcanic activity and zinc production. There is no evidence of dermal absorption and oral absorption is very low. The effects of exposure to cadmium include vomiting, increased salivation, abdominal pain, and diarrhea. Acute inhalation is characterized by coughing and tightness in the chest. Chronic exposure produces a variety of effects on kidneys, lungs, heart, bones, and gonads. Cadmium fumes can damage the olfactory organs. Cadmium toxicity is decreased by the presence of other metals (Csuros and Csuros, 2002).

2.5 Chromium

Although low levels of chromium are both ubiquitous and essential. Chromium is necessary for the proper utilization of sugars and other carbohydrates by optimizing the production and effects of insulin. It is widely distributed in the body. Sources include liver, meat, cheese, whole grain, yeast and wine. High concentrations of it are toxic to humans, animals and plants. Very high doses of chromium may be lethal or impair health severely. Acute exposure due to ingestion of chromium compounds may lead to toxic effects in the gastrointestinal tract and may damage kidneys (Internationa Programme on Chemical Safety IPCS). Also, high levels of chromium can cause spinal/joints degeneration, depressed immune system and lymphatic swelling (Roth, 2009). Deficit causes impaired insulin function, hence increased insulin secretion and the risk of adult onset diabetes mellitus (Csuros and Csuros, 2002).

2.6 Iron

Iron is an essential component of several cofactors including hemoglobin and the cytochromes. There is an active complicated homeostatic mechanism for maintaining proper iron levels in the body. In this mechanism the divalent form is absorbed into the gastro intestinal mucosa. The adequacy of iron stores in the body; however, seem to be the major controlling factor in the absorption of iron by gastrointestinal tract. Absorption increase when iron stores are low and decreases when body stores are sufficient (Hall *et al*., 1997).

Acute pulmonary exposures to iron compound are associated with Kidney and liver damage. Altered respiratory rates and convulsion are among the neurological effects. Chronic exposure to or excessive in take of iron may lead to hemosderosis or hemochromatosis (Hall *et al*., 1997). Iron is a potentially toxic heavy metal. In excess, it can cause cancer, heart disease and other illnesses. Just like lead, mercury, cadmium, nickel and other heavy metals, stored iron produces destructive free radicals (RayPeat, 2006).

2.7 Nickel

Human beings may be exposed to nickel by eating contaminated food containing nickel. Foods naturally high in nickel include soay-beans, nuts and oat meals (Okoronkwo *et al*., 2005). Darmouth Toxic Metal Research Programme discovered that larger does of nickel such as accidental ingestion have been shown to have more adverse effects ranging from stomach aches to heart failure. It was also found out by programme that nickel is carcinogenic to human beings. Nickel can build up in the lungs over time and cause complication such as pulmonary fibrosis, a build up of scar tissue in the lungs as well as bronchitis and lung cancer. Also, according to International Programme on Chemical Safety (IPCS) high level of nickel compounds cause

intestinal disorders, convulsions and asphyxia. Repeated exposure can cause sleeplessness, headache, dizziness, weakness, poor memory, tightness in chest, loss of hair, loss of libido.

2.8 Lead

Lead is very toxic and has very chronic health implication even at low concentration (Meittinien, 1975; and Bryan, 1976). United States Environmental Protection Agency (USEPA) classified lead as being potentially hazardous and toxic to most form of life (USEPA, 1986). It has been found to be responsible for quite a number of ailments in human such as chronic neurological problems (Awofolu, 2005, Hart *et al*., 2005, and Okoronkwo *et al*., 2005) and mental retardation in children (Huges *et al*., 1980), colic anemia and renal diseases (Fischbein, 1992). Lead replaces Ca in the bone (Bryce-Smith, 1971). Its effect is cumulative and long term exposure has been quoted to cause serious health hazard (Essien, 1992) which include inhibition of the synthesis of haemoglobin and also adversely affect the central and peripheral nervous system as well as the kidney (Bhata, 2002).

Lead has been found to be bio-accumulated by benthic bacteria, plants and other aquatic biota (DWAF; 1996). The ubiquity of this metal in the environment could be traced to wide increase in industrial activities and continual use of leaded petrol in many developing nations. Leaded petrol is still in used in Nigeria. It has been pointed out that African's contribution to global lead pollution has increased from just 5% in 1980s to 20% in 1996 (Alloway and Ayres, 1997). Other inputs of lead into the environment include wastes form used lead batteries, atmospheric deposition from automotive and industrial emission. Gibson and Farmer (1984) have compiled a list of 120 occupations (e.g. Auto-mechanic, painting, printing and welding) that may involve exposure to lead. Automobile exhausts are believed to account for more than

80% of the air pollution in some urban centres in Nigeria. The level of lead in Nigeria's super grade gasoline is 600 – 800mg per litre (Morrision *et al*.; 1988) which is much higher than permissible levels in some pollution conscious countries. Lead levels in soils vary depending on the location and nearness to lead based activities and vehicular density.

CHAPTER THREE

MATERIALS AND METHODS

3.1 The Study Area

Zaria lies at latitude 10°28'N and longitude 7°25'E (Africa Atlas, 2002). It is located in the centre area of what used to be called the North Region of Nigeria. The mean annual rainfall in the area ranges from 924.3-1543.6mm. Annual temperature varies between 29°C-38.6°C (Africa Atlas 2002). Today Zaria is a local government in Kaduna State.

The selected areas for this investigation were areas with high traffic and business activities. These areas were busy within the hours of 6.30 – 8.30am when offices and commercial activities commences and 4.00 – 7.30pm in the evening at the close of work and market activities.

Two locations were considered for this analysis. Location one (1) is the Sabon-Gari Market Zaria. Here, four (4) sampling sites were randomly selected and labeled (A-D) with an average distance of 50metres from one another. Site A known as kasuwa mata is characterized by mini-park for trucks, petroleum dispensing station, groundnut oil sales points, and runoff from gutter.

Site B otherwise known as Samaru bus-stop, houses a mini-park for vehicles and motorcycles, with shops surrounding the site and presence of refuse dump site.

Site C has boutiques and shops with regular use of generator and other gasoline-powered equipment. The sale of food stuff is also noticed around the site as well as gutter presence.

Site D has around it a T-junction and a mini-park for motorcycles and tricycles.

The location two (2) of this study is the Aliyu Mustapha Social Center A.B.U Zaria. Three sampling sites were also randomly selected and labeled (A-C). Site A has around it a mini-park for motorcycles, gutter, drainage channels from kitchens and also a very close vicinity to the road.

Site B is an enclosure which houses mainly an outlet for air-conditioning system, the presence of football viewing centers, pop-corn making machine, cyber cafe and sales of sport materials.

Site C is an enclosure that houses a theatre, business centers, boutique and stationary shops.

Sabon-Gari Market and Aliyu Mustapha Social Centre Ahmadu Bello University all in Zaria metropolis are characterized by high population density, high energy demand and erratic power supply. These, make Sabon-Gari Market and Aliyu Mustapha Social Centre a suitable location for this study.

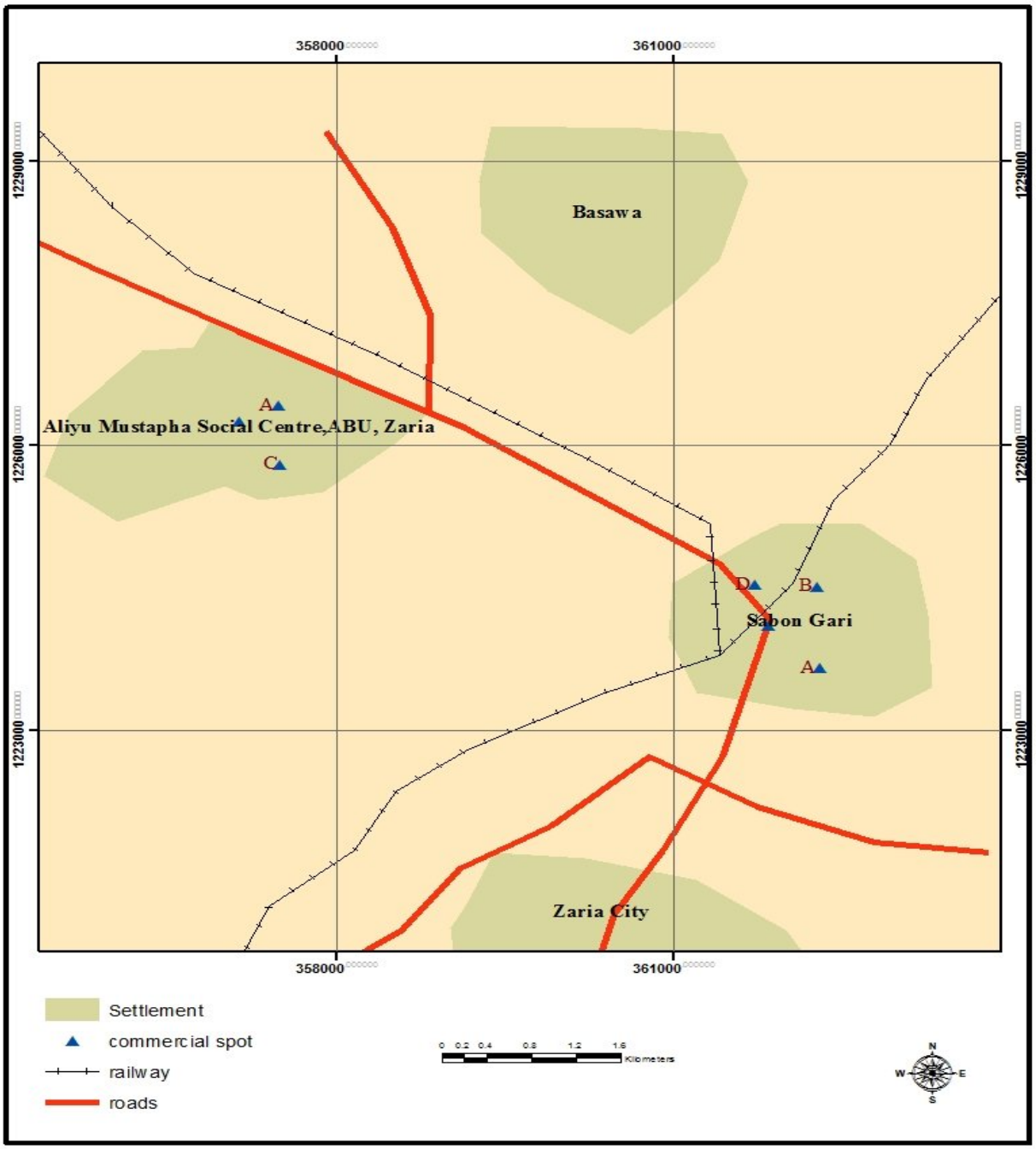


Fig: 3.1 MAP OF ZARIA SHOWING THE SAMPLING LOCATIONS AND SITES

3.2 Reagents

All reagents used were of analaR grade and distilled, deionised water were used for all preparation.

3.3 Preparation of Solutions

3.3.1 Stock solutions

1000ppm Cadmium Solution: prepared by dissolving 2.7435g of $Cd(NO_3).4H_2O$ in a $100cm^3$ beaker in a minimum amount of distilled deionised water. The dissolved solution was then quantitatively transferred into a $1000cm^3$ standard flask and diluted to mark with distilled deionised water.

1000ppm Chromium Solution: prepared by dissolving 5.6577g $K_2Cr_2O_7$ in a $100cm^3$ beaker in a minimum amount of distilled deionised water. The dissolved solution was then transferred into a $1000cm^3$ standard flask and diluted to mark with distilled deionised water.

1000ppm Iron Solution: prepared by dissolving 4.9643g $Fe(SO_4)_2.7H_2O$ in a $100cm^3$ beaker in a minimum amount of $1:1HNO_3$. The dissolved solution was then transferred into a $1000cm^3$ standard flask and diluted to mark with distilled deionised water.

1000ppm Nickel Solution: prepared by dissolving 4.9523g $Ni(NO_3)_2.6H_2O$ in a $100cm^3$ beaker in a minimum amount of distilled deionised water. The dissolved solution was then transferred into a $1000cm^3$ standard flask and diluted to mark with distilled deionised water.

1000ppm Lead Solution: prepared by dissolving 1.5985g $Pb(NO_3)_2$ in a $100cm^3$ beaker in a minimum amount of distilled deionised water. The dissolved solution was then transferred into a $1000cm^3$ standard flask and diluted to mark with distilled deionised water.

3.3.2 Standard Working Solutions

Following a range finding test, working standard concentrations were prepared from 1000ppm of each metal stock solutions by serial dilution as follows: 0.2, 0.4, 0.6, 0.8 and 1.0ppm Cd; 0.5, 1.0, 1.5, 2.0, and 2.5ppm Cr; 1.0, 2.0, 3.0, 4.0 and 5.0ppm Fe; 0.2, 0.4, 0.6, 0.8 and 1.0ppm Ni and 0.5, 1.0, 1.5, 2.0 and 2.5ppm Pb.

3.4 Sample Collection

3.4.1 Gas Samples

The concentrations of carbon monoxide, hydrogen sulphide and sulphur dioxide were determined from four different sites around the Sabon Gari Market in Zaria (Location 1) as shown in Fig 1. A total of two hundred and eighty-eight (288) readings were taken for each of the three gases using the automatic gas sampler (EEx) between May and August 2010.

The concentrations of carbon monoxide, hydrogen sulphide and sulphur dioxide were also determined from three different sites at Aliyu Mustapha Social Centre, Ahmadu Bello University, Zaria (Location 2) as shown in Fig 1. A total of two hundred and sixteen two (216) readings were taken for each of the gases within the sampling period.

Samples were collected daily with sampling times between 6:30am and 7:30pm. Appropriate gas sensor models were used for the three different gases.

3.4.2 Street Dust Samples

Street dust samples were collected using brush and plastic scoop to collect the settled dust along the streets. Samples were collected between November-December, 2010.

The samples collected were stored in a clean polyethene bags till the analysis (Al-Khashman, 2004). At each sampling site, composite samples were obtained by mixing subsamples from four points at each site (Marsan *et al*., 2008). The samples were differentiated via labelling using the respective Sites in the location.

3.5 Sample Treatment

3.5.1 Gas sample treatment

With the unit placed in normal air, the switch was turned to the GAS position. The green LED and the sounder (if factory set) was operated once every three seconds. The LCD display showed 000 for "TO" and "FL" versions. If not, remove the black cover below the display was adjusted to ZER' preset until the display was 000 (for "TO" or "FL" versions).

3.5.2 Street Dust Sample Treatment

The Samples were gently ground, dried at 105^0C to a constant mass, then sieved through a 2-mm stainless steel sieve to remove extraneous matter such as pieces of brick, paving stone and other debris. Care was taken to reduce the disturbance of the fine particles, which were readily lost by resuspension (Manta *et al*., 2002).

3.6 Determination of physiochemical parameters of street dust

3.6.1 Determination of pH

10g of the air, dried soil samples were weighted into a 50cm^3 beaker and 20cm^3distilled deionized water added. The mixture was allowed to stand for 30 minutes with occasional stirring

with glass rod. The electrodes of a pre-calibrated HANNA pH meter (model 111991000) were inserted into the partly settled suspension and the pH of the soil taken (Herdershot *et al*., 1993).

3.6.2 Determination of Organic Matter

The method of described by Rowell D. (1994) was employed for the determination of organic matter. In this method, organic carbon is oxidized by $K_2Cr_2O_7$ in the presence of H_2SO_4 leading to the formation of CO_2 according to the operation given below:

$2K_2Cr_2O_7 + 6H_2SO_4 \rightarrow 2K_2SO_4 + 2Cr_2(SO_4)_3 + 3O_2$

$3C + 3O_2 \rightarrow 3CO_2$

1g of the soil sample was weighed in triplicates into $250cm^3$ conical flask. $10cm^3$ of $K_2Cr_2O_7$ ($0.02mol/dm^3$) was transfered into each flask and was swirled gently to disperse the soil followed by addition of $20cm^3$ of H_2SO_4 (r.d 1.84, 98%w/v). The flask was swirled gently until soil and reagents were thoroughly mixed. The mixture was then allowed to stand for 30min on a hot plate. $100cm^3$ of distilled water was added followed by the addition of 4 drops of ferro indicator, after which it was titrated with 0.25 mol dm^{-3} ammonium ferrous sulphate. Blank titration was similarly carried out.

The percentage organic carbon is given by the equation:

$$\% \text{ Organic carbon} = \frac{(\text{Blank Titre} - \text{Actual Titre}) \times 0.3 \times m \times f}{\text{Weight of air – dried soil taken}}$$

Where f = correction factor = 1.33

m = concentration of ferrous sulphate

then, the % organic matter in soil = % organic carbon x 1.729

3.6.3 Particle Size Distribution

The method described by White R. (2006) was used to determine particle size distribution. 50g of 2mm sieved soil was weighed into a 250cm^3 plastic beaker. 100cm^3 of 50% calgon was added and then stirred with a glass rod. 100cm^3 of distilled water was then added and stirred. The beaker was left to stand for about 30 minutes with occasional stirring and then transferred into a 250cm^3 plastic container and shaken on an end to end for ten minutes. The sample was next transferred into a 1000cm^3 measuring cylinder and made to the mark with distilled water. The suspension in the cylinder was mixed vigorously using long handle plunger making sure that the sediment at the bottom was thoroughly disturbed before the hydrometer reading was taken. Readings at 40 sec and 2hr were taken.

A blank cylinder was prepared by making 100cm^3 of the 50% calgon solution up to the 100cm^3 marks with distilled water. The blank hydrometer reading was taken at the respective time interval. The temperature of the suspension and blank was also noted.

The corrected hydrometer reading C(g/I) was obtained by subtracting the blank reading RL(g/I) from the hydrometer readings in the soil suspensions R(g/I) and adding 0.36g/I for every degree above 20^0C

$$C = R + 0.36\,(T - 20^0C)$$

Where T = Room temperature at 20^0C

$$\%\ \text{clay} = \frac{\text{Corrected 2hrs reading} - \text{Blank}}{\text{Weight of the soil taken}} \times 100$$

$$\%\ \text{silt} = \frac{\text{Corrected 40 secs reading} - \text{Blank}}{\text{Weight of soil taken}} \times 100$$

$$\%\ \text{sand} = 100 - (\%\ \text{clay} + \%\ \text{silt})$$

3.6.4 Determination of phosphate (PO_4^{3-}) (Agbenin, 1995)

$15cm^3$ of $1.0moldm^3$ NH_4F and $25cm^3$ of $0.5moldm^{-3}$ KCI was mixed with $460cm^3$ of distilled water and the mixture stored in a glass bottle giving the extraction solution. 0.2197g of KH_2PO_4 was oven dried at 105^0C for 1 hour, dissolved in distilled water and diluted to $100cm^3$ in a volumetric flask giving phosphate stock solution (0.05mg/l). Working standards of 5, 10, 15, 20 and 25µg/l PO_4^3P, were prepared. Absorbances were read with calorimeter at 690nm and a calibration curve of absorbance versus concentration was plotted. $35cm^3$ of extraction solution was added. The bottle was shaken for 1 minute and filtered into dry beaker. Filtration was repeated until filtrate was clear. $10cm^3$ of the filtrate was shaken with $0.4cm^3$ of ammonium molybadate reagent (Denige's reagent) and 2 drops of stannous chloride were added. Absorbance was measured after 11 minutes for all samples at 690nm and concentration read from the curve.

$$\text{Mg } PO_4^{3-} \text{ - pkg}^{-1} = \frac{\text{conc. (from curve) x extractant volume}}{\text{aliquot of sample x sample weight}}$$

3.6.5 Determination of chloride

The Mohr's method in which alkaline or alkaline earth chlorides react with silver nitrate in the presence of a few drops of potassium chromate solution as indicator is a simple, direct and accurate method for chloride determination.

The soil sample is dried at 110^0C for 1 hour and cooled in a dessicator. 2g of the sample was then weighed into $250cm^3$ Erlenmeyer flask and dissolved to about $100cm^3$ of distilled water. Small quantities of $NaHCO_3$ were added until effervescence ceased. About $2cm^3$ of

K_2CrO_4 was introduced and the solution was titrated to the first permanent appearance of red $Ag_2Cr_2O_4$.

The chloride free $CaCO_3$ in $100cm^3$ of distilled water contains $2cm^3$ of K_2CrO_7. The percentage of chloride is this computed using the formular below.

Moles of Cl^- = M_{AgNO3} x V_{AgNO3}

Mass of Cl^- = Moles of Cl^- x Molar mass

$$\% Cl^- = \frac{\text{Mass of } Cl^-}{\text{Mass of sample}} \times 100$$

3.6.6 Determination of mineral Nitrogen (NH_4^+-n; NO_3^--n)

The method used is that descibed by Brady N (1984). 15g of the soil sample was weighed into centrifuge tube, to which $30cm^3$ of 1N KCl was added and agitated for one hour on a shaker. The mixture was centrifuged to obtain a clear solution. $10cm^3$of the KCl extract was transfered into the distillation flask followed with 2g of magnesium oxide. The content was distilled over a 2%boric acid with 2-3 drops of mix indicator. 30-$50cm^3$ of the distillate was collected and labeled A.

Into thesame distillation flask, 1g of devarda's allow was added and distilled for nitrate over another 2%boric acid with 2-3 drops of mix indicator. 30 – $50cm^3$ of the distillate was as well collected and labeled B.

Both flask A and B were titrated with 0.01M H_2SO_4 and the titre value from the flask are for NH_4 and NO_3 respectively.

3.7 Instrumentation

3.7.1 Crowncon-Gasman

The Crowcon-Gasman Detection Instrument was used for this work. The Gasman "FL" and "TO" were used. Gasman "FL" is designed to monitor for the presence of flammable gases. Gasman "TO" is designed to monitor for the presence of specific toxic gases and is certified EEx is HC T3/T4. Temperature classification T3 applies if the unit was fitted with Crowcon rechargeable battery pack while the T4 applies if the unit was fitted with disposable batteries.

3.7.2 Calibration

To adjust the span of "TO" and "FL" gas of a known concentration, a reliable delivery system to the sensor are required. Calibration gas test kits, comprising gas mixtures, either in disposable cylinders, regulator, tube and calibration adaptor. The calibration gas test kits were fitted into the top of the sensor housing and the gas cylinder valve was opened. The gas flow rate was set to the sensor. 0.5l/min and the reading on the display were allowed to stabilize. The CAL preset was adjusted so that the display indicated the concentration shown on the cylinder. Once adjustment was completed, the cylinder valve was closed and the adaptor disconnected. The control valve knob was carefully turned to achieve the required gas flow shown on the gas flow indicator. The control valve was completely closed and carefully screwed on to the can outlet thread. The valve knob was carefully turned to achieve the required gas flow shown on the gas flow indicator.

3.7.3 Operation

With the unit placed in normal air, the switch was turned to the GAS position. The green LED and the sounder (if factory set) was operated once every three seconds. The LCD display showed 000 for “TO” and “FL” versions. It was ensured that the cover was placed after adjustments have been made.

An alarm condition was indicated by means of the flashing red LED and sounder and was automatically reset after the gas concentration has passed out of alarm range. The switch was turned to the TEST position. The audible alarm and red LED operated in intermittent mode and the LCD display showed a valve between 30 and up to 170. The battery was at full capacity if the valve was between 30 and 170. If the valve shown was below 40, the battery pack was recharge or the dry cells replaced.

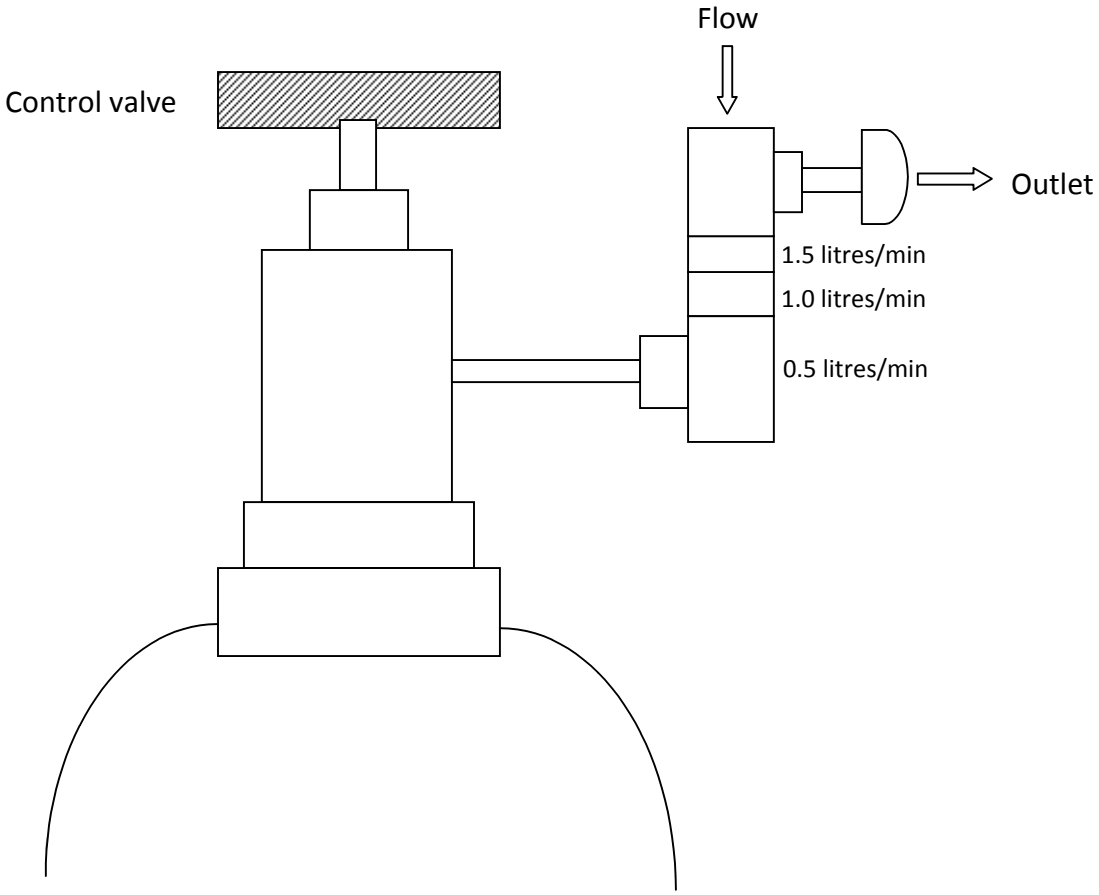


FIGURE: 3. 2:- SCHEMATIC DIAGRAM OF THE AUTOMATIC SAMPLER

3.7.4 Instrumental

A SHIMADZU AA 6800 Atomic Absorption Spectrophotometer was used for the Heavy metals determination.

3.8 Digestion of Sample

2.0 g of the dried sample was accurately weighed into a conical flask and10$cm^3$of nitric acid was added and the mixture heated on a hot plate untill the sample was almost dry and then cooled. The procedure was repeated with another 10cm^3 of concentrated nitric acid followed by the addition of 10cm^3 of 2M Hydrochloric, the digested dust was warmed with 20cm^3 of 2M HCl and filtered into a 50cm^3 volumetric flask through whatman filters. It was then diluted to the mark with double distilled water (Divrikli *et al*., 2003). Metals in the final solutions were determined by Atomic Absorption Spectrophotometer (model AA 6800).

3.9 Calibration curves

A calibration curve of absorbance against concentration for each metal was prepared as shown in Appendices I-V for Cd, Cr, Fe, Ni and Pb respectively, which yielded a good linearity. This obey the Beer Lambert's law (A α C) and implied that, the instrument responded very well to the standard analyte of interest and therefore would respond to analyte in the samples. The calibration curves were used for the determination of metal concentrations in the samples.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 RESULTS

Table 4.1: Air Quality Guidelines for the Priority Pollutants

POLLUTANTS	WHO	FEPA
CO	30.00ppm (1 hour) 9.00ppm (8 hours)	0.1ppm (24 hours)
SO_2	0.50ppm (1 hour) 0.11ppm (24 hours)	0.01ppm (24 hours)
H_2S	7.00ppm (1 hour) 8.00ppm (30 mins)	8.00ppm (24 hours)

Source: WHO(1999) & FEPA(2003)

Table 4.2: Air Quality Index and Rating

AQI	AQI rating	CO(ppm)	SO_2(ppm)	H_2S(ppm)
Very Good(0-15)	A	0-2	0-0.02	0-2
Good(16-31)	B	2.1-4.0	0.02-0.04	2.1-3.0
Moderate(32-49)	C	4.1-6.0	0.04-0.06	3.1-5.0
Poor(50-99)	D	6.1-9.0	0.06-0.08	5.1-7.0
Very poor(100or over)	E	>9.0	>0.10	>7.0

Source: USEPA(2000)

Table 4.3: Summary of AQI Rating for Ambient Air from the Study

A. **Location 1**				
Sites	**Sessions**	**AQI(CO)**	**AQI(H_2S)**	**AQI(SO_2)**
A	**6.30am**	C	C	E
	1.30pm	C	C	E
	6.30pm	E	C	E
B	**6.30am**	E	C	E
	1.30pm	D	C	E
	6.30pm	E	C	E
C	**6.30am**	B	C	E
	1.30pm	A	C	E
	6.30pm	B	C	E
D	**6.30am**	D	C	E
	1.30pm	D	C	E
	6.30pm	E	C	E

B. **Location 2**				
A	**6.30am** **1.30pm** **6.30pm**	A A B	C C C	D E E
B	**6.30am** **1.30pm** **6.30pm**	A A A	C C C	D E E
C	**6.30am** **1.30pm** **6.30pm**	A B B	C C C	D E E

Table 4.4: Air Quality Data for Site A of Location 1

Date	6.30 - 8.00am			1.00 - 2.30pm			6.30 - 8.00pm		
	CO (ppm)	H_2S (ppm)	SO_2 (ppm)	CO (ppm)	H_2S (ppm)	SO_2 (ppm)	CO (ppm)	H_2S (ppm)	SO_2 (ppm)
17-05-'10	5.330 (0.577)	4.330 (0.577)	0.230 (0.058)	7.000 (1.000)	5.670 (0.577)	0.130 (0.577)	11.00 (1.000)	4.000 (0.000)	0.160 (0.058)
18-05-'10	2.330 (0.577)	3.000 (0.000)	0.100 (0.000)	8.000 (1.000)	4.670 (1.528)	0.230 (0.058)	10.33 (0.577)	4.670 (0.577)	0.100 (0.000)
19-05-'10	5.230 (0.577)	4.330 (0.577)	0.230 (0.958)	7.000 (1.000)	5.670 (0.577)	0.130 (0.058)	10.00 (1.000)	4.000 (0.000)	0.170 (0.058)
20-05-'10	6.330 (0.577)	3.330 (0.577)	0.070 (0.058)	5.330 (0.577)	5.000 (0.000)	0.100 (0.000)	9.330 (2.309)	3.670 (0.577)	0.230 (0.058)
21-05-'10	7.330 (1.155)	4.670 (0.577)	0.200 (0.000)	6.000 (1.000)	5.670 (0.577)	0.170 (0.058)	10.67 (1.155)	4.690 (0.577)	2.670 (0.058)
22-05-'10	9.000 (1.000)	4.670 (0.577)	0.200 (0.000)	5.670 (0.577)	3.000 (0.000)	0.130 (0.058)	10.67 ()1.528	3.670 (0.577)	0.170 (0.058)
14-06-'10	5.000 (0.000)	4.330 (0.577)	0.100 (0.000)	6.000 (1.000)	5.670 (0.577)	0.200 (0.100)	14.00 (2.000)	4.000 (0.000)	0.130 (0.058)
15-06-'10	2.330 (0.577)	3.000 (0.577)	0.100 (0.000)	8.000 (1.000)	4.670 (1.528)	0.230 (0.058)	12.67 (1.528)	4.000 (0.000)	0.100 (0.000)
16-06-'10	6.330 (1.528)	3.330 (0.577)	0.23 (0.057)	7.00 (1.000)	5.67 (0.577)	0.100 (0.058)	11.00 (1.000)	4.000 (0.000)	0.100 (0.058)
19-06-'10	2.330 (0.577)	3.000 (0.000)	0.100 (0.000)	8.000 (1.000)	4.670 (1.528)	0.230 (0.058)	10.33 (0.577)	4.670 (0.577)	0.100 (0.000)
21-06-'10	7.670 (0.577)	4.670 (0.577)	0.200 (0.000)	6.000 (1.000)	5.670 (0.577)	0.170 (0.058)	10.67 (1.155)	4.670 (0.577)	0.270 (0.058)
22-06-'10	6.000 (1.000)	5.670 (0.577)	0.200 (0.100)	5.000 (0.000)	4.330 (0.577)	0.100 (0.000)	14.00 (2.000)	4.000 (0.000)	0.130 (0.058)
12-07-'10	8.000 (1.000)	4.07 (1.528)	0.230 (0.058)	3.000 (1.000)	3.000 (0.000)	0.100 (0.000)	12.67 (1.528)	4.000 (0.000)	0.130 (0.058)
13-07-'10	7.000 (1.000)	5.670 (0.577)	0.230 (0.058)	5.330 (1.528)	4.000 (0.000)	0.130 (0.058)	11.00 (1.000)	4.330 (0.577)	0.170 (0.058)
14-07-'10	7.670 (0.577)	5.670 (0.577)	0.200 (0.000)	6.000 (1.000)	4.670 (0.577)	0.170 (0.058)	10.67 (1.155)	4.670 (0.577)	0.270 (0.058)
15-07-'10	8.000 (1.000)	4.670 (1.528)	0.230 (0.058)	2.330 (0.577)	3.000 (0.000)	0.130 (0.058)	10.33 (0.577)	4.670 (0.577)	0.130 (0.058)
16-07-'10	9.000 (1.000)	4.670 (1.528)	0.200 (0.058)	5.670 (0.577)	3.000 (0.000)	0.130 (0.058)	10.67 (0.577)	3.670 (0.577)	0.170 (0.058)
MEAN	**6.093 (0.960)**	**4.817 (0.660)**	**0.183 (0.850)**	**5.910 (0.130)**	**4.587 (0.540)**	**0.157 (1.700)**	**11.153 (0.150)**	**4.180 (0.250)**	**0.300 (1.700)**

Value – Mean of triplicate determinations, (xxx) – Standard Deviation.

Table 4.5: Air Quality Data for Site B of Location 1

Date	6.30 - 8.00am			1.00 - 2.30pm			6.30 - 8.00pm		
	CO (ppm)	H_2S (ppm)	SO_2 (ppm)	CO (ppm)	H_2S (ppm)	SO_2 (ppm)	CO (ppm)	H_2S (ppm)	SO_2 (ppm)
17-05-'10	4.330 (0.577)	3.330 (0.577)	0.230 (0.058)	6.000 (1.000)	6.000 (1.000)	0.100 (0.000)	12.33 (0.577)	3.670 (0.577)	0.230 (0.058)
18-05-'10	4.330 (0.577)	3.330 (0.577)	0.130 (0.058)	7.000 (1.000)	5.000 (1.000)	0.200 (0.000)	16.00 (1.000)	3.670 (0.577)	0.230 (0.058)
19-05-'10	4.330 (0.577)	3.330 (0.577)	0.230 (0.058)	6.000 (1.000)	6.000 (1.000)	0.100 (0.000)	12.33 (0.577)	3.670 (0.577)	0.230 (0.058)
20-05-'10	30.00 (1.000)	3.670 (0.577)	0.270 (0.115)	9.000 (1.000)	3.670 (0.577)	0.170 (0.058)	13.33 (1.528)	4.000 (0.000)	0.270 (0.115)
21-05-'10	11.00 (1.000)	4.670 (0.577)	0.200 (0.000)	10.33 (2.082)	5.000 (0.000)	0.130 (0.058)	12.67 (1.155)	5.000 (0.000)	0.130 (0.058)
22-05-'10	8.330 (0.577)	3.330 (0.577)	0.170 (0.058)	5.670 (0.577)	4.670 (0.577)	0.100 (0.000)	8.000 (2.646)	4.000 (1.000)	0.130 (0.058)
14-06-'10	6.330 (1.528)	4.000 (0.000)	0.130 (0.058)	4.330 (0.577)	5.000 (0.000)	0.130 (0.058)	10.67 (1.528)	3.330 (0.577)	0.170 (0.058)
15-06-'10	16.00 (1.000)	3.330 (0.570)	0.130 (0.058)	7.000 (1.000)	5.000 (1.000)	0.170 (0.058)	20.67 (1.528)	3.670 (0.577)	0.200 (0.000)
16-06-'10	6.330 (0.577)	3.330 (0.577)	0.330 (0.100)	5.330 (0.577)	5.000 (0.000)	0.100 (0.000)	9.330 (2.309)	3.670 (0.577)	0.200 (0.000)
19-06-'10	4.330 (0.577)	3.000 (0.577)	0.130 (0.058)	7.000 (1.000)	5.000 (1.000)	0.170 (0.058)	16.00 (1.000)	3.670 (0.577)	0.230 (0.058)
21-06-'10	11.00 (1.000)	4.670 (0.577)	0.200 (0.000)	10.33 (2.082)	5.000 (0.000)	0.130 (0.058)	12.67 (1.155)	5.000 (0.000)	0.270 (0.058)
22-06-'10	6.330 (1.528)	5.000 (0.000)	0.130 (0.058)	4.330 (0.577)	3.000 (0.000)	0.130 (0.058)	10.67 (1.528)	4.000 (0.000)	0.170 (0.058)
12-07-'10	16.00 (1.000)	5.000 (1.000)	0.160 (0.058)	7.000 (1.000)	3.330 (0.577)	0.130 (0.058)	20.67 (1.528)	3.670 (0.577)	0.200 (0.000)
13-07-'10	6.330 (0.577)	3.670 (0.577)	0.330 (0.100)	5.330 (0.577)	3.330 (0.577)	0.100 (0.000)	9.330 (2.309)	5.000 (0.000)	0.200 (0.000)
14-07-'10	11.00 (1.000)	5.000 (0.000)	0.200 (0.000)	10.330 (2.083)	4.670 (0.577)	0.130 (0.058)	12.33 (1.155)	5.000 (0.000)	0.270 (0.058)
15-07-'10	7.000 (1.000)	5.000 (1.000)	0.170 (0.058)	4.330 (0.577)	3.330 (0.577)	0.130 (0.058)	16.00 (1.000)	3.670 (0.577)	0.230 (0.058)
16-07-'10	8.330 (1.000)	4.670 (1.000)	0.160 (0.058)	5.670 (0.577)	3.330 (0.577)	0.100 (0.058)	8.000 (1.000)	4.000 (0.577)	0.130 (0.058)
17-07-'10	4.330 (0.577)	3.330 (0.577)	0.230 (0.058)	6.000 (1.000)	6.000 (1.000)	0.100 (0.000)	12.33 (0.577)	3.670 (0.577)	0.230 (0.058)
MEAN	**8.957 (0.090)**	**4.020 (0.490)**	**0.193 (0.500)**	**6.767 (0.040)**	**4.520 (0.300)**	**0.130 (2.100)**	**13.067 (0.140)**	**4.030 (0.300)**	**0.537 (1.400)**

Value – Mean of triplicate determinations, (xxx) – Standard Deviation.

Table 4.6: Air Quality Data for Site C of Location 1

Date	6.30-8.00am			1.00-2.30pm			6.30-8.00pm		
	CO (ppm)	H_2S (ppm)	SO_2 (ppm)	CO (ppm)	H_2S (ppm)	SO_2 (ppm)	CO (ppm)	H_2S (ppm)	SO_2 (ppm)
17-05-'10	1.000 (1.000)	3.330 (0.577)	0.100 (0.000)	1.670 (1.000)	5.000 (1.000)	0.100 (0.000)	2.330 (0.577)	2.330 (0.577)	0.130 (0.058)
18-05-'10	2.670 (1.155)	3.330 (1.528)	0.100 (0.000)	1.670 (0.577)	4.330 (0.577)	0.160 (0.058)	2.670 (0.577)	3.670 (0.577)	0.100 (0.000)
19-05-'10	1.000 (1.000)	3.330 (0.577)	0.060 (0.058)	1.660 (0.577)	5.000 (0.000)	0.100 (0.000)	2.330 (0.577)	3.670 (0.577)	0.130 (0.058)
20-05-'10	0.330 (0.577)	3.000 (0.000)	0.070 (0.058)	1.330 (0.577)	3.330 (0.577)	0.100 (0.000)	8.000 (1.000)	3.670 (0.577)	0.170 (0.058)
21-05-'10	2.670 (0.577)	3.670 (0.577)	0.130 (0.058)	3.330 (1.528)	4.670 (0.577)	0.200 (0.000)	3.330 (0.577)	4.330 (0.577)	0.270 (0.058)
22-05-'10	4.670 (1.155)	4.330 (0.577)	0.130 (0.058)	4.000 (1.000)	5.000 (0.000)	0.200 (0.000)	0.130 (0.577)	3.330 (0.577)	0.100 (0.000)
14-06-'10	0.670 (0.577)	3.000 (0.000)	0.170 (0.058)	1.000 (1.000)	4.330 (0.577)	0.200 (0.000)	1.000 (1.000)	3.000 (0.000)	0.100 (0.000)
15-06-'10	2.670 (1.155)	2.670 (0.577)	0.130 (0.058)	1.670 (0.577)	4.330 (0.577)	0.160 (0.058)	6.000 (1.000)	3.000 (0.000)	0.130 (0.058)
16-06-'10	1.000 (1.000)	3.330 (0.577)	0.100 (0.000)	1.670 (0.577)	4.670 (0.577)	0.100 (0.000)	2.330 (0.577)	3.670 (0.577)	0.130 (0.058)
19-06-'10	2.670 (1.155)	2.670 (0.577)	0.070 (0.058)	1.670 (0.577)	4.670 (0.577)	0.170 (0.058)	2.670 (0.577)	3.330 (0.577)	0.100 (0.000)
21-06-'10	2.670 (0.577)	3.670 (0.577)	0.130 (0.058)	3.330 (1.528)	4.370 (0.577)	0.200 (0.000)	3.330 (0.577)	4.330 (0.577)	0.270 (0.058)
22-06-'10	1.000 (1.000)	4.330 (0.577)	0.200 (0.000)	0.670 (0.577)	3.000 (0.000)	0.170 (0.058)	1.000 (1.000)	3.000 (0.000)	0.100 (0.000)
12-07-'10	2.670 (1.155)	4.330 (0.577)	0.160 (0.058)	0.170 (0.577)	2.670 (0.577)	0.130 (0.058)	6.000 (1.000)	3.000 (0.000)	0.130 (0.058)
13-07-'10	2.000 (0.000)	4.670 (0.577)	0.100 (0.000)	1.000 (1.000)	3.330 (0.577)	0.100 (0.000)	2.330 (0.577)	3.670 (0.577)	0.120 (0.058)
14-07-'10	3.330 (1.528)	4.670 (0.577)	0.220 (0.000)	2.670 (0.577)	3.670 (0.577)	0.130 (0.058)	3.330 (0.577)	4.330 (0.577)	0.270 (0.058)
15-07-'10	2.670 (1.155)	4.670 (0.577)	0.170 (0.058)	1.670 (0.577)	2.670 (0.577)	0.070 (0.058)	2.670 (0.577)	3.330 (0.577)	0.100 (0.000)
16-07-'10	4.670 (1.155)	5.000 (0.577)	0.200 (0.058)	4.000 (1.000)	3.330 (0.577)	0.100 (0.000)	1.330 (0.577)	4.330 (0.577)	0.130 (0.058)
17-07-'10	1.000 (1.000)	3.330 (0.577)	0.100 (0.000)	1.670 (1.000)	5.000 (0.000)	0.100 (0.000)	2.330 (0.577)	2.330 (0.577)	0.130 (0.058)
MEAN	**2.423 (0.020)**	**3.783 (0.360)**	**0.137 (0.960)**	**2.097 (0.029)**	**4.100 (0.680)**	**0.143 (1.700)**	**3.403 (0.039)**	**3.620 (0.540)**	**0.280 (1.800)**

Value – Mean of triplicate determinations, (xxx) – Standard Deviation.

Table 4.7: Air Quality Data for Site D of Location 1

Date	6.30-8.00am			1.00-2.30pm			6.30-8.00pm		
	CO (ppm)	H_2S (ppm)	SO_2 (ppm)	CO (ppm)	H_2S (ppm)	SO_2 (ppm)	CO (ppm)	H_2S (ppm)	SO_2 (ppm)
17-05-'10	7.000 (2.000)	3.000 (0.577)	0.100 (0.000)	4.670 (1.528)	4.670 (0.577)	0.100 (0.000)	10.67 (1.528)	4.000 (0.000)	0.200 (0.000)
18-05-'10	9.000 (1.155)	4.670 (0.577)	0.130 (0.058)	10.00 (1.000)	4.670 (0.577)	0.230 (0.058)	10.67 (1.155)	3.670 (0.577)	0.200 (0.000)
19-05-'10	6.330 (0.577)	3.330 (0.577)	0.300 (0.100)	5.330 (0.577)	5.000 (0.000)	0.100 (0.000)	3.670 (0.577)	3.670 (0.577)	0.200 (0.000)
20-05-'10	7.000 (2.000)	3.330 (0.577)	0.100 (0.000)	3.670 (0.577)	4.670 (0.577)	0.130 (0.058)	10.67 (1.528)	4.000 (0.000)	0.200 (0.000)
21-05-'10	8.330 (0.577)	4.000 (0.000)	0.220 (0.000)	5.330 (0.577)	3.000 (0.000)	0.130 (0.058)	12.67 (1.155)	4.330 (0.577)	0.330 (0.115)
22-05-'10	11.00 (1.000)	3.330 (0.577)	0.130 (0.058)	7.000 (1.000)	3.330 (0.577)	0.100 (0.000)	7.330 (0.577)	3.000 (0.000)	0.130 (0.058)
14-06-'10	7.000 (1.000)	4.300 (0.577)	0.100 (0.000)	5.330 (0.577)	5.000 (0.000)	0.100 (0.000)	7.330 (1.528)	3.000 (0.000)	0.130 (0.058)
15-06-'10	9.000 (2.646)	4.670 (0.577)	0.130 (0.058)	8.330 (0.577)	4.670 (0.577)	0.230 (0.058)	8.000 (1.000)	3.670 (0.577)	0.170 (0.058)
16-06-'10	4.330 (0.577)	3.330 (0.577)	0.230 (0.058)	6.000 (1.000)	6.000 (1.000)	0.100 (0.000)	12.67 (0.577)	3.670 (0.577)	0.230 (0.058)
19-06-'10	9.000 (2.646)	4.670 (0.577)	0.130 (0.058)	10.00 (1.000)	4.470 (0.577)	0.230 (0.058)	10.67 (1.155)	3.670 (0.577)	0.200 (0.000)
21-06-'10	8.330 (0.577)	4.000 (0.000)	0.200 (0.000)	5.330 (0.577)	3.000 (0.000)	0.130 (0.058)	12.66 (1.155)	4.330 (0.577)	0.330 (0.115)
22-06-'10	7.000 (1.000)	5.000 (0.000)	0.100 (0.000)	5.330 (0.577)	4.330 (0.577)	0.100 (0.000)	7.330 (1.528)	4.000 (1.000)	0.130 (0.058)
12-07-'10	9.000 (2.646)	4.670 (0.577)	0.230 (0.058)	7.670 (0.577)	3.670 (0.577)	0.130 (0.058)	8.330 (0.577)	4.670 (0.577)	0.160 (0.058)
13-07-'10	6.000 (1.000)	3.670 (0.577)	0.230 (0.058)	4.670 (0.577)	3.330 (0.577)	0.100 (0.000)	12.67 (0.577)	6.000 (1.000)	0.230 (0.058)
14-07-'10	8.330 (0.577)	4.000 (0.000)	0.200 (0.000)	5.330 (0.577)	3.000 (0.000)	0.130 (0.058)	12.57 (1.155)	4.330 (0.577)	0.330 (0.115)
15-07-'10	10.00 (1.000)	4.670 (0.577)	0.230 (0.058)	9.000 (2.646)	3.670 (0.577)	0.130 (0.058)	10.67 (1.155)	4.670 (0.577)	0.200 (0.000)
16-07-'10	7.330 (0.577)	3.330 (0.000)	0.130 (0.058)	7.000 (2.000)	3.000 (0.577)	0.100 (0.000)	11.00 (1.000)	3.000 (0.577)	0.130 (0.058)
17-07-'10	7.000 (1.000)	3.000 (0.577)	0.100 (0.000)	4.670 (1.528)	4.670 (0.577)	0.100 (0.000)	10.67 (1.528)	4.000 (0.000)	0.200 (0.000)
MEAN	**7.860 (0.063)**	**4.073 (0.650)**	**0.170 (1.600)**	**6.500 (0.048)**	**4.117 (0.910)**	**0.137 (1.900)**	**10.000 (0.068)**	**3.967 (0.740)**	**0.207 (2.600)**

Value – Mean of triplicate determinations, (xxx) – Standard Deviation.

Table 4.8: Air Quality Data for Site A of Location 2

Date	6.30-8.00am			1.00-2.30pm			6.30-8.00pm		
	CO (ppm)	H_2S (ppm)	SO_2 (ppm)	CO (ppm)	H_2S (ppm)	SO_2 (ppm)	CO (ppm)	H_2S (ppm)	SO_2 (ppm)
17-05-'10	1.330 (0.577)	3.330 (0.577)	0.100 (0.000)	1.670 (0.577)	3.670 (0.577)	0.170 (0.058)	2.000 (0.000)	4.000 (0.000)	0.200 (0.000)
18-05-'10	0.670 (0.577)	2.670 (0.577)	0.100 (0.000)	0.670 (0.577)	2.670 (0.577)	0.100 (0.000)	1.000 (0.000)	3.670 (0.577)	0.100 (0.000)
19-05-'10	1.330 (0.577)	3.330 (0.577)	0.100 (0.000)	5.000 (0.000)	4.670 (0.577)	0.130 (0.058)	2.000 (0.000)	3.670 (0.577)	0.170 (0.058)
20-05-'10	0.330 (0.577)	3.330 (0.577)	0.100 (0.000)	0.670 (0.577)	3.670 (0.577)	0.130 (0.058)	1.330 (0.577)	3.670 (0.577)	0.170 (0.058)
21-05-'10	0.670 (0.577)	3.330 (0.577)	0.100 (0.000)	0.130 (0.577)	3.330 (0.577)	0.170 (0.058)	2.000 (0.000)	3.670 (0.577)	0.200 (0.000)
22-05-'10	3.330 (0.577)	4.000 (0.000)	0.070 (0.058)	5.000 (0.000)	4.330 (0.577)	0.130 (0.058)	5.000 (1.000)	4.670 (0.577)	0.200 (0.000)
14-06-'10	0.670 (0.577)	3.000 (0.000)	0.030 (0.058)	1.670 (0.577)	3.330 (0.577)	0.100 (0.000)	5.000 (0.000)	3.660 (0.577)	0.130 (0.058)
15-06-'10	0.670 (0.577)	2.670 (0.577)	0.100 (0.000)	0.070 (0.058)	2.670 (0.577)	0.070 (0.058)	0.100 (0.000)	3.000 (0.000)	0.100 (0.000)
16-06-'10	1.330 (0.577)	3.330 (0.577)	0.130 (0.058)	2.000 (0.000)	4.670 (0.577)	0.100 (0.000)	5.000 (0.000)	3.330 (0.577)	0.130 (0.058)
19-06-'10	0.670 (0.577)	3.330 (0.577)	0.100 (0.000)	0.330 (0.058)	3.670 (0.577)	0.130 (0.058)	1.330 (0.577)	3.670 (0.577)	0.170 (0.058)
21-06-'10	0.330 (0.577)	3.330 (0.577)	0.100 (0.000)	1.330 (0.577)	3.670 (0.577)	0.170 (0.058)	2.000 (0.000)	3.330 (0.577)	0.200 (0.000)
22-06-'10	1.330 (0.577)	3.330 (0.577)	0.100 (0.000)	2.000 (0.000)	3.670 (0.577)	0.170 (0.058)	5.000 (0.000)	4.670 (0.577)	0.130 (0.058)
12-07-'10	0.330 (0.577)	3.330 (0.577)	0.100 (0.000)	1.670 (0.577)	3.670 (0.577)	0.130 (0.058)	2.000 (0.000)	4.000 (0.000)	0.200 (0.000)
13-07-'10	0.670 (0.577)	3.000 (0.000)	0.100 (0.000)	0.670 (0.577)	2.670 (0.577)	0.100 (0.000)	1.000 (0.000)	3.670 (0.058)	0.100 (0.000)
14-07-'10	0.670 (0.577)	3.330 (0.577)	0.100 (0.000)	0.130 (0.577)	3.330 (0.577)	0.170 (0.058)	1.330 (1.155)	3.670 (0.577)	0.200 (0.000)
15-07-'10	3.330 (0.577)	4.000 (0.000)	0.070 (0.058)	5.000 (0.000)	4.330 (0.577)	0.130 (0.058)	5.000 (1.000)	4.670 (0.577)	0.200 (0.000)
16-07-'10	0.330 (0.577)	4.000 (0.000)	0.100 (0.000)	1.000 (0.000)	4.330 (0.577)	0.130 (0.058)	1.330 (1.155)	4.670 (0.577)	0.170 (0.058)
17-07-'10	0.330 (0.577)	3.330 (0.577)	0.100 (0.000)	1.670 (0.577)	3.670 (0.577)	0.130 (0.058)	2.000 (0.000)	3.670 (0.577)	0.200 (0.000)
MEAN	**0.917 (0.051)**	**3.263 (0.790)**	**0.090 (1.800)**	**1.657 (0.043)**	**3.603 (0.900)**	**0.127 (1.500)**	**2.470 (0.620)**	**3.807 (0.610)**	**0.163 (2.700)**

Value – Mean of triplicate determinations, (xxx) – Standard Deviation.

Table 4.9: Air Quality Data for Site B of Location 2

Date	6.30-8.00am			1.00-2.30pm			6.30-8.00pm		
	CO (ppm)	H_2S (ppm)	SO_2 (ppm)	CO (ppm)	H_2S (ppm)	SO_2 (ppm)	CO (ppm)	H_2S (ppm)	SO_2 (ppm)
17-05-'10	0.660 (0.577)	3.330 (0.577)	0.330 (0.058)	1.670 (0.577)	3.670 (0.577)	0.100 (0.000)	2.000 (0.000)	4.000 (0.000)	0.170 (0.000)
18-05-'10	0.330 (0.577)	2.330 (0.577)	0.100 (0.000)	1.330 (0.577)	3.670 (0.577)	0.160 (0.058)	1.670 (0.577)	4.000 (0.000)	0.200 (0.000)
19-05-'10	1.670 (0.577)	3.330 (0.577)	0.030 (0.058)	7.000 (1.000)	3.670 (1.528)	0.170 (0.058)	2.330 (0.577)	3.670 (0.577)	0.200 (0.000)
20-05-'10	0.670 (0.577)	3.330 (0.577)	0.330 (0.058)	1.000 (0.000)	3.330 (0.577)	0.070 (0.058)	1.330 (0.577)	4.000 (0.000)	0.100 (0.000)
21-05-'10	0.330 (0.577)	3.330 (0.577)	0.100 (0.000)	0.670 (0.577)	3.330 (0.577)	0.130 (0.058)	1.000 (0.000)	3.330 (0.577)	0.170 (0.058)
22-05-'10	0.000 (0.000)	4.000 (0.000)	0.070 (0.058)	0.130 (0.577)	4.000 (1.000)	0.100 (0.000)	2.330 (0.577)	4.000 (0.000)	0.130 (0.058)
14-06-'10	0.330 (0.577)	3.000 (0.000)	0.030 (0.058)	0.670 (0.577)	3.670 (0.577)	0.070 (0.058)	2.000 (0.000)	3.670 (0.577)	0.670 (0.058)
15-06-'10	0.330 (0.577)	2.330 (0.577)	0.070 (0.058)	0.670 (0.577)	3.330 (0.577)	0.100 (0.000)	1.330 (0.577)	3.670 (0.577)	0.030 (0.577)
16-06-'10	1.670 (0.577)	3.330 (0.577)	0.070 (0.058)	7.000 (1.000)	3.670 (1.528)	0.170 (0.058)	2.000 (1.000)	3.670 (0.577)	0.200 (0.000)
19-06-'10	1.000 (0.000)	3.330 (0.577)	0.030 (0.058)	0.670 (0.577)	3.330 (0.577)	0.070 (0.058)	1.330 (0.577)	4.000 (0.000)	0.070 (0.058)
21-06-'10	0.330 (0.577)	3.330 (0.577)	0.100 (0.000)	0.670 (0.577)	3.670 (0.577)	0.170 (0.058)	0.330 (0.577)	3.330 (0.577)	0.120 (0.058)
22-06-'10	1.670 (0.577)	3.330 (0.577)	0.030 (0.058)	2.330 (0.577)	3.670 (0.577)	0.200 (0.000)	7.000 (1.000)	3.670 (1.528)	0.170 (0.058)
12-07-'10	0.670 (0.577)	3.330 (0.577)	0.030 (0.058)	0.670 (0.577)	3.670 (0.577)	0.100 (0.000)	2.000 (0.000)	4.000 (0.000)	0.170 (0.060)
13-07-'10	0.330 (0.577)	2.330 (0.577)	0.100 (0.000)	1.330 (0.557)	3.670 (0.577)	0.170 (0.058)	1.670 (0.577)	4.000 (0.000)	0.200 (0.000)
14-07-'10	0.330 (0.577)	3.330 (0.577)	0.100 (0.000)	0.670 (0.577)	3.670 (0.577)	0.130 (0.058)	1.000 (0.000)	3.330 (0.577)	0.170 (0.058)
15-07-'10	0.000 (0.000)	4.000 (0.000)	0.070 (0.058)	1.330 (0.577)	4.330 (1.155)	0.100 (0.000)	2.330 (0.577)	4.000 (0.000)	0.130 (0.557)
16-07-'10	0.670 (0.577)	3.330 (0.577)	0.030 (0.058)	1.000 (0.000)	3.330 (0.577)	0.070 (0.058)	1.330 (0.577)	4.000 (0.000)	0.100 (0.000)
17-07-'10	0.660 (0.577)	3.330 (0.577)	0.330 (0.577)	1.670 (0.577)	3.670 (0.577)	0.100 (0.000)	2.000 (0.000)	4.000 (0.000)	0.160 (0.577)
MEAN	**0.547 (0.066)**	**3.207 (0.760)**	**0.097 (6.500)**	**1.683 (0.031)**	**3.640 (0.960)**	**0.123 (1.800)**	**1.913 (0.047)**	**3.760 (0.580)**	**0.180 (3.800)**

Value – Mean of triplicate determinations, (xxx) – Standard Deviation.

Table 4.10: Air Quality Data for Site C of Location 2

Date	6.30-8.00am			1.00-2.30pm			6.30-8.00pm		
	CO (ppm)	H_2S (ppm)	SO_2 (ppm)	CO (ppm)	H_2S (ppm)	SO_2 (ppm)	CO (ppm)	H_2S (ppm)	SO_2 (ppm)
17-05-'10	0.670 (0.577)	3.330 (0.577)	0.330 (0.058)	1.000 (0.000)	3.330 (0.577)	0.160 (0.058)	1.670 (0.577)	4.000 (0.000)	0.200 (0.000)
18-05-'10	0.000 (0.000)	2.330 (0.577)	0.030 (0.058)	0.670 (0.577)	3.330 (0.577)	0.100 (0.000)	1.670 (0.577)	3.670 (0.577)	0.130 (0.058)
19-05-'10	1.670 (0.577)	4.000 (0.000)	0.100 (0.000)	4.330 (1.155)	4.670 (0.577)	0.200 (0.100)	5.000 (1.000)	4.330 (0.577)	0.130 (0.058)
20-05-'10	0.670 (0.577)	3.330 (0.577)	0.070 (0.551)	0.000 (0.000)	3.330 (0.577)	0.130 (0.058)	1.670 (0.577)	4.000 (0.000)	0.100 (0.000)
21-05-'10	0.330 (0.577)	3.330 (0.577)	0.130 (0.058)	2.330 (0.577)	3.330 (0.577)	0.130 (0.058)	3.670 (0.577)	4.330 (0.577)	0.230 (0.058)
22-05-'10	2.670 (0.577)	4.000 (1.000)	0.070 (0.058)	4.670 (0.577)	4.330 (0.577)	0.100 (0.000)	5.670 (0.577)	4.000 (0.000)	0.130 (0.058)
14-06-'10	0.670 (0.577)	4.670 (0.577)	0.030 (0.058)	1.670 (0.577)	3.660 (0.577)	0.100 (0.000)	5.670 (0.577)	4.000 (0.000)	0.100 (0.000)
15-06-'10	0.670 (0.577)	2.330 (0.577)	0.070 (0.058)	0.000 (0.000)	3.300 (0.577)	0.130 (0.058)	1.330 (0.577)	3.670 (0.577)	0.170 (0.577)
16-06-'10	1.670 (0.577)	4.000 (0.000)	0.200 (0.100)	5.330 (0.577)	4.670 (0.577)	0.100 (0.000)	4.000 (0.100)	3.670 (0.577)	0.130 (0.058)
19-06-'10	0.000 (0.000)	3.330 (0.577)	0.070 (0.058)	0.670 (0.577)	3.670 (0.577)	0.100 (0.000)	1.670 (0.577)	4.000 (0.000)	0.130 (0.058)
21-06-'10	0.330 (0.577)	3.330 (0.577)	0.100 (0.000)	1.670 (1.528)	3.330 (0.577)	0.130 (0.058)	3.670 (0.577)	4.330 (0.577)	0.230 (0.577)
22-06-'10	1.670 (0.577)	4.000 (0.000)	0.100 (0.000)	4.330 (1.155)	4.670 (0.577)	0.200 (0.100)	5.000 (1.000)	4.330 (0.577)	0.130 (0.058)
12-07-'10	0.670 (0.577)	3.330 (0.577)	0.030 (0.058)	1.000 (0.000)	3.330 (0.577)	0.170 (0.058)	1.000 (0.000)	4.000 (0.000)	0.200 (0.000)
13-07-'10	0.000 (0.000)	2.330 (0.577)	0.030 (0.058)	0.670 (0.577)	3.330 (0.577)	0.100 (0.000)	1.670 (0.577)	3.670 (0.577)	0.130 (0.058)
14-07-'10	0.330 (0.577)	3.330 (0.577)	0.130 (0.058)	2.330 (0.577)	3.670 (0.577)	0.130 (0.058)	3.670 (0.577)	4.330 (0.577)	0.230 (0.058)
15-07-'10	2.670 (0.577)	4.000 (1.000)	0.070 (0.058)	4.670 (0.577)	4.330 (0.577)	0.100 (0.000)	5.670 (0.577)	4.000 (0.000)	0.130 (0.058)
16-07-'10	0.670 (0.577)	3.330 (0.577)	0.070 (0.058)	0.670 (0.577)	3.670 (0.577)	0.130 (0.058)	1.670 (0.577)	4.000 (0.000)	0.100 (0.000)
17-07-'10	0.670 (0.577)	3.330 (0.577)	0.330 (0.577)	1.000 (0.000)	3.330 (0.577)	0.160 (0.577)	1.670 (0.577)	4.000 (0.000)	0.200 (0.000)
MEAN	**0.803 (0.065)**	**3.437 (2.500)**	**0.093 (2.200)**	**2.070 (0.047)**	**3.760 (0.990)**	**0.130 (1.600)**	**3.223 (0.610)**	**4.017 (0.410)**	**0.160 (1.400)**

Value – Mean of triplicate determinations, (xxx) – Standard Deviation.

4.20 DISCUSSION

4.2.1 General Discussion of Gaseous Pollutants

The pollutant gases sulphur dioxide (SO_2), carbon-monoxide (CO) and hydrogen-sulphide (H_2S) are dispersed throughout the atmosphere at the Sabon-Gari market and Aliyu Mustapha Social Centre A.B.U. Zaria. The concentration of these gases especially the criteria pollutants sulphur dioxide and carbon-monoxide are high in some sites with respect to the timing of the day and low in some other sites; though, they are not high enough to cause serious health problems; but information on their spatial distribution is of importance. It may be useful in tighter emission standards, closer monitoring of the gases, creating alternative sources of energy to reduce over dependence on fossil and natural fuels thus, creating a cleaner air.

Tables 4.1, 4.2 and 4.3 shows the air quality guildelines for the priority pollutants by world Health Organization (WHO) and Federal Environmental Protection Agency (FEPA) of Nigeria, the Air Quality index and rating by United State Environmental Protection Agency (USEPA) and the summary of the Air Quality Index rating from the study respectively.

The Air Quality Index (AQI) for the priority pollutants, the ratings is set by USEPA for determining ambient air quality. The result of this research work on the ambient air measurement was compared with the USEPA ambient air rating obtained in the table. The ambient air pollutants are classified into categories ranging from very good to very poor. From (0 – 15) AQI rating is A which is very good, (16 – 31) AQI is B which is good, (32 – 49) AQI is C which is moderate, (50 – 99) AQI is D which is poor and (100 or above) AQI is E which is very poor, showing critical values. Thus, the lower the AQI value, the better the air quality. The AQI rating for the chosen pollutants are tabulated in Table 4.3.

The results of the monitored air quality at four sampling sites (A – D) of location 1 and three sampling sites (A – C) of location 2 and the mean of triplicate determination with its'Standard deviations in bracket tabulated in tables 4.4 – 4.10 respectively.

4.3 Location 1 (Sabon-Gari Market Zaria)

4.3.1 Carbon-Monoxide

At Site A, the concentrations of carbon-monoxide are in the range of 2.33 – 9.00ppm, 2.33 – 8.00ppm and 9.33 – 14.00ppm with mean concentrations as 6.09, 5.91 and 11.15ppm respectively for the morning, afternoon and evening. The AQI rating varies from being moderate (C), for morning and afternoon to very poor (E) at the evening hours. This is probably due to increase in anthropogenic activities in the evening and low traffic flow in the evening.

At site B, the concentrations of carbon-monoxide are in the range of 4.30 – 30.00ppm, 4.33 – 10.33ppm and 8.00 – 20.67ppm, having mean concentrations of 8.96, 6.77 and 13.07ppm for morning, afternoon and evening respectively, which showed a very poor (E) AQI rating for the morning and evening hours and poor (D) AQI rating to the afternoon hour.

A Site C, the concentrations of carbon-monoxide AQI rates from being good (B) for the morning with concentration range as 0.33 – 4.67ppm and mean concentration of 2.42ppm, to very good (A) for the afternoon having 0.13 – 6.00ppm as concentration range and 2.10ppm as mean concentration, while the evening ranges from 0.13 – 10.67ppm with mean concentration of 3.40ppm with a good (B) rating index.

At Site D, the concentrations of carbon-monoxide AQI rating varies from poor (D) for both morning and afternoon respectively to very poor (E) for the evening hours. The concentration ranges from 4.33-11.00ppm, 3.67-10.00pm and 3.67-12.67ppm with mean concentrations of 7.86, 6.50 and10.00ppm respectively for the morning, afternoon and evening hours.

4.3.2 Hydrogen Sulphide

At Site A, the Concentrations of Hydrogen sulphide (H_2S) are in the range 3.00 – 14.00ppm, 3.00 – 5.67ppm and 3.67 – 4.67ppm having mean concentrations of 4.82, 4.59 and 4.18ppm respectively for morning, afternoon and evening. This shows moderate (C) AQI rating for all the hours.

At Site B, the concentrations of hydrogen sulphide (H_2S) ranges from 3.00 – 5.00ppm, 3.33 – 6.00ppm and 3.33 – 5.00ppm and mean concentrations of 4.02, 4.52 and 4.03ppm respectively for all the hours. It also showed a moderate (C) AQI rating for all the hours. This may be because of gutter and refuse dumps present at the site.

At Site C, the concentrations of hydrogen sulphide has moderate (C) AQI rating for all the sessions with its concentration range as 2.67-5.00ppm, 2.67-5.67ppm and 2.33-4.67ppm and mean concentrations as 3.78, 4.10 and 3.62ppm for the morning, afternoon and evening hours respectively.

At Site D,the concentrations of hydrogen sulphide AQI rates moderate (C) for all the hours having its concentration ranging from 3.00-5.00ppm, 2.00-5.00ppm and 3.00-6.00ppm and mean concentrations as 4.07, 4.12 and 3.97ppm respectively for the morning, afternoon and evening hours.

4.3.3 Sulphur Dioxide

At Site A, the concentrations of sulphur dioxide ranged from 0.07 – 0.30ppm, 0.10 – 0.23ppm and 0.10 – 2.67ppm for morning, afternoon and evening hours and mean concentrations as 0.18, 0.16 and 0.30ppm respectively. This shows a very poor (E) AQI rating for all the hours.

Decomposition of organic matters and emissions from vehicles and other gasoline powdered equipments may be the source of this gas.

A site B, the concentrations of sulphur dioxide AQI rating for all the sessions at this site is very poor (E) where its concentration ranges from 0.12 – 0.33ppm, 0.10 – 0.20ppm and 0.13 – 0.27ppm with mean concentrations of 0.19, 0.13 and 0.54ppm for the morning, afternoon and evening respectively.

At Site C, the concentrations of sulphur dioxide has a very poor (E) AQI rating for all the sessions and having the concentration range for morning, afternoon and evening as 0.06-2.20ppm, 0.07-0.20ppm and 0.10-0.27ppm and mean concentrations as 0.14, 0.14 and 0.28ppm respectively.

At Site D, the concentrations of sulphur dioxide AQI rates very poor (E) for all the hours having its concentration range from 0.10-0.23ppm, 0.10-0.23ppm and 0.13-0.33ppm with mean concentrations of 0.17,0.14 and 0.21ppm for the morning, afternoon and evening hours respectively.

4.4 Location 2- (Aliyu Mustapha Social Centre, A.B.U. Zaria)

4.4.1 Carbon-Monoxide

At Site A, the concentrations of carbon-monoxide AQI rates very good (A) for morning and afternoon hours respectively, and varies to good (B) for the evening hour. The concentration for the three sessions ranges from 0.33-1.33ppm, 0.07-5.00ppm and 0.10-5.00ppm with mean concentrations of 0.92, 1.66 and 2.47ppm respectively.

At Site B, the concentrations of carbon-monoxide shows a very good (A) AQI rating for all the hours with the concentrations ranging from 0.00-1.67ppm, 0.13-7.00ppm and 0.33-2.33ppm and

mean concentrations of 0.55, 1.68 and 1.91ppm respectively for the morning, afternoon and evening hours.

At Site C, the concentrations of carbon-monoxide ranges from 0.00-2.67ppm, 0.00-4.33ppm and 0.13-5.67ppm and mean concentrations of 0.80,2.07 and 3.22ppm respectively for the morning, afternoon and evening hours. The AQI rating varies from very good (A) for the morning hour to good (B) for both afternoon and evening hours respectively.

4.4.2 Hydrogen Sulphide

At Site A, the concentrations of hydrogen sulphide AQI rates moderate (C) for all the hours and concentration range of 2.67-4.00pm, 2.67-5.00ppm and 3.00-5.00ppm with mean concentration of 3.26, 3.60 and 3.81ppm for the morning, afternoon and evening respectively.

At Site B, the concentrations of hydrogen sulphide shows a moderate (C) AQI rating for all the hours. The concentration ranges from 2.33-4.00ppm, 3.30-4.30ppm and 3.00-4.00ppm and mean concentration of 3.21, 3.46 and 3.76ppm for morning, afternoon and evening hours respectively.

At Site C, the concentrations of hydrogen sulphide AQI rates moderate (C) for all the hours with the concentration ranging from 2.33-4.00ppm, 3.33-4.67ppm and 3.67-4.33ppm and mean concentratons of 3.44,3.76 and 4.02ppm respectively for the morning, afternoon and evening hours.

4.4.3 Sulphur Dioxide

At Site A, the concentration of sulphur dioxide ranged from 0.03-0.13ppm, 0.07-0.17ppm and 0.10-0.20ppm with mean concentration as 0.90,0.13 and 0.16ppm respectively for the morning,

afternoon and evening hours. The AQI rates poor (D) for the morning hour and very poor (E) for both afternoon and evening hours respectively.

At Site B, sulphur dioxide had concentration range of 0.07-0.10ppm, 0.07-0.20ppm and 0.07-0.20ppm and mean concentrations of 0.10, 0.12 and 0.18ppm respectively for the morning, afternoon and evening hours while the AQI rating varies from poor (D) for the morning hour to very poor (E) for the afternoon and evening hours respectively.

At Site C for sulphur dioxide, apart from the morning session whose AQI rates poor (D) with concentration ranging from 0.03-0.30ppm, 0.10-0.20ppm and 0.10-0.23ppm with mean concentrations as 0.09,0.13 and 0.16ppm respectively for the morning, afternoon and evening hours. Its AQI for the hours had very poor (E) rating.

Table 4.11: Descriptive Statistics of Carbon-Monoxide, Location 1

	Mean	Std. Deviation	Variance	Kurtosis	Maximun	Minimum	Range
Site A							
6.30am	0.096	0.075	0.0060	5.7	9.00	2.33	6.67
1.30pm	0.13	0.034	0.0010	0.19	8.00	2.33	5.67
6.30pm	0.15	0.047	0.0020	-0.99	14.00	9.33	4.67
Site B							
6.30am	0.10	0.09	0.0090	3.7	30.00	4.33	25.67
1.30pm	0.12	0.04	0.0020	-1.3	10.00	4.33	6.00
6.30pm	0.18	0.14	0.019	12.1	20.67	8.00	12.67
Site C							
6.30am	0.09	0.020	0.0000	5.5	7.33	0.33	7.00
1.30pm	0.13	0.029	0.0010	-0.33	6.00	0.67	5.33
6.30pm	0.16	0.039	0.0020	-1.3	10.67	0.13	10.54
Site D							
6.30am	0.17	0.063	0.0040	-1.0	11.00	4.33	6.67
1.30pm	0.13	0.048	0.0020	0.94	10.00	3.67	6.33
6.30pm	0.21	0.068	0.0050	-0.034	12.00	3.67	8.33

Table 4.12: Descriptive Statistics of Hydrogen Sulphide, Location 1

	Mean	Std. Deviation	Variance	Kurtosis	Maximun	Minimum	Range
Site A							
6.30am	3.4	0.66	0.43	-0.062	14.00	3.00	11.00
1.30pm	3.8	0.54	0.29	-0.95	5.67	3.00	2.67
6.30pm	4.0	0.25	0.06	-1.05	4.67	3.67	1.00
Site B							
6.30am	3.2	0.49	0.23	0.59	5.00	3.00	2.00
1.30pm	3.6	0.30	0.090	1.88	6.00	3.00	3.00
6.30pm	3.7	0.30	0.091	0.77	5.00	3.33	1.67
Site C							
6.30am	3.3	0.36	0.13	0.94	5.00	2.67	2.33
1.30pm	3.7	0.68	0.47	-0.42	5.67	2.67	3.00
6.30pm	3.9	0.54	0.29	-0.027	4.67	2.33	2.34
Site D							
6.30am	3.9	0.65	0.42	-1.6	5.00	3.00	2.00
1.30pm	4.1	0.91	0.82	-0.73	6.00	3.00	3.00
6.30pm	3.9	0.74	0.55	2.4	6.00	3.00	3.00

Table 4.13: Descriptive Statistics of Sulphur Dioxide, Location 1

	Mean	Std. Deviation	Variance	Kurtosis	Maximum	Minimum	Range
Site A							
6.30am	0.81	0.85	0.73	0.90	0.30	0.07	0.23
1.30pm	1.8	1.7	2.9	-0.38	0.23	0.10	0.13
6.30pm	2.9	1.7	2.8	-1.2	2.67	0.10	2.57
Site B							
6.30am	0.54	0.50	0.26	1.4	0.33	0.13	0.20
1.30pm	1.7	2.1	4.3	4.3	0.20	0.10	0.10
6.30pm	1.9	1.4	2.0	11.4	0.27	0.13	0.14
Site C							
6.30am	0.93	0.96	0.92	3.6	0.22	0.06	0.16
1.30pm	1.6	1.7	3.0	0.51	0.20	0.07	0.13
6.30pm	2.6	1.8	3.1	-1.2	2.67	0.10	2.57
Site D							
6.30am	7.9	1.6	2.6	0.36	0.23	0.10	0.13
1.30pm	6.5	1.9	3.7	-0.60	0.23	0.10	0.13
6.30pm	9.9	2.6	6.7	0.47	0.33	0.13	0.20

Table 4.14: Descriptive Statistics of Carbon Monoxide, Location 2

	Mean	Std. Deviation	Variance	Kurtosis	Maximum	Minimum	Range
Site A							
6.30am	0.14	0.051	0.0030	-1.3	3.33	0.33	3.00
1.30pm	0.14	0.043	0.0020	-1.4	5.00	0.07	4.93
6.30pm	0.29	0.62	0.38	16.7	5.00	0.10	4.90
Site B							
6.30am	0.19	0.066	0.0040	0.24	1.67	0.00	1.67
1.30pm	0.13	0.031	0.0010	-0.0040	7.00	0.17	6.83
6.30pm	0.21	0.047	0.0020	-0.76	7.00	0.33	6.67
Site C							
6.30am	0.18	0.065	0.0040	-0.69	2.67	0.00	2.67
1.30pm	0.15	0.047	0.0020	-0.88	5.33	0.00	5.33
6.30pm	0.31	0.61	0.37	16.7	5.67	0.13	5.54

Table 4.15: Descriptive Statistics of Hydrogen Sulphide, Location 2

	Mean	Std. Deviation	Variance	Kurtosis	Maximum	Minimum	Range
Site A							
6.30am	3.8	0.79	0.63	-1.6	4.00	2.67	1.33
1.30pm	4.1	0.90	0.82	-1.04	5.00	2.67	2.33
6.30pm	3.5	0.61	0.38	-0.24	4.67	3.00	1.67
Site B							
6.30am	4.0	0.76	0.58	-1.8	4.00	2.33	1.67
1.30pm	4.5	0.96	0.92	-1.1	4.33	3.33	1.00
6.30pm	4.0	0.58	0.33	-0.50	4.00	3.00	1.00
Site C							
6.30am	4.9	2.5	6.4	12.1	4.67	2.33	2.34
1.30pm	4.5	0.99	0.98	-0.95	4.67	3.30	1.37
6.30pm	4.2	0.41	0.17	-1.7	4.33	3.67	0.67

Table 4.16: Descriptive Statistics of Sulphur Dioxide, Location 2

	Mean	Std. Deviation	Variance	Kurtosis	Maximum	Minimum	Range
Site A							
6.30am	2.5	1.8	3.3	2.03	0.10	0.03	0.07
1.30pm	2.1	1.5	2.1	1.9	0.17	0.07	0.01
6.30pm	3.4	2.7	7.5	1.9	0.20	0.13	0.07
Site B							
6.30am	9.5	6.5	41.7	5.9	0.33	0.03	0.30
1.30pm	6.5	1.8	3.3	0.15	0.20	0.07	0.13
6.30pm	12.9	3.8	14.7	0.12	0.20	0.07	0.13
Site C							
6.30am	6.2	2.2	4.8	-0.40	0.20	0.03	0.17
1.30pm	5.8	1.6	2.4	0.71	0.20	0.10	0.10
6.30pm	11.1	1.4	1.9	0.45	0.23	0.10	0.13

Table 4.17: Time Variation Table (Friedman Test) for the Gases at Each Site of Location 1, at 95 Percent Confidence Level (P<0.05).

Carbon-Monoxide							
Sites	**P-Value**	**df**	**Chi(X2)**	**Median Values**			**Comment**
				6.30am	**1.30pm**	**6.30pm**	
A	0.0000	2	26.235	6.3300	6.0000	10.6700	Not Significant
B	0.0000	2	21.529	7.0000	6.0000	12.3300	Not Significant
C	0.0060	2	10.194	2.6700	1.6700	2.6700	Not Significant
D	0.0000	2	15.647	8.3300	5.3300	10.6700	Not Significant
Hydrogen Sulphide							
A	0.4459	2	1.556	4.6700	4.6700	4.0000	Significant
B	0.3100	2	2.344	3.6700	5.0000	3.6700	Not Significant
C	0.3910	2	1.877	3.6700	4.3300	3.6700	Significant
D	0.8650	2	0.290	4.0000	4.3300	4.0000	Significant
Sulphur Dioxide							
A	0.0590	2	5.656	0.2000	0.1300	0.1700	Significant
B	0.0000	2	16.935	0.1700	0.1300	0.2000	Not Significant
C	0.5330	2	1.258	0.1300	0.1300	0.1300	Significant
D	0.0070	2	10.066	0.1300	0.1300	0.2000	Not Significant

Table 4.18: Time Variation Table (Friedman Test) for the Gases at Each Site of Location 2, at 95 Percent Confidence Level (P<0.05).

Carbon-Monoxide							
Sites	**P-Value**	**df**	**Chi(X2)**	**Median Values**			**Comment**
				6.30AM	**1.30PM**	**6.30PM**	
A	0.000	2	19.500	0.6700	1.0000	2.0000	Not Significant
B	0.000	2	25.057	0.3300	1.0000	1.8350	Not Significant
C	0.000	2	27.457	0.6700	1.3350	2.6700	Not Significant
Hydrogen Sulphide							
A	0.000	2	23.637	3.3300	3.6700	3.6700	Not Significant
B	0.000	2	17.322	3.3300	3.6700	3.6700	Not Significant
C	0.001	2	14.156	3.3300	3.6650	4.000	Not Significant
SULPHUR DIOXIDE							
A	0.000	2	23.049	0.1000	0.1300	0.1700	Not Significant
B	0.000	2	16.203	0.0850	0.1150	0.1700	Not Significant
C	0.000	2	17.294	0.0700	0.1300	0.1300	Not Significant

4.5 STATISTICAL ANALYSIS

The data obtained for the air pollutants from this research were subjected to some statistical analysis such as Descriptive Statistics ,Test of significance using the Friedman test and the Hierarchical Cluster analysis.

4.5.1 Descriptive Statistics

A descriptive Statistics used is the Kurtosis because we were interested in the peakedness of the distribution of each gas, which gives hint on how concentrated data are around a single value as measured by the Kurtosis index. From the equation of kurtosis, the ideal value for the normal bell curve is zero; that is $\gamma_2 = 0$, (Mesokurtic), the higher the kurtosis index above zero; that is $\gamma_2 > 0$, the more peaked is the distribution (Leptokurtic) indicating low frequency of high concentration of the data set while the lower the Kurtosis index below the zero; that is $\gamma_2 < 0$,the more flat the distribution is (Platykurtic) indicating high frequency of low concentration of the data set.

4.5.2 Friedman test

The Friedman test compares the mean ranks between the related groups and indicates how the group differed; and informs whether there was an overall statistically significant difference. This test was performed to see if there will be a variation in the overall concentration of the gases as well as seeing if any variation was statistically significant.This test were carried out at 95% Confidence level, at each sites considering the times at the two locations for the gases.

A Statistically significant difference indicates the source of such pollutant was not fairly constant throughout the day thus a variation in time while a non- statistically difference indicates a steady source of the pollutant, thus the level of pollution is fairly constant throughout the day.

4.6 Location 1 (Sabon-Gari Market Zaria)

4.6.1 Carbon-Monoxide

At site A of location 1, the distribution pattern is leptokurtic (peaked) at the morning and afternoon hours with Kurtosis index as 5.7 and 0.19 respectively; while the evening hour had platykurtic (flat) distribution pattern with the kurtosis index of -0.98. Of the three sessions, the degree of distribution is closer to mesokurtic (normal) in the afternoon than morning and evenings, based on their kurtosis index since it has the least kurtosis index. This observed pattern of distribution may be attributed to high vehicular movement experienced during the morning and evening periods compared to the afternoon period.

Analysis of variation of the gas for the three periods indicated no significant variation at ($P<0.05$) as presented in Table 4.17. This indicates that the gas concentration was fairly constant for the day.

The distribution of the gas at site B of location 1, is leptokurtic (peaked) for morning and evening hours with kurtosis index as 3.7 and 12.5 respectively. The afternoon hour had platykurtic (flat) distributon having kurtosis index as -1.3. The distribution is closer to mesokurtic (normal) distribution during the afternoon hour compared to morning and evening hours respectively. The use of generator and other gasoline powered equipment and heavy

vehicular movement could be linked to the observed pattern of distribution (Deckoning *et al*., 1985).

Analysis of variation of the gas for the three periods indicated no significant variation at ($P<0.05$) as presented in Table 4.17 This indicates that the gas concentration was fairly constant for the day.

Site C of location 1 distribution pattern indicated a leptokurtic (peaked) distribution for the morning hour with kurtosis index as 5.5, while it is platykurtic (flat) for the afternoon and evening hours with kurtosis index as -0.34 and -1.3 respectively. This observed pattern indicated more closeness to normal distribution (mesokurtic), at the afternoon hour compared to the morning and evening hours. The observed pattern is attributed to emission from generator and other gasoline-powered equipment as well as smokes from tobacco use.

Analysis of variation of the gas for the three periods indicated significant variation at ($P>0.05$) as presented in Table 4.17. This indicates that the gas concentration was not fairly constant for the day.

The distribution pattern observed for site D of location 1 is platykurtic (flat) for both morning and evening hours with their kurtosis index as -1.0 and -0.034 respectively; but leptokurtic (peaked) with a kurtosis index of 0.94 for the afternoon hour. Emission due to poor traffic flow and tobacco accounts for the observed distribution pattern.

Analysis of variation of the gas for the three periods indicated no significant variation at ($P<0.05$) as presented in Table 4.17. This indicates that the gas concentration was fairly constant for the day.

4.6.2 Hydrogen Sulphide

At site A of location 1, the distribution pattern is platykurtic (flat) for all the hours with kurtosis index as -0.062, -0.095 and -1.0 respectively. The distribution pattern at the morning hour shows more closeness to the normal curve (mesokurtic) when compared to the afternoon and evening hours respectively. This is so probably because the pattern of distribution is constant. This observed distribution pattern may be attributed to emissions from vehicular movement which seen higher in the morning period compared to afternoon and evening. Though other sources for this observation are burning of solid waste and fossil fuels, decay of organic matters from gutter and dump site of wastes (Howard *et al*., 1985, Alberta 2006).

Analysis of variation of the gas for the three periods indicated significant variation at (P>0.05) as presented in Table 4.17. This indicates that the gas concentration was constant for the day.

At site B of location 1, the distribution pattern is leptokurtic (peaked) for all the hours with kurtosis index for morning, afternoon and evening hours as 0.59, 1.9 and 0.77; respectively. The distribution at the morning hour when compared with others showed more closeness to normal distribution (mesokurtic) considering the kurtosis index. This observed distribution pattern may be attributed to congested traffic flow at the area, inadequate drainage system and burning of solid wastes and fossil fuels. (Alberta,2006).

Analysis of variation of the gas for the three periods indicated significant variation at (P>0.05) as presented in Table 4.17. This indicates that the gas concentration was not constant for the day.

The distribution pattern observed for site C of location 1, is leptokurtic (peaked) with kurtosis index as 0.94 and platykurtic (flat) for the afternoon and evening hours with kurtosis index as -0.42 and -0.027 respectively. Of the three periods, distribution in the evening hour is closer to normal distribution (mesokurtic) when compared to the morning and afternoon using their kurtosis index.

Analysis of variation of the gas for the three periods indicated significant variation at (P>0.05) as presented in Table 4.17. This indicates that the gas concentration was not fairly constant for the day. This pattern of distribution may be attributed to poor drainage systems, decay of organic matters from gutters, dump sites of wastes and emission from generator and other gasoline powered equipment (Alan, 1988).

At site D of location 1, the distribution pattern is platykurtic (flat) for both the morning and afternoon hours having kurtosis index of -1.6 and -0.73 respectively, while it is leptokurtic (peaked) for the evening hour with kurtosis index of 2.4. The distribution pattern of the afternoon showed more closeness to normal distribution (mesokurtic) when compared to the morning and evening hours respectively with respect to their kurtosis index. The distribution pattern may be attributed to poor traffic flow at the area, burning of solid wastes and fossil fuel, inadequate drainage system and decay of organic matter from gutter and dump sites of waste (Alberta, 2006).

Analysis of variation of the gas for the three periods indicated significant variation at (P>0.05) as presented in table 4.17. This indicates that the gas concentration was not fairly constant for the day.

4.6.3 Sulphur Dioxide

The distribution pattern at site A of location 1 show a leptokurtic (peaked) distribution for the morning period having kurtosis index of 0.90 respectively. The pattern for the afternoon and evening is platykurtic (flat) with kurtosis index as -0.37 and -1.2 respectively. Of these three periods, the pattern of distribution tends to be closer to normal (mesokurtic) during the afternoon period when compared with the other two periods based on their kurtosis index.

Analysis of variation of the gas for the three periods indicated significant variation at ($P>0.05$) as presented in Table 4.17. This indicates that the gas concentration was not fairly constant for the day. This observed distribution may be attributed to burning of solid waste and fossil fuels (Starkman,1975), bacterial decomposition of organic matter from dump sites (Howard *et al*.; 1985).

At site B of location 1, the distribution pattern is leptokurtic (peaked) for all the three period with kurtosis index as 1.4, 4.3 and 11.4 respectively for the morning, afternoon, and evening hours. This distribution pattern may be attributed to improper disposal of wastes and poor traffic flow, burning of solid waste and fossil fuels, which created a smoky environment particularly in the morning when combustion is highest and in the evening when traffic appears heavy.

Analysis of variation of the gas for the three periods indicated no significant variation at ($P<0.05$) as presented in Table 4.17. This indicates that the gas concentration was fairly constant for the day.

The distribution pattern at site C of location 1 is leptokurtic (peaked) during the morning and afternoon hours with kurtosis index as 3.6 and 0.51 respectively. For the evening, it showed a platykurtic (flat) distribution pattern with kurtosis index of -1.2. The distribution pattern of the

afternoon hour is closer to normal (mesokurtic) when compared to the morning and evening periods respectively using their kurtosis index. The pattern of distribution may be linked to partial combustion of fuel mainly from generator and other gasoline powered equipment used, burning of solid wastes (Starkman, 1975).

Analysis of variation of the gas for the three periods indicated significant variation at (P>0.05) as presented in Table 4.17. This indicates that the gas concentration was not fairly constant for the day.

The distribution pattern at site D of location 1 is leptokurtic (peaked) with kurtosis index as 0.361. The afternoon and evening hours showed a platykurtic (flat) distribution pattern with respective kurtosis index as -0.60 and -0.47. Of the three, the distribution pattern of the morning hour is closer to normal (mesokurtic) based on their kurtosis index. This observed distribution pattern may be attributed to burning of solid wastes and fossil fuel (Starkman, 1975), bacterial decomposition of organic matter from dump sites (Howard *et al*; 1985), improper disposal of waste and poor traffic flow in the area which is highest in the evenings.

Analysis of variation of the gas for the three periods indicated no significant variation at (P<0.05) as presented in Table 4.17. This indicates that the gas concentration was fairly constant for the day.

4.7 Location 2- (Aliyu Mustapha Social Centre, A.B.U. Zaria)

4.7.1 Carbon-Monoxide

The distribution pattern at site A of location 2, indicates platykurtic (flat) for both the morning and afternoon hours with kurtosis index as -1.3 and -1.4 respectively, whereas it

showed leptokurtic with kurtosis index of 16.7 for the evening hour, this is because it has the least kurtosis index. Emission from cars, motorcycles, generator and other gasoline-powered equipments and congestions of traffic during the evening hours are the reasons for this observed pattern of distribution.

Analysis of variation of the gas for the three periods indicated no significant variation at ($P<0.05$) as presented in Table 4.18. This indicated that the gas concentration was fairly constant for the day.

Site B of location 2 shows a distribution pattern of leptokurtic (peaked) with kurtosis index of 0.24 for the morning hour and platykurtic (flat) with kurtosis index of -0.0040 and -0.76 respectively for the afternoon and evening hours. This indicates that the data is closer to a normal distribution (mesokurtic) at the afternoon hour when compared to the morning and evening hours using the kurtosis index. This observed pattern of distribution is attributed to cluster of activities during the morning and evenings especially smokes from tobacco usage, heat from the viewing centre and cyber café along side the use of generator and other gasoline-powered generating equipment.

Analysis of variation of the gas for the three periods indicated no significant variation at ($P<0.05$) as presented in Table 4.18. This indicates that the gas concentration was fairly constant for the day.

At site C of location 2, the distribution pattern is platykurtic (flat) for both the evening and afternoon hours with the kurtosis index of -0.69 and -0.88 respectively while the evening hour is leptokurtic (peaked) with an index of 16.7. The evening period showed a large variation from the normal curve (mesokurtic) compared to the morning and afternoon hours. This

observed distribution pattern is attributed to lot of activities going on at the area in the evening period when compared to morning and afternoon periods.

Analysis of variation of the gas for the three periods indicated no significant variation at ($P<0.05$) as presented in Table 4.18. This indicates that the gas concentration was fairly constant for the day.

4.7.2 Hydrogen Sulphide

At site A of location 2, the distribution pattern is platykurtic (flat) for all the periods, morning, afternoon and evening with the kurtosis index as -1.6, -1.0 and -0.23 respectively. Of these three periods, distribution in the evening is closest to normal distribution (mesokurtic). This distribution pattern is attributed to burning of solid wastes and fossil fuels, smokes from the kitchen located at the area and decay of organic matter from gutters and dump site of wastes (Howard *et al*., 1985).

Analysis of variation of the gas for the three periods indicated no significant variation at ($P<0.05$) as presented in Table 4.18. This indicates that the gas concentration was fairly constant for the day.

The distribution pattern of site B of location 2, is platykurtic (flat) for all the periods having their kurtosis index of -1.8, -1.1 and -0.49 respectively. This shows a more closeness to a normal (mesokurtic) distribution at the evening period considering the kurtosis index. This pattern of distribution may be attributed to poor ventilation; along side the emissions from the use of generator and other gasoline powered equipment.

Analysis of variation of the gas for the three periods indicated no significant variation at ($P<0.05$) as presented in Table 4.18. This indicates that the gas concentration was fairly constant for the day.

The site C of location 2 pattern of distribution is leptokurtic (peaked) having a kurtosis index of 12.1 platykurtic (flat) for both afternoon and evening hours having the kurtosis index as -0.95 and -1.7 respectively. The distribution pattern may be attributed to emission from the use of generator and other gasoline powered equipment, burning of solid waste and fossil fuels (Alberta, 2006).

Analysis of variation of the gas for the three periods indicated no significant variation at ($P<0.05$) as presented in Table 4.18. This indicates that the gas concentration was fairly constant for the day.

4.7.3 Sulphur Dioxide

The distribution pattern at site A of location 2 is leptokurtic (peaked) for all the periods with kurtosis index of 2.0, 1.9 and 1.9 for morning, afternoon and evening hours respectively. When the pattern of distribution is compared, it is closer to a normal (mesokurtic) distribution at the afternoon and evening hours respectively to the others. The pattern of distribution may be attributed to partial combustion of coal, wood from the kitchen located around the area, burning of solid wastes, decay of organic matter from dump sites and emission from motorcycle and cars due to vicinity of the site to the road.

Analysis of variation of the gas for the three periods indicated no significant variation at ($P<0.05$) as presented in Table 4.18. This indicates that the gas concentration was fairly constant for the day.

At site B of location 2, the distribution pattern is leptokurtic (peaked) for all the hours. The kurtosis index is 5.9, 0.15 and 0.12 for morning, afternoon and evening hours respectively. This observed distribution pattern is closer to normal (mesokurtic) in the evening hour when the three periods are compared using their kurtosis index. Distribution pattern may be attributed to partial combustion of fuel from generating set and other gasoline powered equipment.

Analysis of variation of the gas for the three periods indicated no significant variation at ($P<0.05$) as presented in Table 4.18. This indicates that the gas concentration was fairly constant for the day.

The distribution pattern of site C of location 2 is platykurtic (flat) at the morning hour with kurtosis index of -0.40. The pattern of distribution for the afternoon and evening are leptokurtic (peaked) with kurtosis index as 0.71 and 0.45 respectively. Distribution during the morning hour is closer to normal (mesokurtic) based on their kurtosis index when compared with the afternoon and evening hours respectively. The distribution pattern may be attributed to burning of fuel from the use of generator and other gasoline powered equipment. This could also be linked to improper disposal of animal wastes and decomposition of organic matter from damp sites. (Howard *et al*.;1985).

Analysis of variation of the gas for the three periods indicated no significant variation at ($P<0.05$) as presented in Table 4.18. This indicates that the gas concentration was fairly constant for the day.

Table 4.19: Tables for Cluster Analysis

Location 1- Average Linkage (Between Groups)				
Agglomeration Schedule				
		Cluster Combined		
Time	**Stage**	**Cluster 1**	**Cluster 2**	**Coefficients**
6.30am	1	2	4	1.050
	2	1	2	3.883
	3	1	3	9.061
1.30pm	1	2	4	2.819
	2	1	2	6.091
	3	1	3	7.000
6.30pm	1	1	4	1.306
	2	1	2	4.641
	3	1	3	8.471
Location 2- Average Linkage (Between Groups)				
6.30am	1	1	3	3.196
	2	1	2	7.402
1.30pm	1	1	2	2.218
	2	1	3	7.891
6.30pm	1	1	2	3.320
	2	1	3	7.340

Key

Cluster	**Sites**
1	**A**
2	**B**
3	**C**
4	**D**

4.8 Cluster Analysis

Cluster analysis or clustering is the assignment of a set of observations into subsets (called *clusters*) so that observations in the same cluster are similar in some sense. There are numerous ways in which clusters can be formed. Hierarchical clustering is one of the most straightforward methods. It can be either agglomerative or divisive.

Agglomerative hierarchical clustering begins with every case being a cluster unto itself. At successive steps, similar clusters are merged. The algorithm ends with everybody in one jolly, but useless, cluster. Divisive clustering starts with everybody in one cluster and ends up with everyone in individual clusters. Obviously, neither the first step nor the last step is a worthwhile solution with either method.

In agglomerative clustering, once a cluster is formed, it cannot be split; it can only be combined with other clusters. Agglomerative hierarchical clustering does not let cases separate from clusters that they have joined, once in a cluster; always in that cluster.

This cluster analysis is to shows the relationship between Sites in the distribution pattern of the gases. The clusters with the least coefficient indicated a greater relationship and that the activities in those cluster are similar.

Considering location one (Sabon-Gari market), at the morning hour (6:30am), sites B and D shows higher similarity in distribution pattern with its cluster coefficient as 1.050 when compared to sites A and B, likewise to sites A and C with coefficient as 3.883 and 9.061 respectively, as seen in Table 4.19.

This observed distribution pattern may be attributed to the similarity in nature of activities especially at sites B and D which shows highest similarity as both sites are T-junctions with low traffic flow and heavy vehicular movement.

At the afternoon hour (1:30pm), sites B and D with cluster coefficient of 2.819 compared to sites A and B and sites A and C with coefficient 6.019 and 7.000 respectively indicated the sites with highest similarity in their distribution pattern as seen in Table 4.19. This observation may be due to the similarities of activities in those sites.

At the evening hour (6:30pm), the site with highest similarity in terms of distribution pattern is indicated as sites A and D with the lowest coefficient as 1.306 compared to sites A and B and sites A and C with 4.641 and 8.471 as their cluster coefficient respectively, as seen in Table 4.19. This observed distribution pattern may be attributed to heavy vehicular movement and slow traffic especially at sites A and D which are both T-junctions and exit routes respectively from the market.

Considering location two (Aliyu Mustapha Social Centre), at the morning hour (6:30am), sites A and C with coefficient 3.196 shows greater similarity in the distribution pattern when compared to sites A and B with coefficient 7.402 as seen in Table 4.19.

This observed pattern may be linked to the vicinity of site A to the road where there is increased vehicular and motorcycle emissions during the period and high usage of generator and gasoline powered equipment evident in site C at this hour as well.

The afternoon hour (1:30pm), shows a greater similarity at sites A and B with coefficient 2.218 when compared to sites A and C with coefficient 7.891 as seen in Table 4.19 since it has the least coefficient. This observed pattern of distribution may be attributed to similarity in activities at the sites during this hour.

The evening hour (6:30pm), indicates sites A and B with coefficient 3.320 as the sites with highest similarity in distribution pattern when compared to sites A and C with coefficient 7.340 as seen in Table 4.19. At this hour, there seems to be less activities at site C and rather an increase activities at sites B and A respectively observed during sampling thus, may be linked to these observations.

4.9 Discussion for Trace Metals

Table 4.20: Physiochemical Parameters of the Street Dust Sample

Sites	pH	Clay(%)	Silt(%)	Sand(%)	O.C(%)	NH_3(%)	NO_3^-(%)	Cl^-(mg/l)	AP(mg/l)
A	7.15	12.00	8.00	80.00	5.83	0.0105	0.042	10.00	87.50
B	7.81	10.00	14.00	76.00	3.09	0.0320	0.025	3.45	66.50
C	7.64	12.00	10.00	78.00	5.12	0.0105	0.039	5.00	42.00
D	8.10	12.00	10.00	78.00	3.52	0.0280	0.039	3.25	61.25

Table 4.21: Correlation matrix among physicochemical parameters in street dust sample

	pH	CLAY	SILT	SAND	O.C	NH_3	NO_3^-	Cl^-	AP
Ph	1.000								
CLAY	-0.226	1.000							
SILT	0.529	-0.927	1.000						
SAND	-0.677	0.816	-1.0**	1.000					
O.C	-0.865	0.668	-0.825	0.862	1.000				
NH_3	0.761	-0.689	0.770	-0.772	-0.975*	1.000			
NO_{3-}	-0.380	0.983*	-0.98*	1.00**	0.758	-0.744	1.000		
Cl^-	1.000**	0.418	-0.717	0.849	0.876	-0.749	0.574	1.000	
AP	-0.555	-0.078	-0.266	0.458	0.232	-0.010	0.091	0.667	1.000

**Correlation is significant at 0.01, *Correlation is significant at 0.05 and AP is available phosphorus

4.9.1 Physicochemical parameters of Dust sample

Table 4.20 shows the result of the physicochemical parameters of street dust within the study area. The percentage particle size distribution ranges are 10-12%, 8-14% and 76-80% for clay, silt and sand respectively. Generally, the texture class of the dust sample was mainly loamy sand. The pH varied from 7.15-8.10 which indicates neutral to slightly alkaline conditions. This is within the range reported by Abechi *et al*.,(2006). The pH serves as useful index for availability of nutrients, the potency of toxic substances present in the soil and the physical properties of the soil. Several studies have shown that availability of heavy metals is pH dependent (Iwegbue *et al*.,2006; Gonzalex-Fernandez *et al*., 2008). The pH values of the study areas indicated tendency for availability of these heavy metals.

The organic content ranged between 3.09-5.83% for the study area. The different in the % Organic carbon content within these sites could be due to the activities involved such as sales of groundunt oil and petroleum products which release hydrocarbon waste.

The level of phosphate, chloride, ammonia and nitrate ranged from 42.0- 87.50mg/L, 3.25-10.0mg/L, 0.011-0.032% and 0.025-0.042% respectively.

Table 4.21 presents correlation coefficient between the physicochemical parameters of the dust samples. As may be seen in the table, significant at ($P<0.05$) positive correlation were found between nitrate and clay and at ($P<0.01$) confidence level between nitrate and sand. Other relationships among physicochemical parameters are not significant.

Table 4.22: Heavy Metal concentrations in street dust samples (Mean ± SD) µg g^{-1}

Sites	Cr	Ni	Cd	Pb	Fe
A	21.65 ± 0.60	6.04 ± 0.58	0.61 ± 0.06	48.58 ± 0.55	315.61 ± 1.15
B	33.82 ± 0.55	3.05 ± 0.56	0.50 ± 0.02	68.64 ± 0.57	240.91 ± 0.58
C	18.77 ± 0.58	3.59 ± 0.58	1.45 ± 0.55	121.35 ± 0.58	241.19 ± 0.57
D	16.92 ± 1.00	3.83 ± 0.55	0.40 ± 0.05	25.79 ± 0.55	265.42 ± 1.14

A, kasuwa mata; B,Samaru Bus stop (Lagos street junction); C,Inside market (Boutique and foodstuff); D, Yoruba road junction.

4.9.2 Heavy metal concentration in street dust

As shown in Table 4.22, the highest level of chromium (Cr) in street dust samples were found in site B (mean = 33.82μgg^{-1}); while the lowest is found in site D (mean = 16.92μgg^{-1}). The level of chromium in the investigated area was generally lower than the set standards by world health Organisation (WHO).

For nickel (Ni), the values in the dust samples were found to be within the range 3.05 – 6.04μgg^{-1}. The highest mean value of nickel was found in the sample from site A while the lowest in site B. the mean concentration of nickel was lower than the world-wide value (50-100μgg^{-1}) (Fergussion and Kim, 1991), thusb did not pose any health risk.

The highest mean cadmium (Cd) concentration was found in site C (mean = 1.45μgg^{-1}) with the minimum at Site D (mean = 0.40μgg^{-1}). The levels of cadmium in the samples were generally lower than the world wide value (0.5-4.0μgg^{-1}; Fergusson, 1991).

The highest lead (Pb) values has been detected in street dust samples collected from site C (mean = 121.35μgg^{-1}). The minimum was found in site D (mean = 25.79μgg^{-1}). The mean concentration of lead for street dust samples was lower than for dust samples reported by other literature, such as 697.2μgg^{-1} for Bahrain, 265μgg^{-1} for Manchester,UK, and 236μgg^{-1} for Amman, Jordan. It is as well within the permissible limit and does not pose any health problem.

The highest level of iron (Fe) was found in dust samples from Site A (mean = 315.61μgg^{-1}) and the lowest at site B (mean 240.9μgg^{-1}). Though, at this site the mean concentration of iron of the samples is higher than those reported by Abechi *et al*.,2010 (141.80 – 159.00μgg^{-1}). This is perhaps because Fe forms a major composition of soils in northern Nigeria.

4.9.3 Mean concentration of metals in the street dust samples across the sites.

The average of triplicate determinations of metal concentration (Cr, Ni, Cd, Pb and Fe) in street dust of the varrious sampling sites is presented in μg/g in figures 3-7.

The level of chromium from all the sites ranged from 17.0 (site D) to 34.0μg/g (site B). The level of chromium in all the sites were generally lower than those determined in other cites in developed countries (El-Sayed *et al*., 2010). Although chromium is a major part of automobile bodies, it's concentration in the samples are not considered dangerous (El-Hassan *et al*., 2006).

The values of Ni in dust samples were found to be within the range 3.0 to 6.0μg/g. The highest mean value of nickel was found in the street dust sample of site A, while the lowest was at site B. The mean concentration of observed is lower than the world-wide values 50-100 $\mu g g^{-1}$ (Fegusson and Kim, 1991). Nickel pollution on a local scale is caused by emission from vehicle engines that use nickel gasoline and by the abrasion and corrosion of nickel from vehicle parts (Al-Shayep and Seaward, 2001).

The concentration of cadmium obtained for all the sites ranged from 0.4 at Site D to 1.47μg/g at site C. The dust sample in this study showed higher levels of cadmium contamination than 0.75μg/g (Jaradat and Momani, 1999), 2.11μg/g (Amusan *et al*., 2003). In the absence of major industry in the sampling sites, the levels of cadmium could be due to lubricating oils and/or old tires that are frequently used on the roads which increase the wearing of tires.

The street dust lead level ranged from a low concentration of 20.5μg/g at site D to a high concentration of 120 μg/g at Site C. The high mean value of the concentrations attested to the use of leaded fossil fuel, which consequently settles on roadside soils. Similar results were found in other parts of the world (Caselles *et al*., 2002; Pouyat *et al*., 1995). This also is in agreement

with the report of Abechi *et al*., (2009). The case of site C being more predominant could be attributed to the mini park for motorcycle. Conversely, site D had the least concentration value of Pb (20.5µg/g) and can be attributed to fewer activities when compared to site C, though, the high mean dust lead level confirms that the roadside environment is generally lead enriched despite a relatively low traffic compared to other studies (Ho *et al*; 1987).

Iron values in the dust samples were found to be in the range of 220-320µgg^{-1}. The lowest mean value of iron was found in the samples from site B and C while the highest was in site A. The study area showed elevated concentrations of iron. This may be attributed to facts that, iron forms a major natural constituent of the soil in northern Nigeria (Abechi *et al*., 2010) and did not reflect any specific anthropogenic source in sites.

4.9.4 Correlation between Heavy Metals Concentrations in Street Dust Samples

In this study, the raw geochemical data was used in calculating the correlation coefficient using the SPSS (Statistical program for the social sciences) computer software package (SPSS Inc., version 16). This coefficient measures the strength of a linear relationship between any two variables on a scale of -1 (perfect inverse relation) through 0 (no relation) to +1 (perfect sympathetic relation).

The correlation coefficient statistical analysis conducted on the metal concentrations indicates a significant positive correlation relationship between Pb and Cd (r = 0.928) at 95% confidence level and between Cd and Cr (r = 0.200), Pb and Cr (r = 0.400), Fe and Cr (r = 0.400) and Fe and Ni (r = 1.000) at 99% confidence level. This relationship indicates the interdependence of these metal pairs and could be attributed to the presence of these metals in similar source (i.e. the body parts and tires of automobiles as well as vehicular emissions). No

relationship correlation is seen between Cd and Ni (r = 0.000) and negative correlation relationship between Ni and Cr (r = -0.400), Pb and Ni (r = - 0.335) and Fe and Pb (r = - 0.430), this indicates that other sources other than automobile emission, wear and tire of body parts and tires could contribute to concentration of these metals in the street dust.

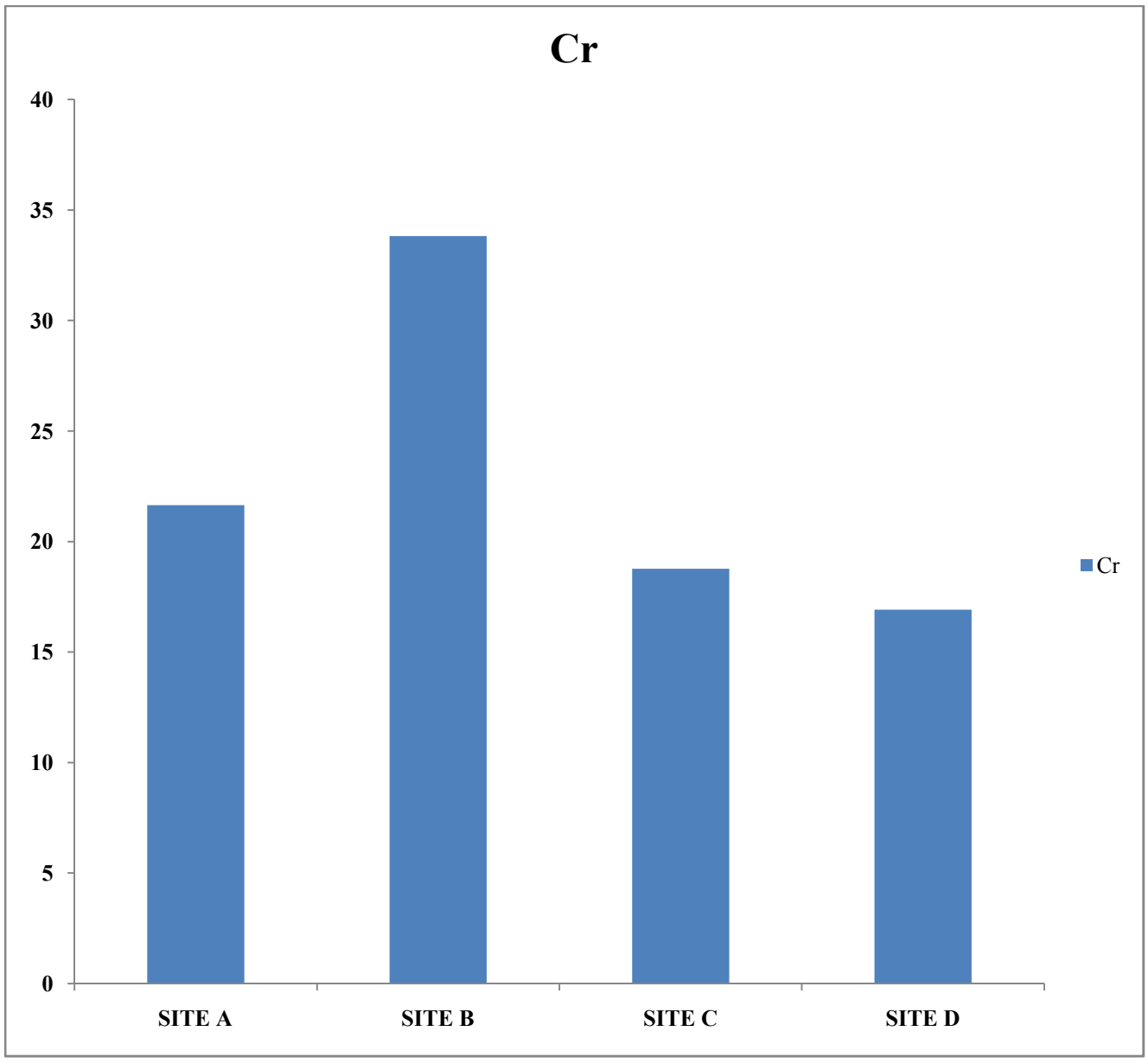


Figure 4.1: Mean concentration (µg/g) of the Cr in the dust sample across the sites.

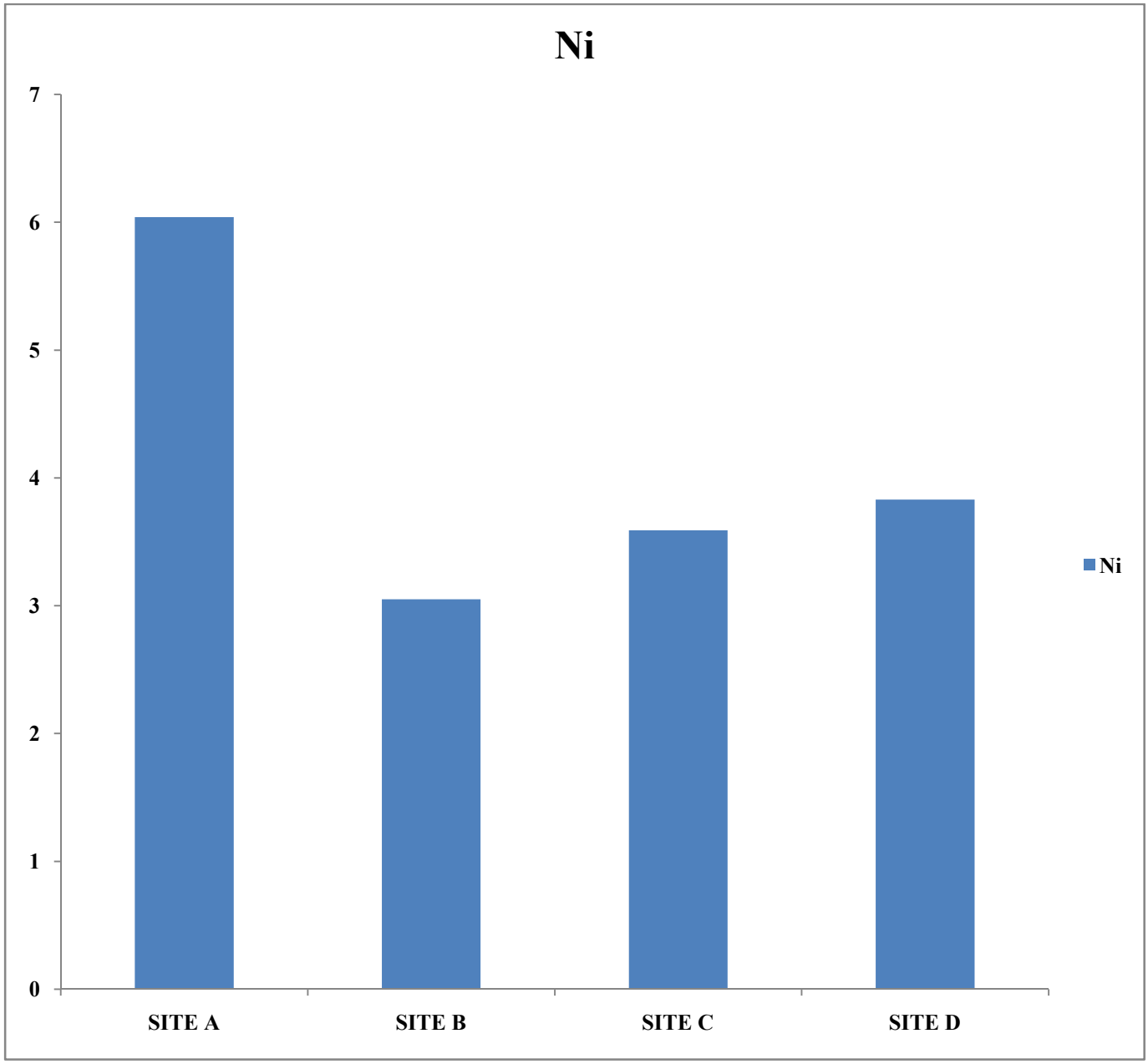


Figure 4.2: Mean concentration (µg/g) of the Ni in the dust sample across the sites.

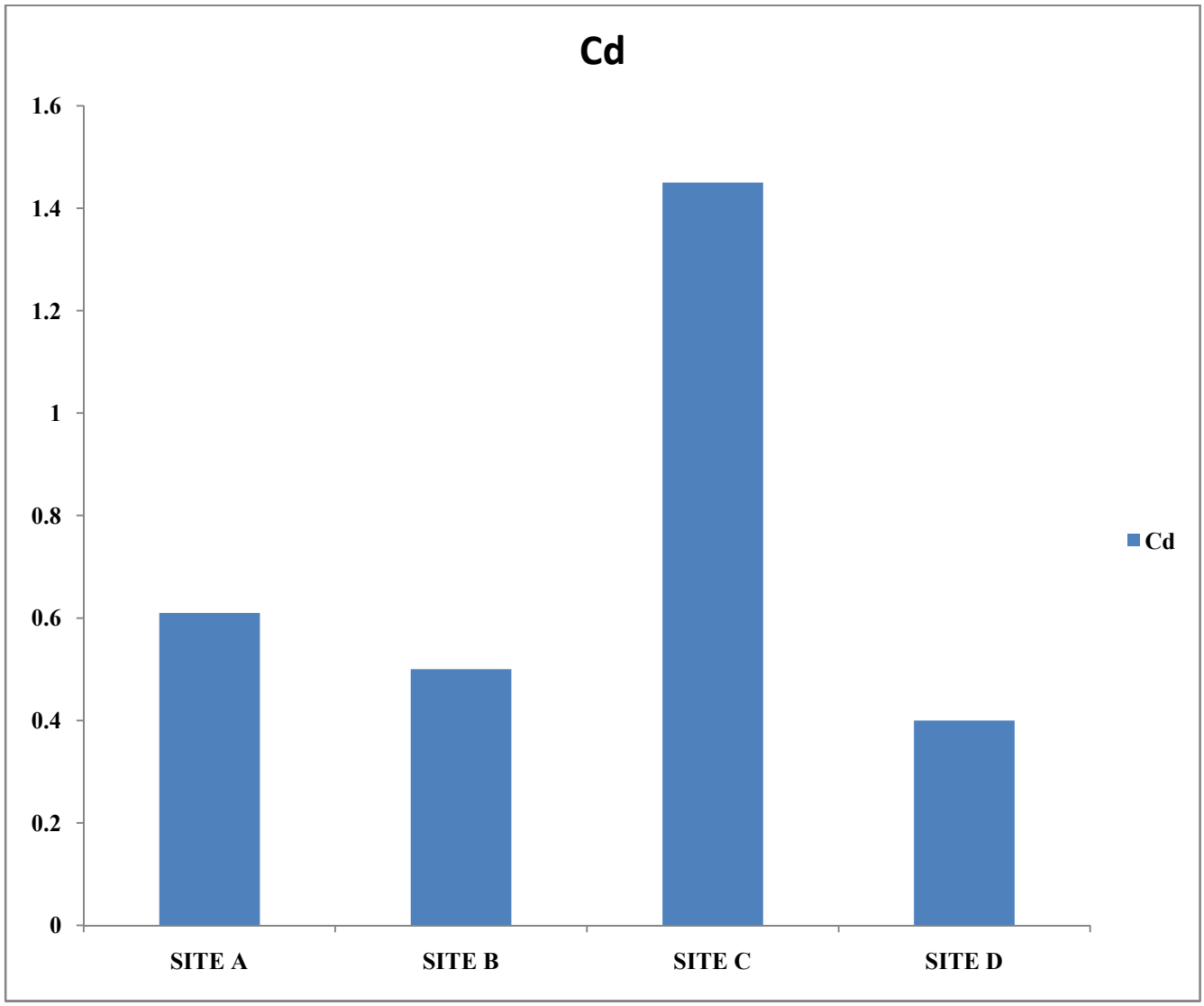


Figure 4.3: Mean concentration (µg/g) of the Cd in the dust sample across the sites.

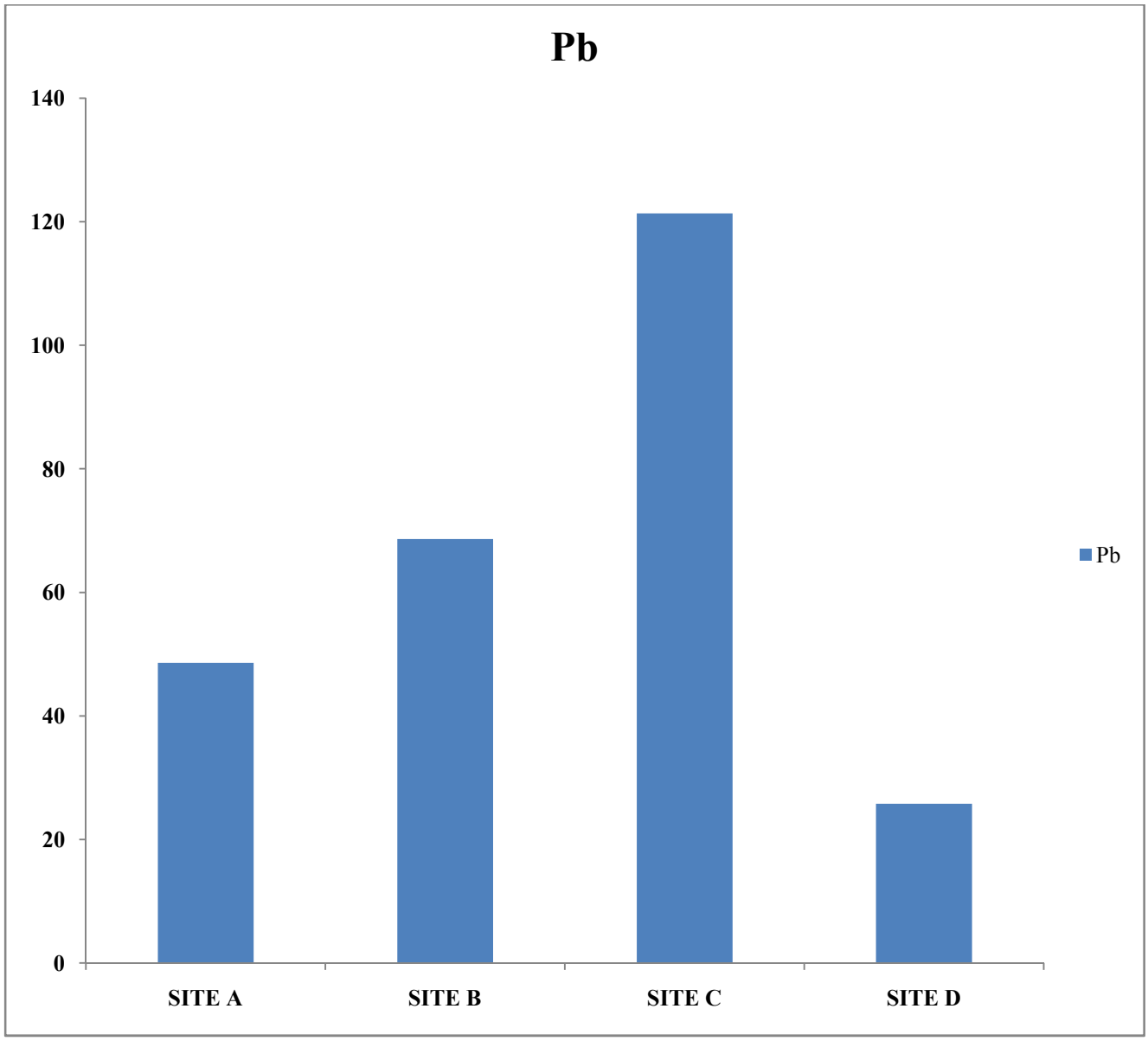


Figure 4.4: Mean concentration (µg/g) of the Pb in the dust sample across the sites.

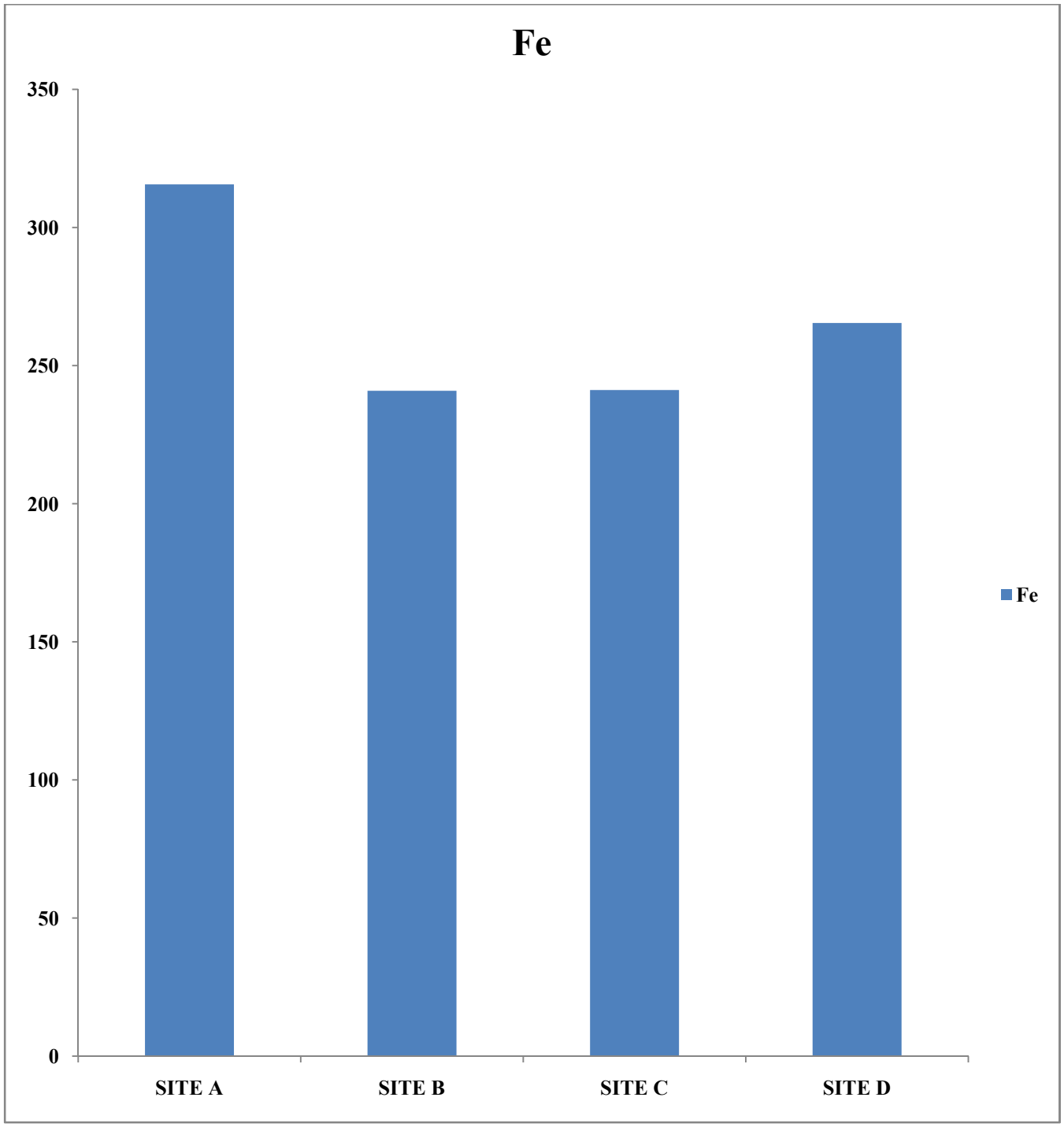


Figure 4.5: Mean concentration (µg/g) of the Fe in the dust sample across the sites.

Table 4.23: Correlation Matrix between Heavy Metals in the Street Dust Sample

Element	Cr	Ni	Cd	Pb	Fe
Cr	1.000				
Ni	-0.400	1.000			
Cd	0.200**	0.000	1.000		
Pb	0.400**	-0.335	0.928*	1.000	
Fe	0.400**	1.000**	0.000	-0.430	1.000

**Correlation is significant at 0.01, *Correlation is significant at 0.05

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The result of the studies conducted is serving as the base data for gaseous pollutant level at the location in Zaria and showed that the concentration of the gaseous pollutant do not pose an immediate threat to humans and the environment, however, it is necessary to check periodically the levels of these pollutant especially sulphur dioxide (SO_2) which rate very poor (E) for all the sessions at all the sites in location 1 and 2 respectively except for the morning hours where best rating is poor (D) for all the site in location 2, for their increase or decrease. These results can serve as evidence to policy maker to enacting laws and regulations that could serve to checkmate further pollution activities and provide treatments to polluted air.

The concentration of heavy metal Cr, Cd, Ni, Pb and Fe and their contamination levels in street dust collected from Sabon- gari market has being studied in this work. The concentrations of the metal in the soil are in the order of Fe>Pb>Cr>Ni>Cd. This order is in congruency with those reported by Abechi *et al*., 2010. The level of Fe at the moment is high compared in other studies in Nigeria this is perhaps because Fe forms a composition of soils in Northern Nigeria (Abechi *et al*., 2010). Hence, possible accumulation in the soil and inhalation by human around could occur as a result of continual usage of the road by automobiles and motorcycles. This can thus lead to accumulation of metal in the tissue of human.

The distribution and concentrations of heavy metals in all the sites shows that automobile originated sources (emission or by wear and tear of different parts of the car) are the main source of pollution.

It is hereby suggested that, for a cleaner environment in air quality, proper air quality management programmes; improve traffic flow and control which requires good road network, improve fuel quality through reduction of sulphur, proper legislative frame work to regulate and control emission and finally with proper implementation of these control measures be encouraged.

5.2 Recommendations

- A comparative analysis should be carried out to correlate the use of chemical and automatic method for gaseous pollutants determination, to ensure a better air quality assessment method.
- Periodic analysis should be embarked on for air quality analysis in the study area and other areas to be able to monitor the pollution level.
- Other gaseous pollutant aside CO, H_2S and SO_2 can as well be monitored to be abreast of their pollution levels.
- Most individuals spent long hours n their work places, it is thus suggested that further studies be carried out to ascertain air quality in work place atmosphere with particular reference to densely populated workplaces like, lecture Halls, factories e.t.c.

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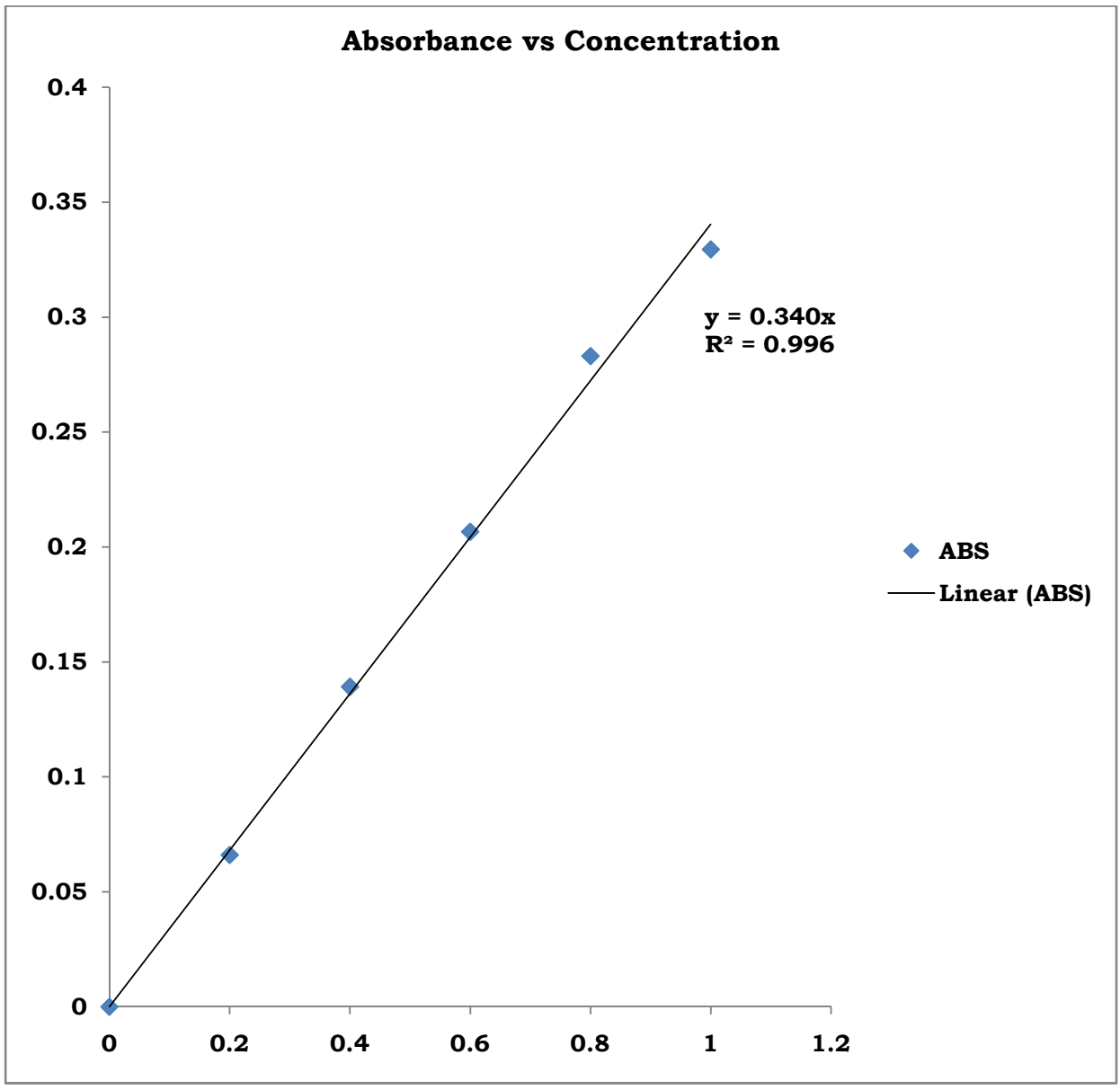
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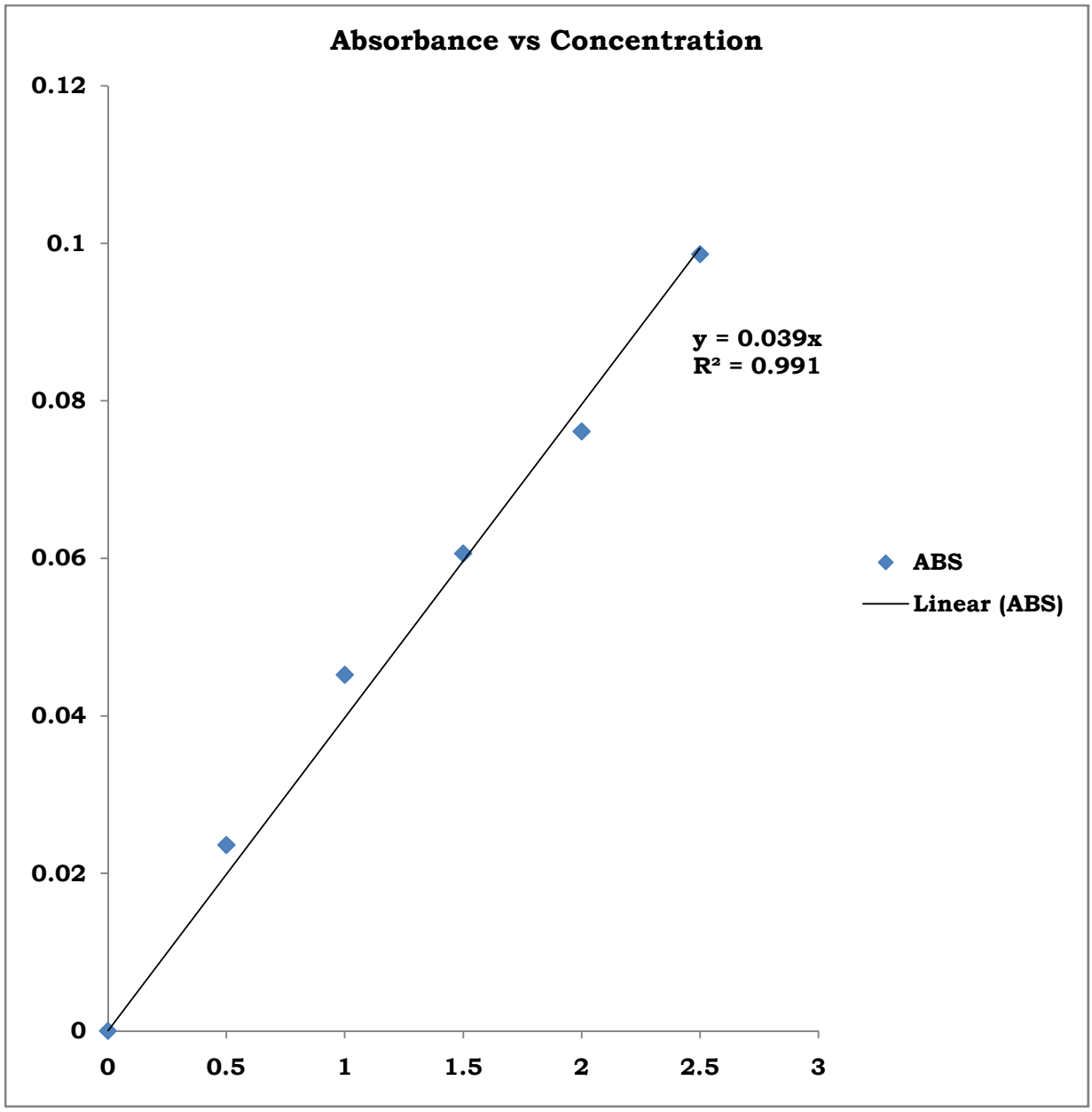
APPENDIX 1

Calibration Curve for Cadmium (Cd)



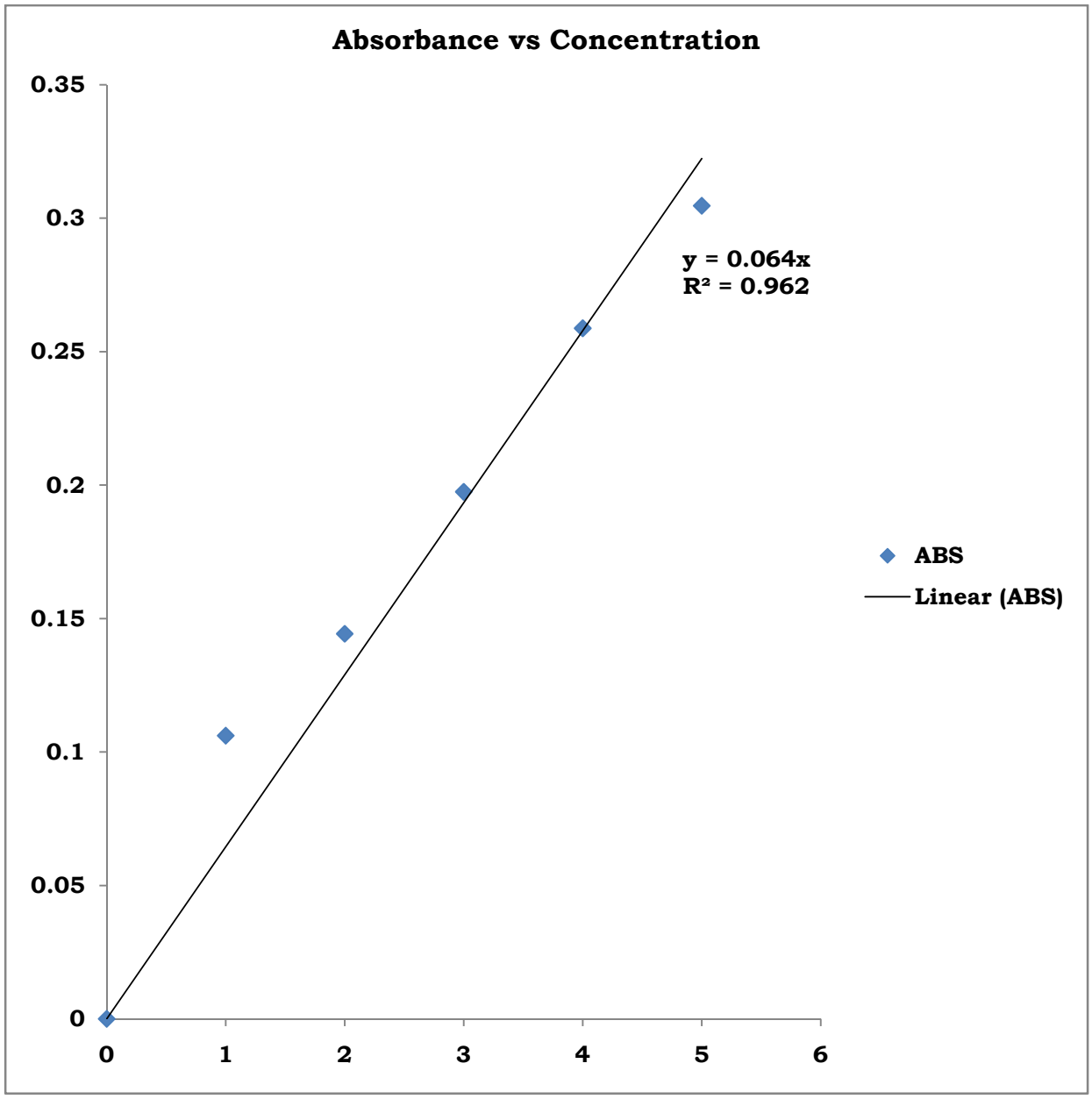
APPENDIX 2

Calibration Curve for Chromium (Cr)



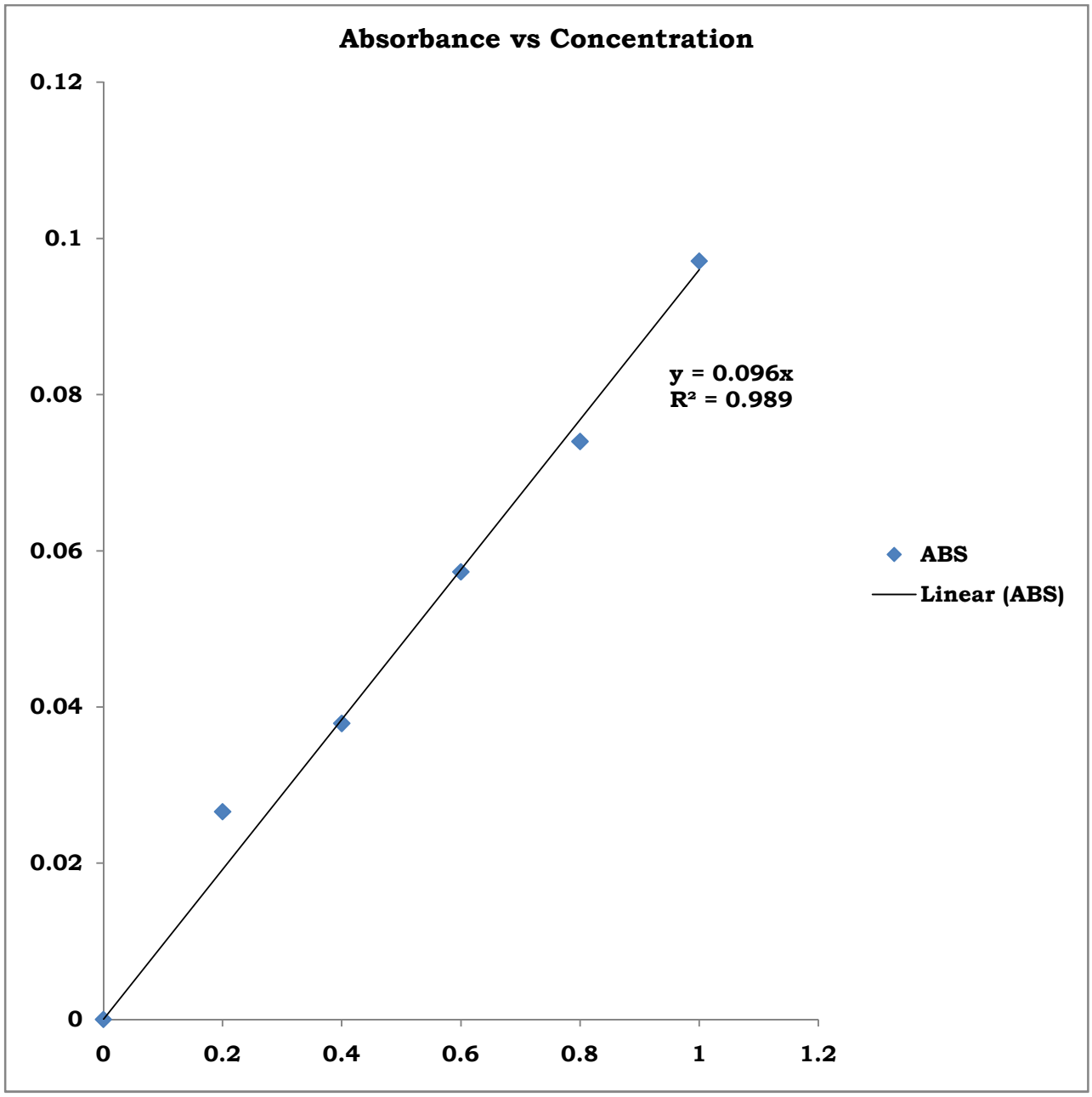
APPENDIX 3

Calibration Curve for Iron (Fe)



APPENDIX 4

Calibration Curve for Nickel (Ni)



APPENDIX 5

CALIBRATION CURVE FOR LEAD (Pb)

