COMPARATIVE ASSESSMENT OF SOIL AND SELECTED CROP IN CEMENT POLLUTED ENVIRONMENT IN OKPELLA, EDO STATE, NIGERIA

BY

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A PROJECT WORK SUBMITTED TO THE DEPARTMENT OF PHYSICAL SCIENCE LABORATORY TECHNOLOGY, IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF THE HIGHER NATIONAL DIPLOMA (HND) IN CHEMISTRY/BIOCHEMISTRY, SCHOOL OF APPLIED SCIENCES AND TECHNOLOGY, AUCHI POLYTECHNIC, AUCHI, EDO STATE.

IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF HIGHER NATIONAL DIPLOMA (HND) DEPARTMENT OF PHYSICAL SCIENCE LABORATORY TECHNOLOGY

NOVEMBER, 2022

CERTIFICATION

This is to certify that this project work was carried out by **Osilukpon Deborah** with Matriculation number **AST/ 2372051957**, and that the work meets the regulations governing the award of Higher National Diploma (HND) in Physical Science Laboratory Technology, Auchi Polytechnic Auchi.

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DR. JEJE O. AYORINDE **DATE**

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DEDICATION

This project work is specially dedicated to God Almighty who is my source of strength, understanding and the giver of life.

ACKNOWLEDGEMENTS

My profound gratitude goes to God Almighty for the strength and understanding he bestowed on me during the course of my Academic pursuit and this project work.

Special thanks go to my project supervisor, **Dr. Jeje O. Ayorinde** for his guidance and support during the course of writing this project work, I am grateful sir.

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Not forgetting my lovely parents and siblings I say thank you for your immerse in prayers and financial support. God bless you.

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ABSTRACT

The aim of this paper is to illuminate the impacts of cement production emissions on the work has shown in Okpela, Edo State, suffer the most from environmental pollution especially air pollution. One of such contributing factors is the behavioural pattern of workers and traders living close to production plants.

Significantly also, data are not available in this region. The need for cement as well as the presence of local raw materials, coupled with the need for local content has resulted in an increase in the number of cement plants. Areas within and around the cement plant are exposed to various air pollutants. These pollutants affect the life and wellbeing of workers, children and people in close communities as well as the flora and fauna. Diseases such as chronic obstructive pulmonary, silicosis, preterm delivery, psychasthenia, endocrine disruption, cancer and infertility are associated with these pollutants. This paper describes the impacts of these pollutants on human's health and plant's growth as well as where studies should focus on in the future. Various high impact papers were selected and cogent findings as it affects different classes of people were discussed in this paper. It is recommended that more data collection, pollutant characterization, risk assessment and dispersion analysis should be carried out in developing countries. More research should be undertaken to determine the impact of alternative fuel and the effectiveness of dust control technologies used in various cement plants.

CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUNG

Soil is the part of the earth's surface consisting of humus and disintegrated rock, it is the layer of earth crust that serves as a natural medium for the growth of plants. Industrialization and urbanization is reducing the cultivable land at a faster rate. At one side there is a growing demand of crops and vegetables for growing population, which require more land available for the cultivation, on the other side, the same population requires land for making homes and industries to fulfill their other requirements. In most countries, after so much cry about the industrial pollution, industries were pushed back to rural areas to avoid the pollution problems to the congested urban population. Industries shifted in the rural areas emitting all types of pollution deteriorating the surrounding environment. Soil quality is also degrading because of pollution from air and water discharge, farmers complaining about the reduction in crops yield because of poor quality of soil (Zerrouqi, Sbaa and Ouijidi 2018).

Data released by the World Health Organization (WHO) in 2018, showed that 9 out of 10 people inhaled air that contains high levels of pollutants above the safe limit defined by the WHO. It has been established globally that about 7 million people die annually from polluted air related cases. The impacts are more critical in Asia and Africa, where 90 % of the air pollution related deaths have been recorded. Pollution index obtained from Numbeo, showed that Asia has a high pollution index while only a few countries in Africa have enough data for these analyses. Some countries in the regions where data are available indicated pollution index from average to maximum. Regions with above average pollution index include Africa, South America and Asia. This is due to the growth in industrialisation and urbanisation, fuel sources and bush burning, little or reduced regulation and enforcement (Karagulian *et al.*, 2015). The effects of this high pollution index across different regions were documented by WHO.

Ischaemic heart disease is the highest recorded effect of pollution on human health as at the year 2018. Globally, different pollutants are responsible for these diseases. This problem is not only in urban or industrialised area, as observed in Africa. In Africa, household pollution from cooking and burning of fossil fuel even in rural areas contributes to this issue. Different sectors and processes contribute to the emission of different air pollutants, and their contribution varies from region to region and therefore, country to country. Different pollutants are responsible for air pollution but the most common include, particulate matter (PM), oxides of nitrogen (NO_X), carbon monoxide (CO), sulfur dioxide (SO_2) and volatile organic compounds. The European Environment Agency reported that commercial, institutional and household activities contribute the highest for PM_{10} emission, followed by industrial emission. $PM_{2.5}$ is released majorly from commercial, institutional and household, followed by road transport and industrial processes in the year 2013, (Karagulian *et al* 2015).

One major source of pollution is industrial processes and consequently, one of such industrial processes includes the cement production. A single cement plant emits a large amount of pollutants into the atmosphere. Furthermore, an increase in production output or change in fuel type and usage as well as dust control technology affects the volume and concentration of contaminant released. Several studies and reports have recognized cement production as the biggest source of PM emission accounting for 20–30 % which is 40 % of the total industrial emission (Sanchez-soberan *et al.*, 2016).

Orchard Plant leafs on research area side.

Global increase in urbanisation has led to an upsurge in cement demand (Adeniran., Yusuf., 2018). The need for local content, availability of raw materials and local demand has resulted in the establishment of more cement plants. Globally, it was estimated that 2.18 billion tonnes of cement was produced in 2012 while 4.3 billion tonnes of cement were produced in 2014. Several works and reports have shown that China is the leading manufacturer of cement, accounting for 59.31 % of the total cement produced worldwide (Lafarge Africa 2019).

One of the major pollutants associated with cement production is its greenhouse gas (GHG) emission, and this accounts for about 5–7 % of global anthropogenic Carbon dioxide (CO_2) emission (Shen *et al.,* 2017). The contribution of this industry to CO_2 production and proposed mitigation processes have been well detailed. The amount of CO_2 emitted by the cement industry is based on the demand for cement, kiln type, fuel used, efficiency of energy utilization as well as clinker to cement ratio. Different articles have reported that CO_2 emission from cement plants is not the only pollutant discharged into the atmosphere. In Nigeria, 4 % of SO_2, 15–30 % of PM and 10 % of NO_X released into the atmosphere annually were generated by

the cement industry (Arfak Y, 2018). In addition, 0.89, 1.69 and 3.58 million tonnes of SO_2, NOX and PM were discharged in the atmosphere in Africa alone in 2009 (Chen, Hong, Xu 2015). While in 2012, 1.09, 1.98 and 0.67 million tonnes of SO_2, NO_X and PM respectively were emitted in Nigeria alone. Different studies mentioned that for every 1380 Million tonnes of $C0_2$ emitted, 410, 1.3 and 2.27 million tonnes of PM, SO_2 and NO_X respectively were also released. Through raw materials and fuel used during production, 1.17–1.53 tons of mercury were emitted annually accounting for 10 % the total mercury released globally (Won, Lee, 2012). Due to effective pollution management, the emissions from cement plants are reduced. However, as cement production increase, even with reduced emission per plant or ton of cement produced, emissions would increase. A similar trend has been observed in various countries at different time frames. In Okpella, through effective management, such as kiln type changes, and reduced cement production, reduced SO_2 emission was recorded between the year 2010 and 2019. A historical trend of pollution from cement plant in Nigeria from 2011 to 2020 shows that as Nigeria production increased exponentially, pollution increased, heavy metal emitted each year also amplified (Zhang *et al*., 2019).

Dust released from different processes such as raw material handling, limestone crushing, kiln processing, clinker production and storage, finished cement grinding and power utilities. Different models and modelling tools such as fugitive dust model (FDM) and View emission dispersion modelling, have been used to examine pollution effects on neighbouring communities. Modelling of air pollution or quality in developing countries such as Nigeria is limited (Adetayo, Sunday and Ademola, 2019). Effective and unbiased monitoring of air quality around factories such as cement manufacturing plants is carried out by a handful of researchers in developing countries. Complaints of people or perceived health implications had necessitated such studies.

Different studies reported that residents around cement plants complained about air pollution (Kim *et al.*, 2015). In most cases, the thick layer of dust on parked cars or on roadways

as well as dirty atmosphere created chaos and public outcry among residents near the plant. In most cases, these residents are unaware of the dangers associated with cement dust in their environment.

1.2 STATEMENT OF PROBLEM

The people leaving in Okpella are continuously exposed to different pollutants of which they lack a basic understanding. Various researchers have worked on the environmental impact of cement plants built within residential communities or residential communities built so close to cement plants. Their findings have not been limited to the effects on human beings but also included the effects on plants and in a few cases, on the aquatic environment. In these communities, children are the most vulnerable (Arfak, 2018). There is a need to highlight various research works on the environmental impact of cement pollution.

1.3 AIM OF STUDY

The aim of this study is to give a comparative assessment of soil and selected crop on cement polluted environment, pollutant emission sources, effects on humans and plants using Okpella community as a case study.

1.4 OBJECTIVE OF STUDY

The objective of this research is to investigate the extent of pollution cement cause on both humans and plants in okpella, Edo State.

Specific Objectives are:

1. To determine the impact of cement industry on soil morphological characteristics in Okpella.
2. To determine the physicochemical and agrochemical properties of crops in Okpella.
3. Characterize the samples using fourier-transform infrared spectroscopy (FTIR).

1.5 SCOPE OF STUDY

The scope of the study is the assessment of soil on cement polluted environment in Okpella Community and to characterize the selected vegetables using FTIR.

1.6 JUSTIFICATION

The environment gets contaminated with a variety of pollutants generated from diverse sources (Industries, agricultural and domestic sources). Among the pollutants, pesticides, heavy metals, and cement dust are the major cause of concern because of their toxicity, persistency and tendency to accumulate in plants. Heavy metals such as lead, cadmium, and mercury do not have any biological significance or beneficial use because of their level of toxicity.

Ischaemic heart disease is the highest reciorded effect of pollution on human health as at the year 2018. Globally, different pollutants are responsible for these disease and this problem is not only in urban or industrialised area as observed in Africa. In Africa, household pollution from cooking and burning of fossil fuel even in rural areas contributes to this issue.

CHAPTER TWO

2.0 LITERATURE REVIEW

Today, the world's environment, especially soils, is becoming more and more polluted due to various industrial activities. In most especially, during the process of industrial waste, the discovery of natural deposits, the production of construction materials and their use in the national economy, there is a deterioration of agricultural lands and changes in a number of soil properties (Aslanov, Khasanov, Khudaybergenov 2021). Cement is the most widely used raw material in the construction industry. Historically, the demand for cement in many countries has increased in direct relation to economic growth. As a result of the increase in the world's population, the construction of industries aimed at meeting the demand for housing and daily needs has developed rapidly. This led to the increase in the production of cement, which is the main material in construction. Today, many developing countries are paying more attention to the rapid development of the cement industry in order to develop infrastructure. The average annual amount of cement production per capita on earth is about 1 ton (Groll, Kulmatov, Mullabaev, Opp, Kulmatora., 2016).

The raw materials used in the production of cement include the following carbonate-rich chalk, limestone, sand, oxides of CaO, Al_2O_3, SiO_2, Fe_2O_3. There are several types of cement depending on the technique and raw materials used for production. Cement production requires the following raw materials, mainly using the dry method (Table 1) (Batty, Dodge, Jiang, and Smith., 2018).

Table 1. Chemical composition of dust emitted from a cement kiln.

Chemical substance	Percentage	Chemical substance	Percentage
CaO	49.3	CuO	0.029
SO_3	3.56	Al_2O_3	4.24
SiO_2	17.1	NiO	0.012
BaO (μg/g (ppm))	78.2	Fe_2O_3	2.89
Xlorid	6.90	SrO	0.37
Cr_2O	3 0.011	K_2O	2.18
Zaxarli olov	15.8	TiO_2	0.34
MgO	1.14	V_2O_5	0.013
Na_2O	3.84	ZnO (μg/g (ppm))	65.8
P_2O	0.12	ZrO	0.011
Alkali (Na2O+0.658 K2O)	5.27		

Source: E3S Web of Conferences 2021

In recent years, industry in Uzbekistan is developing rapidly. The development of the industry is gratifying, of course, because new jobs are being created and it is economically viable, but as a result of the careless use of these industries, the environment is being damaged. As a proof of this, 5-7 % of the mixture of CO_2 gases released into the environment under the influence of anthropogenic factors accounts for the share of industry (Pedersen, and Zari, 2014). Globally, various harmful elements are released as a result of industrial pollution. Gas and dust generated by the cement industry are the main environmental pollutants. 87-91 % of the

substances released into the atmosphere during cement production are released into the environment in the form of 9-13 % gas in the form of dust (Table 2) (Pedersen and Zari 2014).

Table 2. Chemical composition of gas mixtures formed during cement production.

Chemical substance	Percentage
CO	0.75
CO_2	25.0
SO_2	1.00
O_2	4.50
H_2S	0.15
Cl	Trace

Source: sh.m.xoldorov@gmail.com

These particles and gases are distributed during the processing, grinding, grinding, packaging and delivery of raw materials. The main part of the harmful effects on the environment as a result of the cement industry is the cement dust, which emits high concentration of fluorine, sulfuric acid, hydrochloric acid, lead, zinc, copper and manganese. As a result of the production of 1 kg of cement, 0.07 g of dust is released into the atmosphere (Aslanov, Khasanov, Khudaybergenov, Groll 2021. Dust generated during cement production is dispersed by wind for short and long distances, depending on its size.

Hg, Zn, Pb, Cr and Cd are the common heavy metals released into the environment as a result of the activities of many cement plants (Bannari, Musa, Abuelgasim 2020), while Mercury and cadmium are the most harmful elements released into the environment as a result of the cement industry. The cement production process requires intensive energy consumption, resulting in the release of large amounts of CO_2 into the environment. CO_2 is mainly formed

during the extraction of calcium oxide and the processing of calcium raw materials (Leng, Zhang, Kulmator, Wang, 2021).

The mixture of harmful gases released into the atmosphere not only pollutes the atmosphere but also affects human health. Regional and global exposure to harmful gases results in global warming, ozone depletion, acid rain, biodiversity, and crop yields. Moreover, production in cement-producing areas has led to a decline in plant growth, reduced productivity and even death (Igbal, Shafig, 2014).

2.1 EFFECTS OF CEMENT POLLUTION ON PLANT

Humans are not the only ones affected by obnoxious substances released during cement production. Different research have shown that flora and fauna are also affected. Rai, (Cement 2012) stated that effects on plants (injury) are either acute or chronic. Acute injury results from short exposure to high concentration while chronic injury occurs due to exposure to low concentration for prolonged periods. Effects on plants vary from plant growth to productivity. The effect occurs from reduced light for photosynthesis, increase in leaf temperature and mineral availability, alteration of plant enzymes, and reduction in leaf size, number, and foliar area. All organisms' need certain elements in certain proportions, large doses are mostly detrimental. Negative effects observed include oxidative stress, damage of cell membranes, photosynthetic apparatus and photosystem, excessive production of reactive compounds, protein cleavage as well as chlorophyll biosynthesis. Cells have developed different mechanisms such as the enzymatic and non-enzymatic mechanism to cope with the various effects. They include catalase (CAT), peroxidase (POX) and superoxide dismutase (SOD) (Mutlu, Atici, Kaya 2019).

The activity of CAT, SOD, and POX as varied with different plants, especially when close to the pollution source. Erdal and Demirtas 2010 revealed that H_2O_2 levels were higher in plants within the polluted area. Malondialdehyde (MDA) was observed to increase as H_2O_2

increased. Kumar *et al.*, 2018 reported that lives around the cement plant suffer chlorosis and necrosis. Also, Salih *et al.*, 2013 revealed that the levels of P (phosphorus), K (potassium), S (sulfur), and Cl (chlorine) have been reported to be high around factories while Ca (Calcium) and Fe (Iron) elements reduced. This result in stunted growth, leaf resetting, chlorosis, brown-gray necrosis, reduced long term yield. All these elements are required in the plant at acceptable levels, but the constant emission of these elements affects the ability of the plant to internally process and survive on these elements.

Basically, plants require 0.1–0.5 % S, 0.3–0.5 % P and 2–5 % K of the plant dry weight. They also require 0.20–0.40 mg/g of Cl dry weight and 100 ppm Fe of dry matter. Excess or reduction of these elements amounts on plant significantly affects the growth and survival of the plant. Oran and Zahra 2014 observed that cement dust affects local plant species and diversity. Effects of cement dust were observed in beaches in which it was preventing the egg hatching of sea turtles. It is discovered that it prevented oxygen and carbon dioxide diffusion (Pilcher 2019). Alternative fuel sources contribute to air pollution, but the effect and risk associated with its pollutant do not increase diseases among residential areas near the plant. The developments of energy efficiency and CO_2 emission reduction models and scenarios have shown that the number of air pollutant would reduce. Zhang *et al.*, 2015 and project that PM, SO_2, and NO_X would be reduced by 2–5 %, 10–25 % and 8–20 % by the year 2030. In most cases, only one or two elements are above specified standards (Sanchez-soberon *et al*., 2015).

2.2 ASSESSMENT OF SOIL QUALITY NEAR A CEMENT INDUSTRY

Soil may be defined as a thin top layer of earth's crust, which serves as a natural medium for the growth of plants.

Unconsolidated mineral matter has been subjected to and influenced by environmental factors such as parent materials, climate, organism and physio-chemical action of wind, water and

sunlight, all acting over a period of time. Soil differs from parent materials in the morphological, physical and chemical properties.

• Study for impact assessment due to atmospheric pollution on the ecosystem has been demonstrated number of times.

• The main impact of cement industry is because of particulate matter and gaseous pollutants. The particulate matter are having different diameter and they are at the mercy of atmosphere.

• The pollutant from cement industries has lead atmospheric particles to have a consequence in the reduction of biodiversity and quality of products. The main visible pollutants generated by cement industry is particulate matter which is generated throughout the manufacturing process right from extraction of raw material to packing of finished product. It is important to understand that presence of sulfur dioxide in the soil may be entropic origin , that may be because of combustion of the fossil fuels (coke or oil) consumed by the industry and resulting the generation of sulfur dioxide.

• The particles that are generated from the cement industry can enter into the soil as dry, humid or occult deposits and may have impact on its physiochemical properties.

2.3 PHYSICOCHEMICAL ANALYSIS OF CEMENT POLLUTION

In a major research on the effect of pollutant substances on the vegetation performed in areas around the cement industry in most parts of the world, clearly, the destruction of plant life by the rising material entry has been proved. The emissions from cement factories toward the nature via weather, water and soil that are included as the feeder sources of plant and their concentration beside the plant disturbs their metabolic activities in providing the vital needs. Environmental fluctuations, including temperature, pH, soil moisture and erosion as a result of around pollutants will be created. That along with it, supply of energy resources to the different

components of the soil will be placed under this metamorphosis, and the more specialized the vital organs, such as the contents of the plant's chlorophyll, fitomas, protein and starch will indicate a serious reduction (Schuhmacher, Domingo, and Garreta, 2014).

Cement dust in addition to the various toxic heavy metals concentration on the plant components make changes in the plant's soil nutrition and their most important items are soil pH due to the arrival of alkaline compounds and the increase of absorption capacity for soil. Mercury and Cadmium are regarded as a heavy poisonous metal and important environmental pollution factor, which are the major source of pollution and produce the most dangerous pollutants by the growth of industry & cement factories. Whenever the density of pollutants exceeds a certain limit, in addition to the human and animals' health, it can be toxic for plants too. This toxicity is associated with the plant growth reduction and then the yield of plant will be reduced and in more extreme circumstances leads to death (Hajrasuliha, Hodaji, and Najafi, 2015). From the past till now, plants were used as the natural biomonitors for determining the amount of air pollution. Because the plants were able to absorb number of pollutants via their own aerial shoot specially leaves and store in their own, therefore, plant biomonitoring is an appropriate method for estimation of pollutants.

The cement industry is one of the 17 most pollusive industries that are listed by Central Pollution Control Board (Igbal, Jura-Morawiec, and Wloch, 2010). This industry with the production of abundant pollution plays an important role in the sky's balance and sustainability bashing. The cement as the main components of construction industry is produced in large amounts all over the world (Salama, Al-Rumaih, and Al-Dosary, 2011). The establishment of factories executes hard rules of the industrial areas earlier than the deadline. Hence, their proximity to residential areas is an important concern at the moment. Generally, the cement dust deposition upon the pasture plants causes loss of energy stored in plant tissues that the yield of plants is reduced in livestock feeding (Lal, and Ambasht, 2012).

2.4 LOSS OF PLANT AND VEGETATION

Cement industry emit lots of dust and particulates. Atmospheric pollution caused by cement industries include high levels of calcium carbonate and oxides of potassium, silicon and sulphides of sodium and nitrogen which accumulate on the surface of vegetation and also produce an alkaline micro-environment. These dust and particulates cover up leafs and greenery of plants. They are very harmful to plants (Koppel and Heinsoo, 1996; Shukla, Nagpure& Sharma, 2013). Dust and particulates deprive leaf and green parts of plant from receiving sufficient sunlight and fresh air. They also react to disfunction chlorophyll, this process affects photosynthesis. Due to this growth of plant and vegetation get badly affected. In their study Dwivedi and Dubey (2017) found that the carotenoid pigments, chlorophyll, pH of leaf wash, pH of leaf extract and leaf size were reduced in dust exposed plant species as compared to that of control site. Suthar, Gupta, Kansara and Goswami (2014) found in their study that heavily concentration of cement dust pollutants causes invisible injuries to the leaves like progressive decline in the physiological process such as photosynthetic ability and respiration rate. Similarly, visible injuries such as closure leaf stomata, a marked reduction in growth and productivity were also observed.

Alkaline nature of cement dust particulates reduces the absorption of mineral substances form the soil, which leads to changes in physiology and morphology of the plants. Senthil, Sobana, Kavitha and Jegadeesan (2015) attempted to know about the extent of impact of dust pollution on, a plant sesamum. They found that the chlorophyll a, Chlorophyll b, total chlorophyll, and carotenoid content of the leaves have found to decrease in the leaves of the plants grown in polluted areas. Certain parameters of biochemical components such as alkaloids, flavonoids, tannin, and lignin have got decreased in its quantity in case of affected plant sessamum indicum.

2.5 POLLUTION OF SOIL AND LOSS OF CROPS

Lamare and Singh (2020) investigated the effect of cement dust deposition on the physico-chemical properties of soil near some cement plants. The analysis revealed that cement dust from cement plants has changed the soil quality in the surrounding areas of cement plants. The normal soil pH in the area is acidic, however soil pH in area near the cement plants has been found slightly alkaline. The soil parameters such as electrical conductivity and bulk density were higher in values near the cement plants, however water holding capacity, soil moisture content, soil organic carbon and total nitrogen content were lower in values.

At present the changes in soil properties may not be so serious but if the trend of pollution continues, soil properties of a vast area around the cement plants are likely to degrade leading to multiple adverse effects on flora, fauna and socio-economy of the area. The study of Suthar, Gupta, Kansara and Goswami (2014) shows that pH value of soil is gradually increased due the effect of cement dust when compare to control soil. Geochemical analysis of different samples of soil has shown the presence of high values of sulphate in soil, toxic heavy metals, like Zn, Cr, Pb, in the dust. The study of Purushothaman, Mukundant and Viswanath (2016) shows that the particulate deposits of cement kiln effluents influence the ecotypes of local flora and the cropping intensity.

The components of cement kiln dust adversely affect stomatal functioning, photosynthesis and pollen germination and also cause imbalance in cation concentrations of the soil (Sreerangaswami *et al.,* 2013). The dust particulates have an adverse influence on crop yield and hence farm income within the polluted zone. Morphological characters of plants including height, leaves area and number, weight of shoot and root systems showed a significant reduction from control plants as a response to exposure to cement industry pollutants. Also, chlorophyll and carotenoid contents of shoot recorded reductions in comparison to control plant (Salama *at al.,* 2011).

2.6 EFFECTS ON HUMAN

Different studies as shown the impact of cement dust on humans. Studies design such as cross section, case study, ecologic and retrospective cohort focused on children, adults and workers were examined. Association between cement dust and various types of cancer, mortality, respiratory and cardiovascular disease were observed. Several reports have concluded that PCDD/F emissions do not pose a significant threat to human's health (Zemba *et al.*, 2011). This does not mean it cannot be, but generally, its emission is within limits. The possible effects on human's health include endocrine disruption, and carcinogenicity (Zhao *et al.*, 2017).

The inhalation cancer risk was revealed to be between 5.0. 10^{-11} and 2.0. 10^{-8} while that of oral carcinogenic risk is between 1.8. 10^{-8} and 7.6. 10^{-8}. The incremental lifetime risk of cancer for people living close to a plant will be 0.03. Silica dust causes silicosis and fatal lung diseases. The presence of chromium compounds in cement dust might lead to cancer. Several researchers have argued that pollutants might have unknown consequences on the people and the environment (Harley J 2017). Their reaction within the human body could be novel. With various sizes, absorption into the body might be unpreventable.

Research has also shown that cement dust causes morbidity, chronic obstructive pulmonary, preterm delivery, psychasthenia, endocrine disruption, and infertility. The severity is dependent on the duration of exposure, concentration and element constituent of the dust, and individual sensitivity (Guttikunda and Goel 2013). The first victims are usually the factory workers. Factory workers suffered from respiratory diseases, and it is more prevalent among the packing section workers. Dermatitis, caused by hexavalent chromium (Cr^{6+}) in cement are observed within the workforce. High level of Cd observed in the Nigeria cement dust, constitute a high health risk as its average half-life in a human body is between 4 and 19 years (Ogunbileje, Sadagoparamanujam, Anetor 2013).

Long-term exposure might lead to renal tubular dysfunction. It also affects the respiratory tract and immune system modulation and reduces the phagocytic activity of polymorphonuclear neutrophils (PMN). Several research works, including Emmanuel and Alabi (Emmanuel, Alabi, 2015), indicating a higher risk of chronic kidney disease and end-stage renal disease. This research reported showed that cement factory workers have a higher white blood cell (WBC) and lower red blood cell. This is suggested to be due to the response of the body to irritation on the body. Also, it might be due to increase in Lymphocytes count and reduction in monocytes count. The increase in platelets was observed to be due to stress response. Other research reported that cement dust results in a reduction of haemoglobin concentration as well as packed cell volume, which might indicate anaemic condition (Emmanuel and Alabi 2015). Diverse researchers linked theincrease in WBC and RBC to a harmful effect on bone marrow.

2.7 LOSS OF LIVESTOCKS- CATTLE, POULTRY AND ANIMAL HUSBANDRY:

The air pollutants have long been the source of various diseases in human beings (Rai, Mishra and Parihr 2013). Air pollution does not harm only human beings but it harms animal and birds also. All the creature inhaling oxygen for the survival are directly affected by pollution. Composition of dust and gas emitted from cement plants has life risking effect (Mishra and Siddiqui 2014). The manufacturing of cement discharges particulate matter and harmful gases which are associated with the health risks for the living beings in the vicinity of a cement industry.

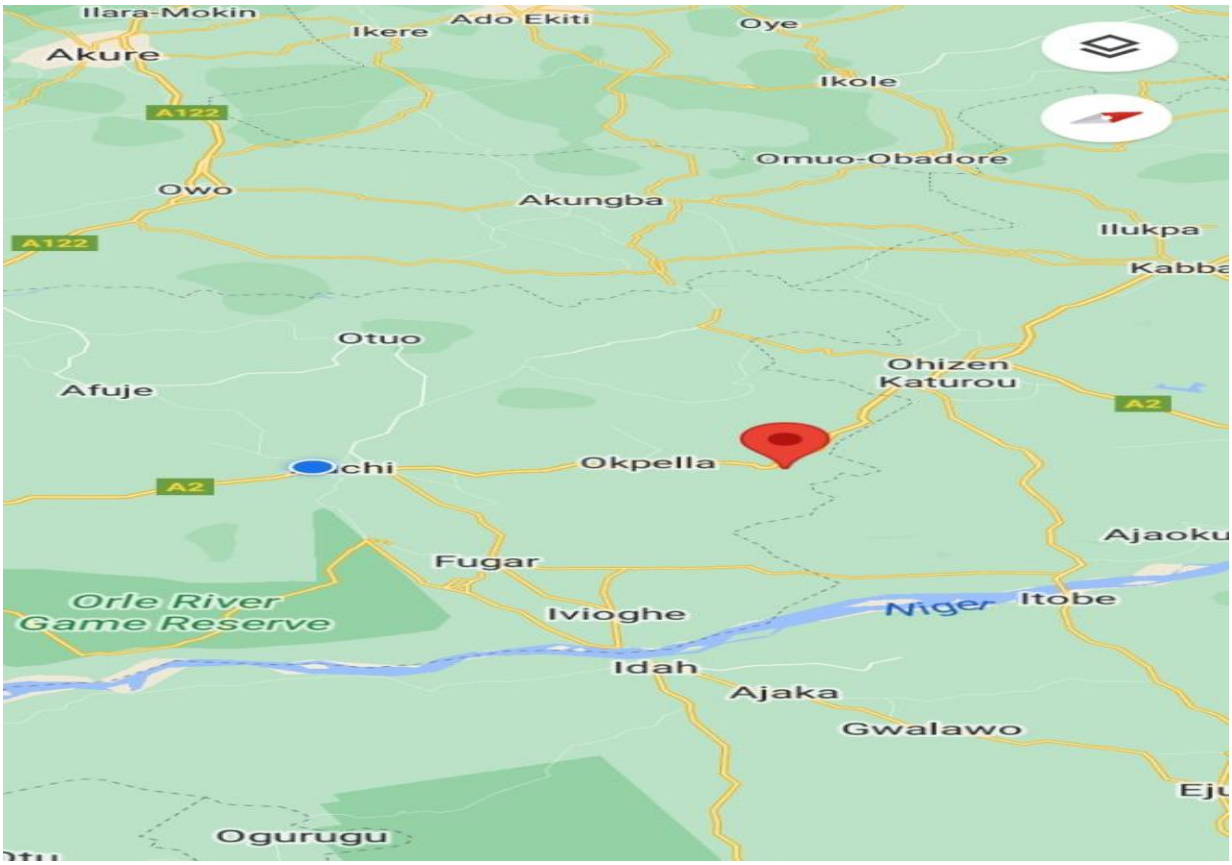
The pollutants are nitrogen oxides (NOX) and sulphur dioxide (SO_2), suspended particulate matter (SPM), respirable suspended particulate matter (RSPM), non-respirable suspended particulate matter (NRSPM) (Mehraj, Bhat, Balkhi & Gul 2013).

CHAPTER THREE

3.0. MATERIALS AND METHODS

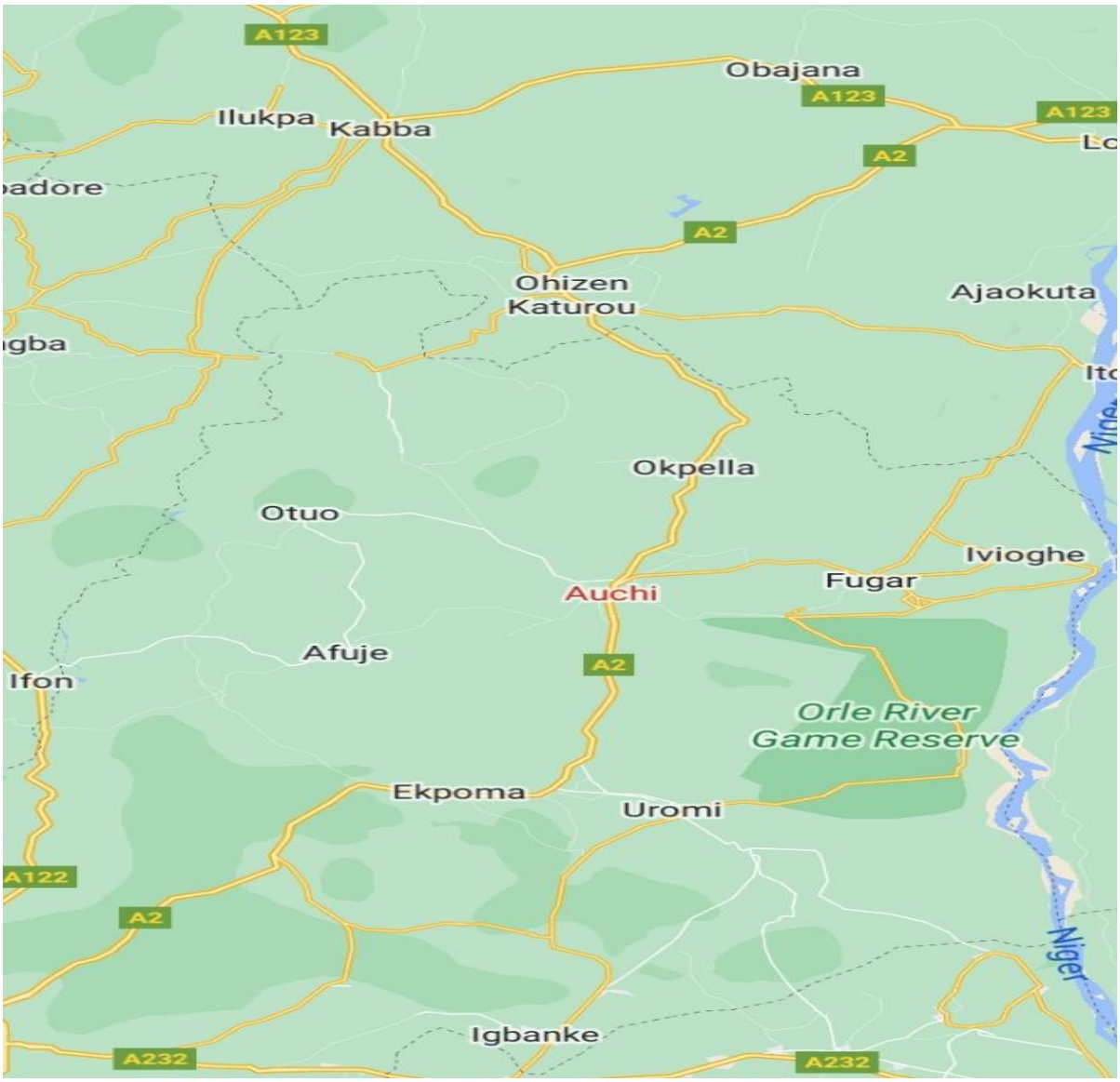
3.1. SAMPLE COLLECTION

Soil sample from the industrial study area was collected at a depth of 0 – 15 cm using a stainless steel spade. One type of crop sample was collected at the same location as soil sample, the crop sample collected was cassava tuber. The sampling location was recorded using global positioning system (GPS).



Longitude = 6.4010° E, Latitude= 7.3546° N

The same set of soil and crop samples were collected using the same method at non-industrial study area. The sample were collected into polyethylene bags labeled snd properly tied. All the chemicals and reagents used in this study were of analytical grade.



Latitude: 7.0493981, Longitude: 6.2704722

3.2. PREPARATION OF SAMPLE

Soil samples were air-dried in the laboratory for three days at room temperature and then dried in an oven at 105^0C for 2 hours. The dried sample were ground to pass through 100um sieve and stored in a close air-tight container for further analysis. The soil sample collected from the industrial site at Okpella was labelled OS1 while the soil sample collected from non-industrial site at Auchi was labelled AS2.

The soil samples were also air-dried for seven days and then oven-dried at 105^0C for 2 hours. The dried were ground to pass through 100um sieve and stored in a close air-tight container for further analysis. Moreover, the cassava powder prepared from cassava tuber collected from industrial site at Okpella was labelled OC1 while the soil sample collected from non-industrial site at Auchi was labelled AC2.

3.3. PROXIMATE COMPOSITION DETERMINATION

3.3.1. Moisture Content: OC1 (2.0g) was weighed and placed in an oven maintained at 100 - 105°C for 16 hours with the weight of the wet sample and the weight after drying noted. The drying was repeated until a constant weight was obtained. The moisture content was expressed in terms of loss in weight of the wet sample. The sample procedure was repeated for AC2.

$$(\%)\ \text{Moisture content} = \frac{\text{Loss in weight due to drying}}{\text{Weight of sample before drying}} \quad \ldots\ldots\ldots\ldots\ldots\ldots$$

$$(\%)\ \text{Moisture content} = \frac{W2-W3}{W2-W1} * 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

Where,

W_1 = Weight of empty Crucible

W_2 = Weight of empty crucible + sample before drying

W_3 = Weight of crucible+ sample after drying (constant weight).

$$\%\ \text{Total Solid} = \frac{W3-W1}{W2-W1} * 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..$$

3.3.2. Ash Content: OC1 (2.0g) was weighed and placed in crucible of known weight. These were ignited in a muffle furnace and ashed for 8 hours at 550°C. The crucible containing the ash

was then removed, cooled in a dessicator and weighed and the ash content expressed in term of the oven-dried weight of the sample.

$$\% \text{ Ash Content} = \frac{\text{weight of ash}}{\text{weight of sample (after drying)}} \times 100 \quad \text{.....eq. 3.17}$$

$$\% \text{ Ash Content} = \frac{W3 - W1}{W2 - W1} \times 100 \quad \text{.....eq. 3.18}$$

3.3.3. Protein: The protein nitrogen in 1g of the dried samples were converted to ammonium sulphate by digestion with concentrated H2SO4 and in the presence of CuSO4 and Na2SO4. These were heated and the ammonia evolved was steam distilled into boric acid solution. The nitrogen from ammonia was deduced from the titration of the trapped ammonia with 0.1M HCl with Tashirus indicator (double indicator) until a purplish pink color was obtained. Crude protein was calculated by multiplying the value of the deduced nitrogen by the factor 6.25mg.

3.3.4. Crude Fibre: 2.0g of each sample was weighed into separate beakers, the samples were then extracted with petroleum ether by stirring, settling and decanting 3 times. The samples were then air dried and transferred into a dried 100ml conical flask. 200cm3 of 0.127M sulphuric acid solution was added at room temperature to the samples. The first 40cm3 of the acid was used to disperse the sample. This was heated gently to boiling point and boiled for 30 minutes. The contents were filtered to remove insoluble materials, which was then washed with distilled water, then with 1% HCI, next with twice ethanol and finally with diethyl ether. Finally the oven-dried residue was ignited in a furnace at 550^{o}C. The fibre contents were measured by the weight left after ignition and were expressed in term of the weight of the sample before ignition.

3.3.5. Lipid Content: The lipid content was determined by extracting the fat from 10g of the samples using petroleum ether in a soxhlet apparatus. The weight of the lipid obtained after

evaporating off the petroleum ether from the extract gave the weight of the crude fat in the sample.

3.3.6. Carbohydrate: The carbohydrate content of the samples were determined as the difference obtained after subtracting the values of protein, lipid, ash and fibre from the total dry matter.

3.4. MICRONUTRIENT DETERMINATION

3.4.1. CALCIUM, POTASSIUM AND SODIUM

Reagents: 2 MHCL.

The ash (0.5g) of OS1 sample obtained was digested by adding 5 mL of 2MHCl in the crucible and heated to dryness on a heating mantle. 5 mL of 2 MHCl was added again, heated to boil and filtered through what man No. 1 filter paper into a 100 mL volumetric flask. The filtrate was made up to mark with distilled water stoppered. Concentration of Calcium, Potassium and Sodium were determined using the Jenway Digital Flame Photometer(PFP7 Model). The same procedure was repeated for AS2, OC1 and AC2.

3.4.2. PHOSPHORUS

2 MHCl (5 mL) was added to 0.5g of OS1 as described for calcium determination above. 10ml of the filtrate solution was pipetted into 50 mL standard flask and 10 mL of vanadate yellow solution was added and the flask was made up to mark with distilled water, stoppered and left for 10 minutes for full yellow development. The concentration of phosphorus was obtained by taking the optical density (OD) or absorbance of the solution on a Spectronic 20 spectrophotometer or colorimeter at a wavelength of 470 nm.

The percentage phosphorus was calculated from using the formula:

%Phosphorus = Absorbance x Slope x Dilution factor. The same procedures was repeated for AS2, OC1 and AC2.

3.5. DETERMINATION OF HEAVY METALS

An Atomic Absorption Spectrometer (AAS) Buck Scientific model 211VGP was used to determine the metal content of the samples in accordance with APHA 20th Edition 3111B and 3111D, ASTM D3561 and ASTM D5198. The concentrations of the metals in the samples were obtained by aspirating the digested samples directly into the flame.

3.6. PHYSICOCHEMICAL PROPERTIES OF OS1 AND AS2

3.6.1. DETERMINATION OF ORGANIC MATTER

Organic matter was determined using gravimetric method by measuring weight change associated with high temperature. After initial oven drying at 105^0C.the samples were ignited in a muffle furnace for two hours at 360^0C .The total organic matter is calculated as the percent weight loss during ignition.

3.6.2. pH

pH of OS1 sample was determined with a pH meter in accordance with ASTM D4972. Prior to sample analysis, the meter was calibrated according to manufacturer instruction with buffer solution 4, 7 and 9. The pH measurement involved inserting the probe of the pH meter into a 1:1 ratio suspension of the sample in distilled water and the displayed reading was taken. The same procedure was repeated for AS2, OC1 and AC2.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

Table 4.0 shows the physio-chemical properties such as soil, organic matter, cation exchange capacity, clay content, electrical conductivity, soil pH and moisture content influence the concentration of potential toxic metals in soil in a great quantity and bio availability and bio accumulation in plant. In this study, nine (9) heavy metals were analyzed in the soil samples. The concentration of heavy metals ranging from 0.001± 0.00 to 228.6±0.03 in cement industrial site (okpella). The least concentration was obtained in Mercury (Hg 0.001±0.00) while the highest concentration was obtained in iron (Fe 228.6±0.03).

In the non-industrial site which represent the control (Auchi), the concentration of heavy metals is in the range of 0.001±0.00 to 252.03±0.15. On with mercury (Hg, 0.001±0.00) with the least concentration while iron (Fe, 252.03±0.15) has the highest concentration. It shows that in the soil sample among the detected heavy metals in the soil sample, the concentration of Iron (Fe) was the highest and the least concentration was recorded in Mercury (Hg) in both the soil samples.

The soil organic matter obtained from this study showed that the value ranges between 2.165±0.01 and 2.340±0.01 in industrial site and non-industrial site respectively. The lower (2.165±0.01) value obtained in the sample from industrial site might be due to decaying in microorganisms as a result of industrial activities. Low and poor organic matter levels may increase soil erosion processes while the high amount of organic matter could affect the pH by reducing it's level (kekane *et al.*, 2015).

The soil pH value ranges between 6.600±0.06 and 6.830±0.03. The control site (non-industrial environment) has the higher pH value (6.830±0.03). The soil samples collected at the

depth of 0cm -15cm showed the availability of nutrients such as Nitrogen (N), phosphorus (P), potassium (k).

The NPK values obtained with respect to the control site (Auchi) ranges from 0.288±0.00 to 21.55±0.07 respectively while the NPK values from the industrial site ranges from 0.553±0.01 to18.40±0.14. The results shows that the availability of the nutrients were much 8n the control site than that of the industrial site with the exception of Nitrogen (N) which was higher in the soil samples collected from the industrial site.

The study showed that the sample from both sides are within the standard of pH range set by world health organization (WHO) (6.5 to 8.5). The soil electrical conductivity (EC) of the soil samples ranges between 115.4±0.28 and 145.7±0.01us/cm. Soil EC is a significant indicator of soil salinity and it's a measure of the amount of salt in the soil but does not indicate the specific salt or ions that might be present, however it's a indicator of salt like sodium (Na), potassium (K), chloride (Cl^-), Sulphate (S), (Ullman,2013).

In this study the soil EC from both sides are low since soil EC lower than 200µs/cm has insufficient nutrients for the plants and could show a disinfected soil with little microbial activity, (verma *et al.*, 2015).n

Table 4.0 The physicochemical properties of OS1 and AS2.

Parameter	OS1	AS2
N (%)	**0.553±0.01**	**0.288±0.004**
OM (%)	**2.165±0.007**	**2.340±0.014**
P (%)	**23.61±0.006**	**28.62±0.013**
K (%)	**18.40±0.141**	**21.55±0.07**
EC (u/s)	**145.7±0.014**	**115.4±0.28**
MC (%)	**6.615±0.007**	**6.560±0.042**
BD (%)	**1.091±0.004**	**1.100±0.028**
pH	**6.600±0.06**	**6.830±0.03**

The obtained values are averages ± standard deviation of duplicate determination

Table 4.1, the results obtained in this study revealed the heavy metals accumulation concentration order in the soil as follows; for OS1, the order is Hg<Co<Cu<Pb<Mn<Cr<Zn<Fe while the AS2 show in the order Hg<Co<Ni<Pb<Cu<Mn<Cr<Zn<Fe.

The result of heavy metals in cassava obtained from both industrial and non-industrial sites are presented in table 4.1. The results obtained reveal that iron(Fe) has the highest concentration with respect to both industrial site and non-industrial site, (2.316±0.01) and (1.971±0.00) respectively. The least concentration was obtained in Mercury (Hg) and with the same value (0.001±0.00) in both site. It is observed that the pollution is not severe as all the selected element does exceed the maximum amount allowed. Based on world health organization (WHO) /Food and Agriculture Organization (FAO) guidelines. Though the highest value obtained with respect

to iron (Fe) could be as a result of it's presence in the earth crust and this justifies it's use as reference metal in the computation of enrichment factor (Alam *et al.*, 2013).

Table 4.1.1 Results of Heavy Metals concentration

METAL (ppm)	OS1	AS2
Mn	0.371±0.002	0.494±0.004
Cu	0.313±0.005	0.272±0.005
Cr	0.815±0.04	0.823±0.194
Co	0.005±0.001	0.002±0.000
Hg	0.001±0.000	0.001±0.000
Ni	0.035±0.003	0.063±0.010
Fe	228.60±0.029	252.03±0.148
Pb	0.324±0.009	0.272±0.004
Zn	0.960±0.006	1.448±0.017

The obtained values are averages ± standard deviation of duplicate determination

Table 4.1.2 Concentration of heavy metals in OC1 and AC2

METAL	OKPELLA	AUCHI
Mn	0.186±0.003	0.209±0.003
Cu	0.117±0.00	0.173±0.004
Cr	0.074±0.004	0.101±0.006
Co	0.002±0..001	0.001±0.000
Mg	0.001±0.001	0.001±0.000
Ni	0.004±0.001	0.005±0.001
Fe	2.316±0.008	1.971±0.001
Pb	0.004±0.001	0.008±0.003
Zn	0.614±0.006	0.402±0.004

The obtained values are averages ± standard deviation of duplicate determination. .

The result of the proximate composition analysis of cassava flour prepared from cassava samples collected from the industrial and non-industrial site are presented in the table 4.2. The moisture content was observed to be higher in the sample collected from the industrial site. The values showed that moisture content of the sample were moderate, and indication that the sample can be conveniently be stored for a longer period of time as they will prevent the growth of microorganisms therefore increasing the shelf- life. The values obtained are acceptable for the

established aim, reach a stable shelf -life (< 20 % moisture) and agree with those previously reported by kayisu *et al*., 1981, Gwenfogbe *et al* .,1988, Daramole and Osanyinlusi, 2006.

Ash refers to the concentration of minerals or inorganic residue that remains after either ignition or complete oxidation of organic matter in a food stuff. It is used for nutritional evaluation. The percentage of Ash content in industrial site sample and non-industrial site sample ranges between 2.39±0.01 and 4.62±0.00 . The low value obtained in the sample from non-industrial site might be due to evaporation of some of the volatile minerals as a result of heat.

Carbohydrates are important in food as major source of energy, to impact crucial textural properties and dietary fiber which influences physiologically processes. The result of carbohydrates obtained from the sample by difference showed that sample collected from non-industrial site was higher (83.42±0.05) while the sample from industrial site was (74.37±0.01) .

Facts are referred to those lipids that are solid at room temperature. The analysis of fats in food is important for accurate nutritional labelling, determination of whether the food meets the standard of identity and to ensure that the product meats manufacturing specifications. Fats values obtained for industrial, non-industrial site were (4.54±0.07) (2.36±0.00) respectively.

Fiber is essentially the sum of the non-digestible components of food stuffs or food product. The fiber content of both samples range between (1.61±0.00) and (2.16±0.04)

Protein are abundant components in all cells and they are important for biological functions and cell structure except the storage proteins.

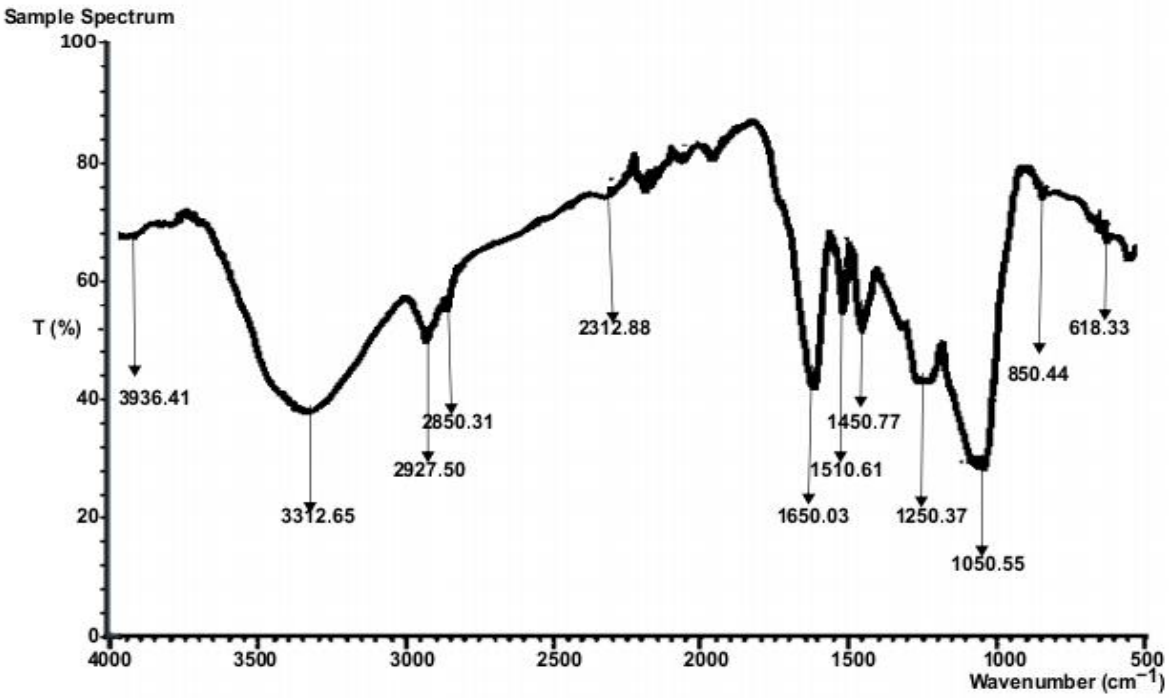
The percentage of crude protein range between (3.37±0.02) and (7.15±0.01) in non-industrial and industrial site respectively

Table 4.2 Proximate Analysis of OC1 and AC2

Parameters (%)	OC1	AC2
Mc	7.170±0.028	6.861±0.027
Ash	4.619±0.002	2.386±0.006
Fat	4.539±0.073	2.361±0.004
Fiber	2.155±0.35	1.607±0.004
Protein	7.150±0.014	3.366±0.023
CHO	74.368±0.007	83.419±0.052

The obtained values are averages ± standard deviation of duplicate determination

Figure 4.0 is the FTIR spectrum of OC1. The peak that appears at 3926.4 cm^{-1} is due to O-H stretching vibration of hydroxyl group. The peak at 3312.65 cm^{-1} correspond to the OH stretching vibration while the absorption peak at 2927.50 cm^{-1} is due to CH2 stretching vibration



from alkyl group of the ammonium salt present in the sample. The peak at 2850.31 cm-1 is as a result of the presence of OH stretching vibration hydroxyl group due to the adsorbed water molecule in the sample. The absorption peak at 2312.88 cm^{-1} is due to Co_3^{2-}(calcite) stretching from carbonates compounds while the peak that appears at 1650.03 cm^{-1} shows the presence of a symmetric OH stretch hydroxyl group of water molecule. The absorption peak at 1510.61 cm^{-1} shows the presence of Si-O asymmetric silicates stretching vibration while the peak at 1450.77 cm^{-1} is due to Si- O-Si stretching silicates. However the absorption peak at 1250.57 cm^{-1} indicates the presence Al-OH vibration of deformation aluminum. The peak at 1050.55 cm-$^{-1}$ is due to Si-O stretching (silicates plane) vibration. The absorption peak at 850.44 cm^{-1} shows the

presence of O-H deformation due to hydroxyl/aluminum while the peak at 618.33 cm^{-1} is due to the Al-O (silicates aluminum Si group).

Figure 4.0: FTIR Spectrum of OC1

Figure 4.1 shows the FTIR spectrum of AC2. The absorption peak at 3775.10 cm^{-1} is due to the presence of OH stretching vibration from hydroxyl group. The peak that appears at 3350.19 cm^{-1} indicates Si-OH stretching (silanol group vibration) while the absorption peak at 2775.84 cm^{-1} is due to CH2 stretching vibration (alkanes). The appearance of a peak at 1250.78 cm^{-1} indicates H-O-H bending vibration (hydroxyl group). The absorption peak at 1150.13 cm^{-1} is due to Si-O stretching vibration of silicates while the peak at 1051.42 cm^{-1} is due to Si- O- Si stretching vibration (silicates compounds). The peak that appears in the spectrum at 974.82 cm^{-1} corresponds to Al-OH-Al (alunimates). The absorption peak at 800.64 cm^{-1} indicates the presence of Si-O and Si-O-Al (silicates/alunimates). However the absorption band at 550.30 cm^{-1} is due to Si-O- Al stretching vibration (silicates/alunimates).

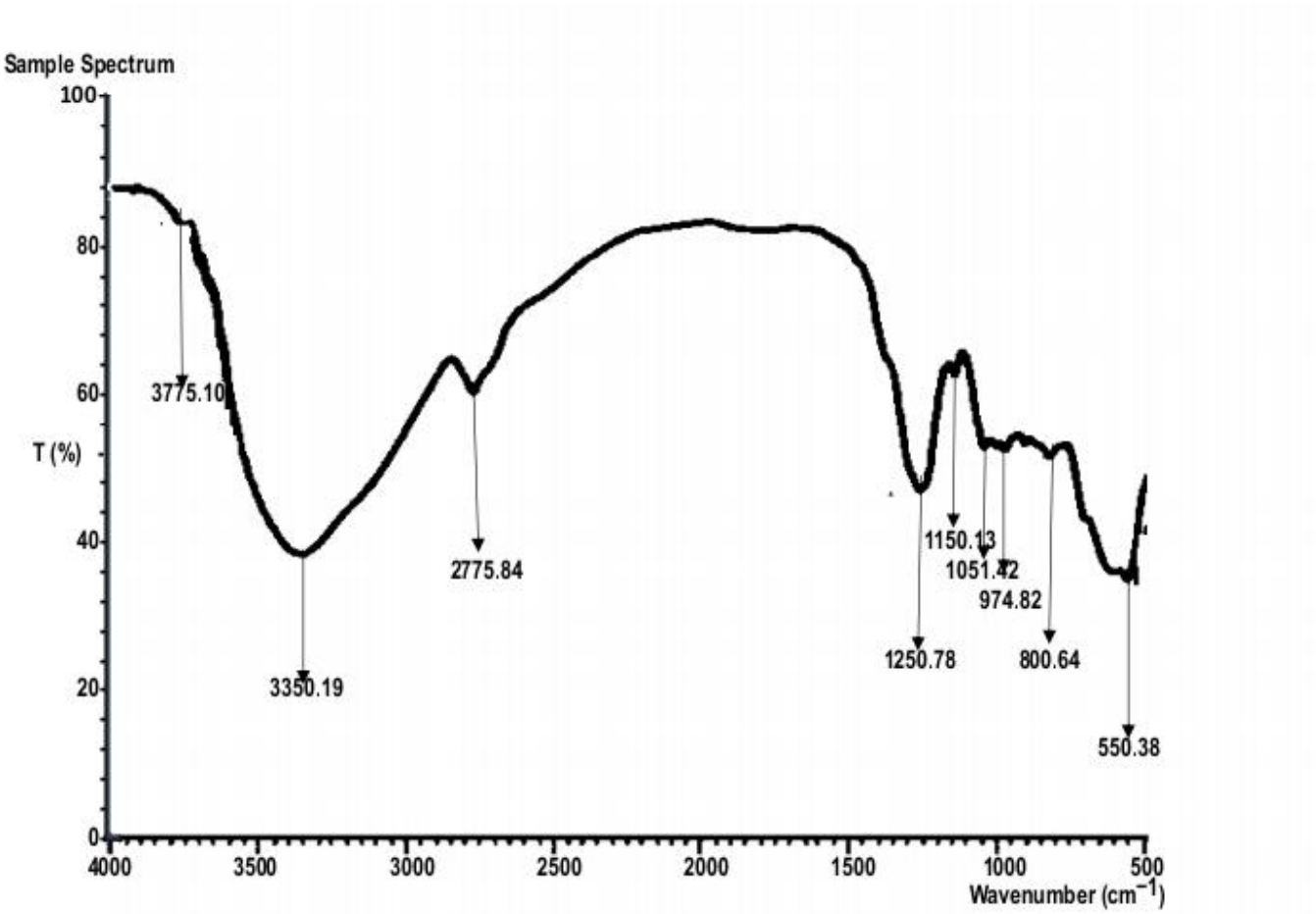
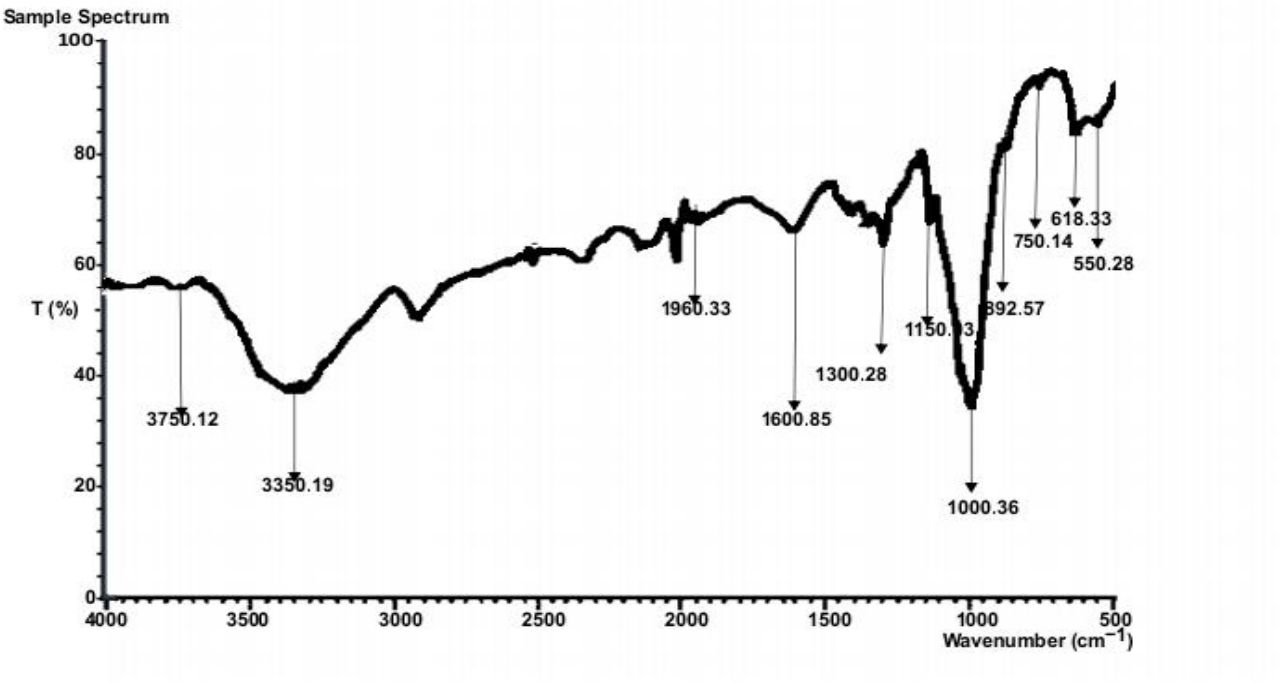


Figure 4.1: FTIR Spectrum of AC2

Figure 4.2 is the FTIR spectrum of OS1The peak that appears at 3750.12 cm^{-1} indicates the presence of O-H stretching vibration of hydroxyl group while the peak at 3350.19 cm^{-1} correspond to OH stretching vibration of hydroxyl group. A peak at 1960.33 cm^{-1} correspond to CH_2 stretching vibration (alkanes). The absorption band at 1600.85 cm^{-1} is the region that correspond to OH stretching vibration due to the adsorbed water presence in the sample (hydroxyl group). The peak at 1300.28 cm^{-1} is due to Co_3^{2-} (calcite) stretching carbonates vibration. The absorption band 1150.03 cm^{-1} shows the presence of symmetric stretching silicates vibration of the Si-O bonds while the peak at 1000.36 cm^{-1} correspond to Si-O

asymmetric silicates stretching vibration. The absorption peak at 892.57 cm^{-1} is due to Si- O-Si stretching silicates vibration and at 750.14 cm^{-1} , the peak correspond to Al-OH deformation of aluminum compounds. The peak that appears at 618.33 cm^{-1} shows the presence of OH bending vibration of hydroxyl group. The absorption band at 550.28 cm^{-1} is due to the presence of O-Si-

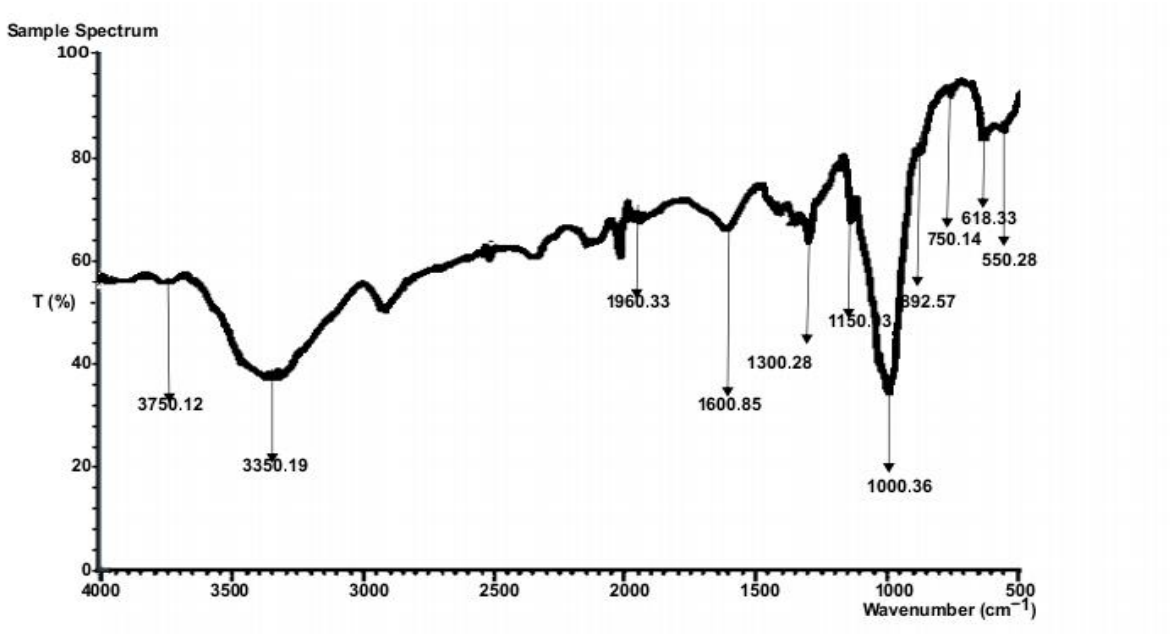


O/O-Al-O bending and silicates/ aluminates stretching vibration.

Figure 4.2: FTIR Spectrum of OS2

Figure 4.3 is the spectrum of AS2. The absorption peak at 3312.65, 2927.50 and 2850.31 cm^{-1} correspond to OH stretching vibration, OH vibration elongation due to hydroxyl group in the di-octahedral part of the mineral, OH stretching vibration (hydroxyl group) due to the adsorbed water presence in the sample respectively. The peak at 1711.85 cm^{-1} is due to asymmetric OH stretch hydroxyl group of water while the peak at 1594.18 cm^{-1} shows the presence of Si-O asymmetric silicates stretching vibration. The absorption peak peak at 1500.29 cm^{-1} indicates the presence of Co_3^{2-}calcite stretching carbonates vibration in the soil sample. The

peak at 1442.63 cm^{-1} is due to Si-O-Si stretching silicates vibration while the absorption peak at 1206.16cm cm^{-1} corresponds to Al-OH aluminum compounds vibration. However, the peak at 1050.55 cm^{-1} shows the presence of Si-O stretching vibration (silicates) and the absorption band



that appears at 800.03 cm^{-1} is due to the presence of OH deformation mode of hydroxyl/aluminates (Al-Al-OH or Al-OH-Al)

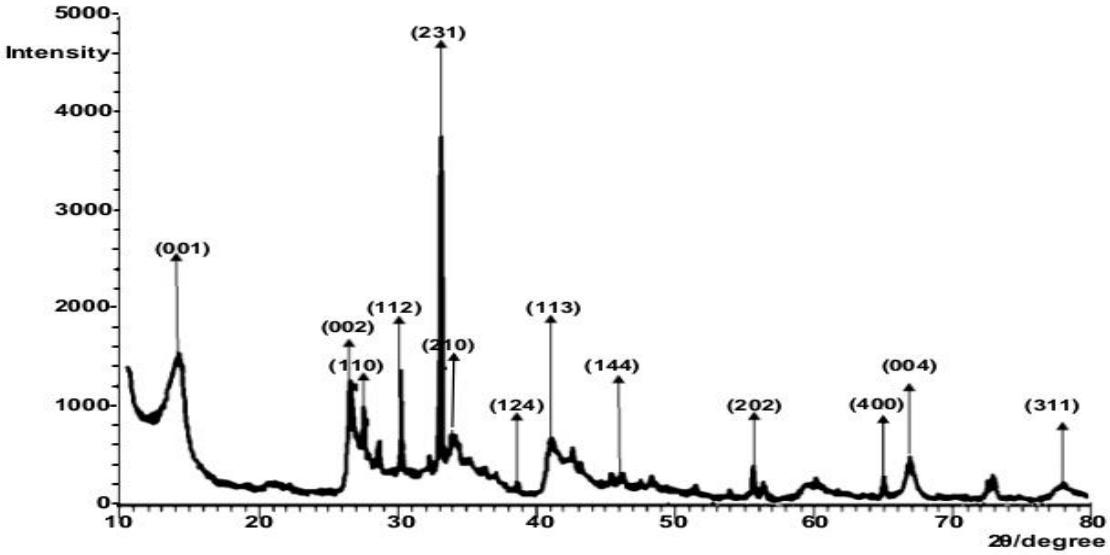
Figure 4.3: FTIR Spectrum of AS2

XRD SPECTRUMS

X-ray diffraction (XRD) was used to analyzed for the mineralogical composition of the samples and the representative XRD patterns are shown below. The XRD indicates crystalline orthogonal phases. The background and peaks positions were identified and based on the peak positions and intensities.

XRD SPECTRUM OF X_1(OSl)

Figure 4.4 is the diffractogram pattern of the OS1. The intensities composition in percentage and the corresponding minerals at 20 degree are listed below. 14.00(3.30), 26.50(21.81), 27.62(15.85), 30.41(5.27), 33.00(4.41), 34.00(3.61), 38.97(11.43), 41.00(9.53), 46.00(2.64), 55.62(5.29), 65.00(3.52), 67.00(4.40), and 78.00(4.01) were for Quartz, Quartz, Hematite, Anatase, kaolinite, Quartz, kaolinite, Muscovite, Microcline, Calcite, kaolinite, kaolinite, and kaolinite respectively. The result showed Quartz to be more abundant (21.81 %),



followed by kaolinite (16.34 %), Hematite (15.85%).

Figure 4.4: XRD Spectrum of OS1

Figure 4.5 is the diffractogram of AS2. The intensities at 20 degree corresponding to the sample and the corresponding minerals are listed below. The intensities at 13.29, 22.00, 27.64, 35.50, 37.21, 43.00, 50.71, 60.20, 68.79 and 78.00 were recorded for kaolinite, Quartz, Quartz, kaolinite, Quartz, Muscovite, Microcline, Cristobalite, Calcite, and Halloysite respectively.

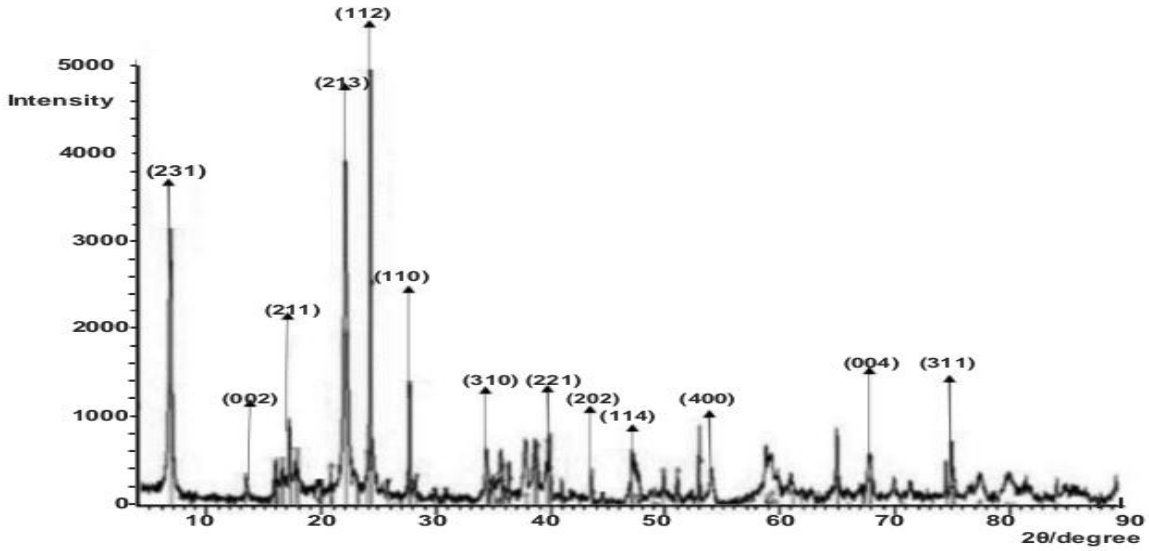


Figure 4.5: XRD Spectrum of AS2

Figure 4.6 is the diffractogram of AC2. The intensities at 20 degree are as follows and the composition (%) in parentheses; 13.00(3.30), 16.50(21.81), 28.61(15.85), 29.94(5.27), 31.10(4.41), 36.23(3.61), 37.40(11?43), 39.94(9.53), 44.23(2.64), 50.37(5.29), 58.00(3.52), 62.50(4.40) and 76.00(4.01) were recorded for Quartz, Quartz, Hematite, Anatase, Quartz, Quartz, kaolinite, Muscovite, Microcline, Calcite, Anatase, Quartz, kaolinite respectively. The result indicates that Quartz was much in abundance (21.81 %) followed by Hematite, (15,85 %), kaolinite (11.43 %).

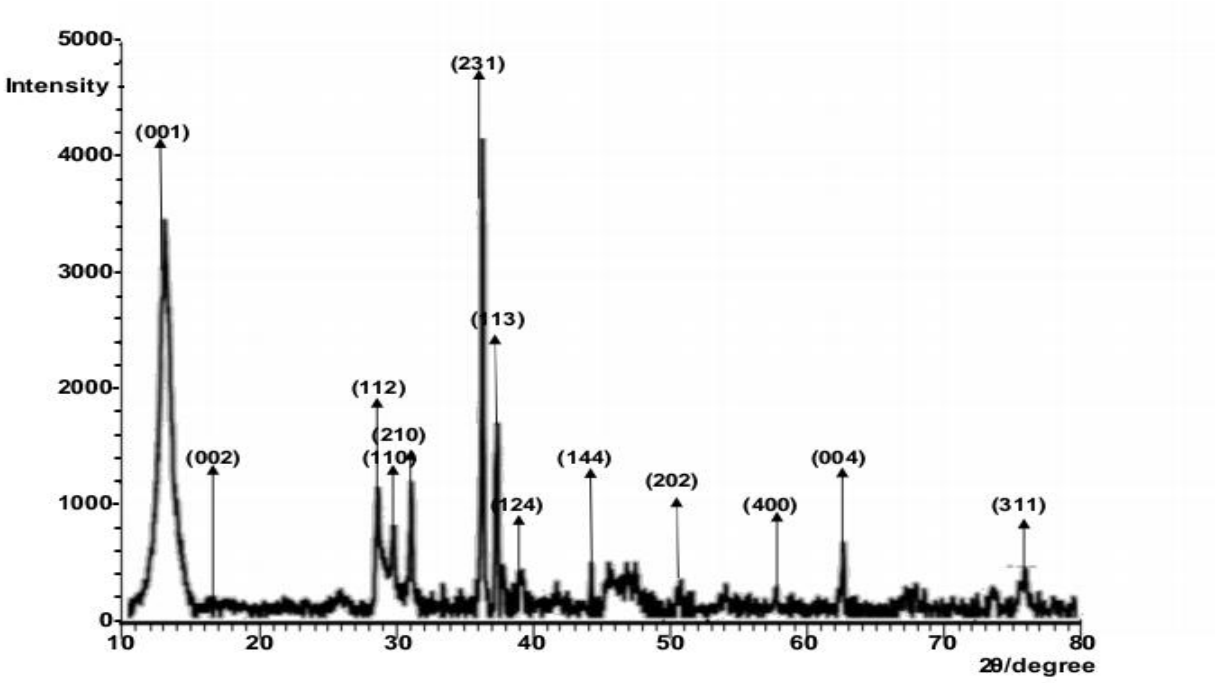


Figure 4.6: XRD Spectrum of AC2

Figure 4.7 is the diffractogram of OC1. The intensities are recorded at 20 degree. The intensities are listed below with their composition and corresponding minerals. 11.98(3.81), 20.64(10.89), 26.50(24.64), 34.50(2.09), 36.43(20.92), 42.50(5.15), 50.14(17.74), 60.20(4.84), 68.79(3.66), and 78.00(6.29) were kaolinite, Quartz, Quartz, kaolinite, Quartz, Muscovite, Microcline, Cristobalite, Calcite, and Halloysite respectively. The result shows that the sample was much in Quartz.

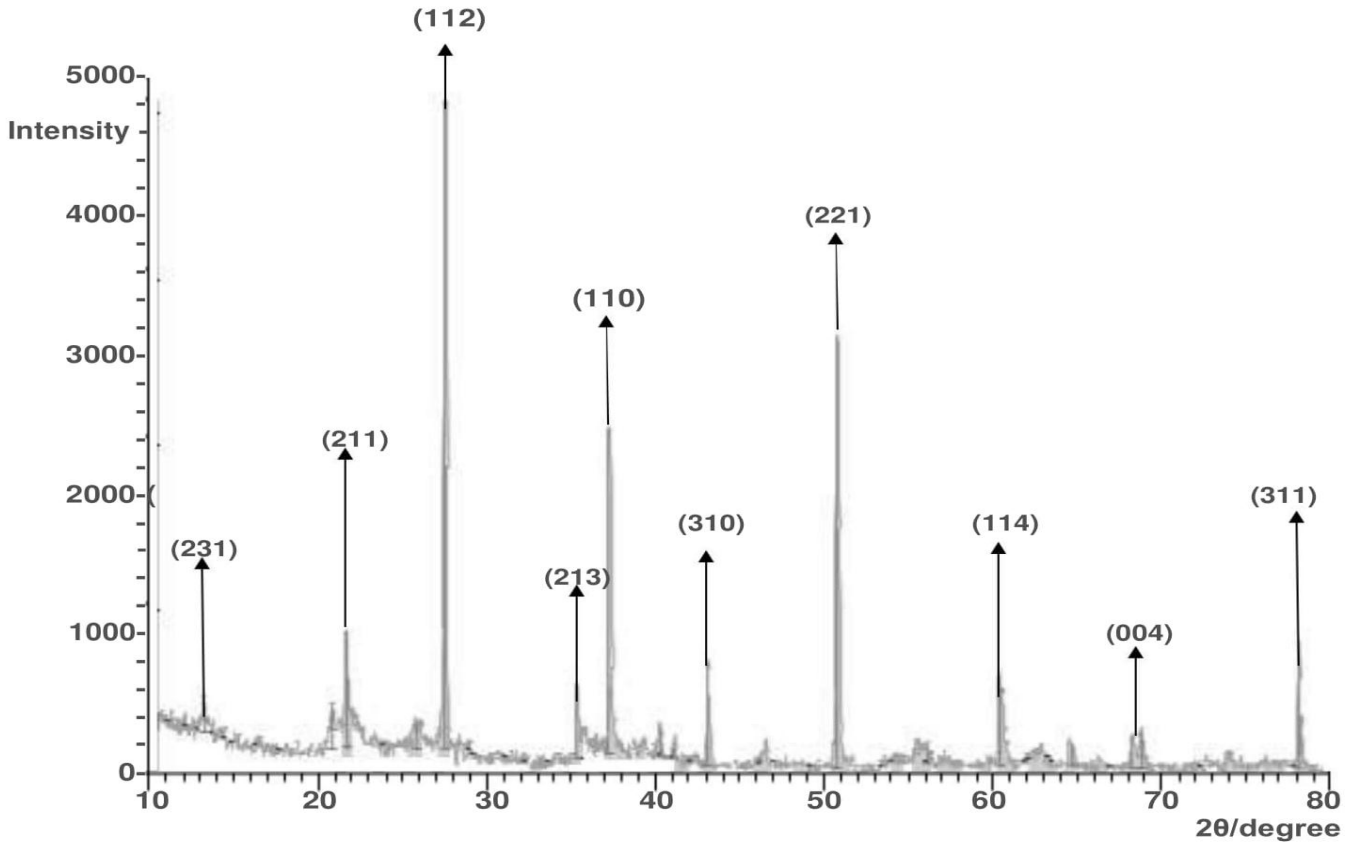


Figure 4.7: XRD Spectrum of OC1

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1. Conclusion

This is a comparative study of the effect of potential toxic metals (heavy metals) in an industrial site and non-industrial site (which serves as control). The result obtained show that the concentration of heavy metals in the samples were relatively low with the exception of Iron (Fe) that may be due to its abundance in the earth crust. The pH was within the acceptable standard. The proximate analysis revealed that OC1 was higher in moisture content, ash content, fat, fibre and protein.

5.2. RECOMMENDATION

Although the heavy metals analysis results shows that the concentration of heavy metals on both the industrial and non- industrial site was low but it is not advisable for farmer to farm in such area because it may causes chronic effects due to long term accumulation of the heavy metals.

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