# HEALTH AND RISK ASSESSMENT OF HEAVY METALS IN SOIL AND PLANTS
# AROUND A DUMP SITE

BY

KOLUBOWEI, OPIRITARI
ENG1704037

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# CRTIFICATION

This is to certify that this work was carried out by **KOLUBOWEI OPIRITARI, MAT. NO ENG1704037**, of the Department of Civil Engineering, Faculty of Engineering, University of Benin City, Edo state, Nigeria.
1403001851

PROJECT SUPERVISOR:
(ENGR. DR. ILABOYA, I.R)
Signature and Date………………………………………

HEAD OF DEPARTMENT
(DR. N IHIMEKPEN)
Signature and Date: …………………………………………………

# DEDICATION

This work is firstly dedicated to Almighty God, who continues to love, care and provide for me in all my times of need, and secondly dedicated to my family for their financial support in carrying out this project.

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# ABSTRACT

Solid wastes constitute a disaster for human health and environmental degradation. Dumpsites in urban settlements are used as sources of nutrient rich soils for cultivating crops without regard to the risks of perceived toxic heavy metal pollution from the wastes. Water sources near the dumpsites are used as domestic water source for the people living near such sites. This water is often contaminated by toxic heavy metals leaching from the dumpsite. Heavy metals are known to accumulate in the plants then passed to the humans through the food chain. Prolonged consumption of unsafe concentrations of heavy metals through foodstuffs may lead to the accumulation of heavy metals in the humans causing disruption of numerous biochemical processes. The aim of this study was to determine the level of heavy metals in the vegetables and soil samples collected around Oluku dumpsite. The study also sought to assess the knowledge of the health risks posed by the site to the residents living around the dumpsite. Heavy metal determination samples collected was carried out using X- ray fluorescence (XRF) analytical method.

The results indicate that the dumpsite didn’t shown to be having high concentrations of heavy metals, since some heavy metals could not be detected in dumpsite. This may be as a result of less contamination with those metals due to human activities. Some metals could not be detected; the implication is that the concentration of these metals are below detection limit or not present at all.

It was also observed that the dumpsite had higher concentration of these metals like magnesium (Mg) than others; this could be attributed to the presence of waste carrying higher amounts of magnesium. The heavy metals concentration in these dumpsites were all within the WHO acceptable limit in the dumpsite.

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# CHAPTER ONE

# INTRODUCTION:

## 1.1 Background of study

Unavoidable waste produced by human activity is solid waste. Solid waste can be defined as any material that has been rejected as a result of home or industrial activity, which can be disposed of and for which there is no market demand (Sridhar, 1998).

Since the beginning of human civilization, both humans and animals have utilised earth's resources for sustenance and waste disposal. Because it was historically relatively small and there was a sufficient amount of space accessible for waste assimilation, disposing of human and other garbage did not present a big difficulty (Tchobanoglous, Theisen, 2008). However, LDCs like Nigeria are grappling with a sizable chunk of the current issue.

In Nigeria, as the number of people living in cities rises, solid waste generation rates rise day by day. Nigeria produces 20 kilogrammes of solid trash per person year, according to Olafusi (2009). This waste is primarily transported from one area to another rather than being properly disposed of, which is known to cause substantial health risks to the population (Nigerian Environment Action Study Team, 2009). The bulk of this waste is collected and dumped on the ground's surface.

In Benin City and most places in Nigeria, efficient trash disposal has been a major issue. Leachates from garbage dumps are a major cause of heavy metal pollution in Nigeria's land and waterways (Obaliagbon & Olowojoba, 2006). In some instances, trash is thrown into the environment carelessly, while in other dumpsites, trash is burned in the open and the ashes are left behind. Burning garbage eliminates organic components and oxidises metals, resulting in ash that is higher in metal content. These metals will first undergo oxidation and corrosion, after which they will be dissolved in rainwater and leached into the soil, where they will be absorbed by developing plants and eventually into the food chain. While the majority of the metals are being carried away by runoff into streams and rivers and harming the marine environment, improper waste management practises also play a role in the poisoning of subsurface water. As a result, heavy metals build up in fish and other aquatic species, endangering the health of consumers (Njojju & Ayoka, 2006).

Since they have the ability to pollute the terrestrial, marine, and aerial environments, solid wastes pose the greatest hazard to life of all waste classes. Due to the health risks that heavy metals pose to humans and other species when they accumulate in a biological system, land pollution caused by these waste components has received a lot of attention in recent years (Adekunle et al., 2003). Recent research have also looked at how considerable amounts of these hazardous and persistent metals can be transferred from garbage dumpsites into the soil ecosystem. Finally, these metals are absorbed by plant parts, which then enter the food chain. Therefore, increased soil concentrations of heavy metals may cause higher plant absorption levels. However, elements including metal species, plant species, plant age, and plant part may have an impact on the rate of metal uptake by agricultural plants.

For the cultivation of particular fruits and vegetables, some of the dumpsites are employed as fertile soils. Some farmers gather the decayed waste from the dumps and use it as manure on their crops. By absorbing these heavy metals as mobile ions in the soil solution through their roots or their leaves, these cultivated plants render the soil unfit for human consumption (Uzoho & Oti, 2006).

Metals with a density greater than five times that of water are considered heavy metals. The phrase "heavy metal" is frequently used to refer to a collection of metals that are linked to toxicity and pollution. In low quantities, they might also include a few elements that are crucial for the survival of living things. The following heavy metals have been identified by the European Commission as posing a major risk to plants and animals: arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), mercury (Hg), nickel (Ni), aluminium (Al), and zinc (Zn). Because they are stable components that the body cannot metabolise, heavy metals are transferred up the food chain to humans (bioaccumulation). Aluminium (Al), Arsenic (As), Cadmium (Cd), Copper (Cu), Lead (Pb), Mercury (Hg), and Nickel (Ni) are among the most prevalent and dangerous heavy metals.

In general, heavy metals can be extremely poisonous and serve no essential purpose in the body. They can be found in food, drink, many manufactured compounds, and other items. The usage of heavy metals in industrial processes and other human activities has increased significantly over the past 50 years, which has led to a sharp rise in the number of heavy metal infections in humans. These activities are the main cause of heavy metal pollution in the environment. For instance, waste disposal, industrial activities, and agricultural activities, among others.

A severe threat to both human health and the socioeconomic well-being of the environment is posed by the presence of heavy metals in the environment, particularly in food sources. It is assumed that there would be heavy metal contamination in residential and commercial areas in urban settings given the understanding that trash dumps are possible sources of heavy metals contamination (Jekin, 1989).

## 1.2 Statement of problem

Due to their non-biodegradability, lengthy biological half-lives, and potential for accumulation in many bodily areas, heavy metals are extremely hazardous. Due to a lack of effective mechanisms for their removal from the body, even at low concentrations, they may harm an animal's bodily organs and other internal organs. Food, the air we breathe, and water all allow heavy metals to enter the human body.

Through the intake of contaminated drinking water, contaminated soil, or crops grown on contaminated land, trace metals may reach the human body. Metals like lead, mercury, cadmium, and copper are very toxic, generate environmental concerns, and accumulate poisons over time. These metals play a significant role in the aetiology of numerous human illnesses, such as carcinogenesis, and are a major source of oxidative stress in cells (Frenkel, 1992; Wang et al., 2004; Leonard et al., 2004; Hei and Filipic, 2004).

(USEPA, 2002; Rotich et al., 2006; UNDP, 2006) Exposure to heavy metal toxicity causes dermatitis, lung cancer, mental retardation, cerebral palsy, lung damage, and gastrointestinal anomalies in addition to the loss of the developing foetus. According to research by Chakrabarti et al. (2001), certain metals can directly alter and/or harm DNA by creating DNA adducts that cause chromosomal breakage.

Due to the unfettered access to the dumpsite, scavengers search for raw materials every day. A large portion of these materials eventually return to neighbourhoods as animal feed and even human food. Animals such as stray chickens, pigs, goats, dogs, and cats prowl waste sites, consuming poisonous materials and vegetables growing nearby, and acting as carriers of parasites and pests that eventually spread to nearby homes, infecting both humans and animals with diseases. The goal of this research is to evaluate the hazards to people's health that the dumpsite poses to those who live nearby.

**Aim and Objectives of the Study:**

To determine the concentration level of heavy metals in the soil and vegetables found around the dumpsites and the perceived health risks posed by the heavy metals to the community around the dumpsite in Oluku, Akure Road by Iyowa, Benin city.

The objectives of this study are as follow:

1. To determine the level of concentration of heavy metals in the soil and plants around the dumpsite.

2. To be able to determine the health risk parameters, Daily metal Intake (DIM), Health Risk Index (HRI) and Total Health Quotent, (THQ) and evaluate the potential human health risks associated with their consumption. (Osae et al., 2023)

## 1.3 Scope of Study

The scope of this study is wide, ranging from collection of sample, digestion and the use of energy dispersive X-ray fluorescence spectroscopy (EDXRF) system determine the heavy metals in soil and vegetation.

## 1.4 Justification of the Study

According to estimations from the World Health Organisation (WHO), extended exposure to environmental pollution is a contributing factor in roughly 25% of the diseases that affect people today (Prüss-Üstün and Corvalán, 2006; Kimani, 2007). It is important to remember that wastes might occasionally be harmful to your health. Benin City and other cities in Nigeria frequently have dump sites. The places are not only ugly to look at, but also dangerous to your health. Due to the rubbish that is discarded, the land near the dump is frequently contaminated with harmful heavy metals. The locals who reside close to the landfill plant vegetables and fruits in this soil. When people and animals eat these plants, which bio-accumulate heavy metals from the soil, the heavy metals build up in the body and have detrimental consequences on human and animal health (USEPA, 2002; UNDP, 2006; Rotich et al., 2006).

Additionally, the dump site serves as a breeding ground for pathogens that seriously impact the local community's health (Eddy et al., 2006; Etekpo, 1999). Hazardous waste can and has resulted in pollution, health problems, and even fatalities. A number of human health issues have been linked to exposure to numerous chemical combinations in communities living close to trash disposal sites (Zupancic, 1997; Palmer et al., 2005; Alimba et al., 2006).

# CHAPTER TWO

# LITERATURE REVIEW

## 2.1 SOLID WASTE

Any abandoned material that is discarded by being disposed of, burned or cremated, recycled, or regarded "waste-like" is referred to as "solid waste." Physically, a solid waste might be a solid, liquid, semi-solid, or container for gaseous substance. Garbage, construction debris, commercial rubbish, sludge from waste treatment facilities, air pollution control facilities, and other abandoned materials are all considered to be solid waste. Industrial, commercial, mining, agricultural, residential, and communal activities can all produce solid waste. Wastes such solid or dissolved materials in domestic sewage, source, special nuclear, or by-product material as defined by federal law are not considered solid waste. Without even mentioning the garbage produced by common citizens in a prosperous, consumer-oriented metropolitan environment, intensive agriculture and modern industrial operations produce startling amounts of waste (Alan, 1996). We are hesitant to use the word "waste." Almost any material that is thrown away and is consequently classified as waste can also be considered a potential resource. Societies have discovered ways to utilise garbage throughout human history, including inert materials for landfills, animal dung for fuel, and organic residues as fertilisers. There are efforts to find new uses for materials that have completed their intended function in the modern day as well.

Source reduction, recycling, storage, collection, transportation, processing, and disposal are all possible methods for managing solid waste. Landfills, composting areas, transfer stations, incinerators, and processing facilities are a few examples of solid waste facilities. These facilities could be privately or publically owned.

## 2.2 Approaches and Challenges to Municipal Solid Waste Management:

Waste handling facilities are lacking in many highly populated areas in most developing and underdeveloped countries due to cost and lack of enforcement of relevant enactment. Poor regional and urban planning, lack of enforcement of relevant laws and edicts on waste disposal, lack of organized landfill sites contribute to the presence of dumpsites within living areas in developing nations. This results in the discharge of household sewage and refuse into the environment untreated. The surface run-off and leachates from dumpsites are sources of fresh water contamination (Abdus-Salam et al., 2011). The recent population and industrial growth has led to increasing production of domestic, municipal and industrial wastes, which are indiscriminately dumped in landfill and water bodies without treatment (Ogunyemi et al., 2003). Municipal solid waste management constitutes one of the most crucial health and environmental problems facing governments of African cities. This is because even though these cities are using 20-50 percent of their budget in solid waste management, only 20-80 percent of the waste is collected. The uncollected or illegally dumped wastes constitute a disaster for human health and the environmental degradation (Achankeng, 2003). Thousands of old landfills and dumpsites exist throughout the developing countries representing a threat for human health for the next decades, unless appropriate measures are taken. Most developing countries follow the practice 12 of open dumping of solid wastes causing environmental and health risks (Kurian et al., 2003). Industrialization, population growth and unplanned urbanization have partially or totally turned our environment to dumping sites for waste materials (Ikem et al., 2002)

## 2.3 **Disposal of Solid Waste**

Land is used for the disposal of solid waste. The term "solid waste" refers to a variety of waste materials, including mine tailings, municipal trash, waste steel from autos, and animal manures. The waste products will unavoidably interact chemically and physically with the environment, but depending on the materials and their level of exposure, the duration of these interactions may be short or long. According to Adekunle et al. (2003), other methods of waste disposal include composting, land filling, open dump systems, and incineration (burning the trash). Many elements that pose a hazard to our civilization, such as heavy metal, have entered our environment as a result of the disposal of this waste. Solid waste disposal has been a problem from ancient times to the present and will only get worse in the future. The removal of waste has become more important for health as cities have grown.

### Behaviour of Inorganic (Heavy Metals) Contamination of The Soil.

The transition metals, sometimes known as heavy metals, are the most common group of elements in subsoils. Copper (Cu), Iron (Fe), Manganese (Mn), Zinc (Zn), Mercury (Hg), Arsenic (As), Lead (Pb), Nickel (Ni), and others are some examples. These metals could be found in soil from industrial sources or garbage dumps.

## 2.4 Lead (Pb)

Lead is a soft heavy metallic element. It was one of the nine chemical elements known and used in the ancient world. Throughout history it has been widely employed in arts and architecture and in modern times it has been used in making printer type faces and reaction shields. It is used as element in lead storage batteries, solder, plumbing, cable covering is also recognized. It is used in interior paints. It causes serious hazards because lead is highly toxic if improperly handled (Wajahat et al., 2006). It is found in organic and inorganic forms. Inorganic lead affects typically the nervous system (CNS), peripheral nervous system (PNS), hematopoietic, renal, cardiovascular and reproductive system. Organic lead toxicity tends to predominantly affect the central nervous system. Inorganic lead enters the body by way of ingestion or inhalation, for adult only about 10% of the ingested dose is absorbed in contrast, children may absorb as much as 50% of an ingested dose. Lead affects the production of blood cells, kidneys and behavior. It passes the placenta and can damage the foetal nervous system, increasing the risk for premature birth, or low birth weight and size babies or it can induce miscarriage. Nutritional deficiencies increase the risk for lead absorption and toxicity.

### 2.5 Chromium (Cr)

The only Chromium compound of practical importance is chromite's, a slack spinal of the idealized composition FeCr2O4 in practice it contains varying amount of MgO, Al2O3 and SiO2 major producers of chromite's include South Africa, Russia, Albania etc. Since 1990, the production of chromite's has doubled roughly every decade, reaching 2.6million tones, in 1984; chromium was more rarely as the mineral crocoite's (PbCrO4) and minor amounts minerals. The greater part of chromite's is produced by heating with coal to give ferrochrome used in the manufacture of alloy steels, pure chromium metal for use in iron is produced by reduction of Cr2O3. Less than 15% of the ore is transformed into chromium compounds, principally chromates, dichromate chromium oxide, chromium (III) oxide etc. (Ndiokwere, 1985). Chromium is toxic in high concentration to both plants and animals. It causes perforation, bronchogenic, carcinoma etc. Chromium poisoning cause's skin disorder and liver damage. Chromium has a wavelength of 357nm.

### 2.6 Cadmium:

Cadmium is a white shining but tarnishes able metal, similar in several characteristics to Zinc and Tin. Cadmium is not found to a great extent in nature, its presence in the earth crust is estimated to range between 0.15 to 0.11mg/g (67th element in order of abundance), with a Zn/Cd ratio around 250:1 (the ratio depends strictly on the nature of rocks). Cadmium can be present as a result of volcanic emission and release from the vegetation. It is not essential to plant growth, but under certain conditions can accumulate in some plants to level that are hazardous to animals and humans. Some sewage sludge contains enough cadmium to encourage accumulation. The chemistry of cadmium reaction in the soil is not well understood, but it is known that the uptake of this element is generally reduced by organic matter, silicate clay, and hydrous oxides of iron and aluminum and poor soil aerations. Cadmium uptake is high in acids soils and is reduced when the soil is limed. This element has a wavelength of 228mm. It is a hazardous air pollutant which enters plants and animals from soil and water thus entering products cadmium has an inhibitory effect on antioxidant processes, it interacts with sulphuric group of essential enzymes. Chronic exposure to cadmium is associated with a wide range of diseases, including heart disease, anaemia, skeletal weakening depressed immune system responses. At extreme levels it causes an illness called tai – “itai” disease characterized by brittle bones and intense pain (Connell & Miller, 1984).

## 2.7 **Nickel (Ni):**

Nickel is widely used in consumer products like buttons, zips, coins, dental braces, orthodontic application (appliances used in the treatment of problems concerning the teeth and jaws) household appliances tools, artificial joints, jewelry, batteries, hair spray etc. Nickel occurs naturally in metal refineries and municipal solid waste incinerators release nickel needed by the human body to produce red blood cells, however, in excessive amounts can become mildly toxic. Short term over exposure can cause some health problems, but long term exposure can lead to decrease of body weight, heart and liver damage and skin irritation. The EPA does not currently regulate nickel levels in drinking water. Nickel can accumulate in aquatic lives, but its presence is not magnified along food chains.

## 2.8 Arsenic (As):

The inorganic arsenic compounds are created when arsenic is coupled with other elements including oxygen, chlorine, and sulphur. Arsenic exists naturally in the environment on the earth's crust and is a necessary element that turns hazardous when consumed in large amounts. Arsenic generally enters the environment through air pollution and hazardous waste dump seepage into the ground and water. Through mining operations, the use of arsenical pesticides, and the combustion of fossil fuels, arsenic enters the aquatic environment. As a result of its widespread usage as pesticides, arsenic compounds such as copper aceto-arsenic, lead and calcium arsenates, and others may accumulate in soils to dangerous levels over time. The chemical form consumed and the concentration rate of absorption both affect how harmful arsenic is. Gastrointestinal issues, diarrhoea, constipation, gastrointestinal abnormalities, loss of appetite, and weight loss are some of the harmful symptoms of arsenic poisoning. Long-term low-level exposure to arsenic can lead to skin discoloration and the development of tiny corns or warts. Arsenic exposure at high doses can be fatal.

## 2.9 **Aluminum (Al):**

Although formerly thought to be a non-heavy metal, aluminium has lately been found to be one. Since acid rain typically dissolves the aluminium in the soil and rocks, everyone is exposed to low levels of aluminium from the atmosphere and water. High concentrations can harm the bones, neurological system, and respiratory system. At least 489 of the 1416 (34% of) sites on the EPA's national priorities list have been discovered to contain aluminium (David, 1989). Aluminium is not an issue for plants at neutral or alkaline pH levels, but in acidic soil, a form of aluminium (Al3+) is dissolved into a soil solution that is extremely harmful to plant roots. On acidic soil, crop productivity is restricted by aluminium toxicity. The poisonous aluminium destroys the roots system in acidic soil, drastically reducing yields.

### Zinc:

Numerous metalloenzymes depend on zinc, which is an essential vitamin for both humans and animals. Alcohol dehydrogenase, alkaline phosphatase, carbonic anhydrase, leucine aminopeptidase, superoxide dismutase, and DNA and RNA polymerase are some of the enzymes in this group. According to Salgueiro et al. (2000) and ATSDR (2005b), an acute oral intake of zinc might result in symptoms like tachycardia, vascular shock, dyspeptic nausea, vomiting, diarrhoea, pancreatitis, and damage to the hepatic parenchyma. 26 By interacting with metallothionein at the brush edge of the intestinal lumen, excessive doses of zinc in the diet restrict copper absorption. However, copper has a stronger affinity for metallothionein than zinc and displaces zinc from the metallothionein protein. Copper and zinc both appear to bind to the same metallothionein protein. When the mucosal cells are shed, the copper complexed with metallothionein is maintained in the mucosal cell, largely inaccessible for transfer to plasma, and expelled in the faeces. Accordingly, an excess of zinc may lead to a reduction in dietary copper availability and the emergence of copper insufficiency (Gyorffy and Chan, 1992; Barone et al., 1998). On the other hand, zinc deficiency has been linked to dermatitis, anorexia, growth retardation, poor wound healing, hypogonadism with reduced reproductive capacity, impaired immune function, and decreased mental function (Sandstead, 1981; Elinder, 1986; Cotran et al., 1989). It has also been linked to an increased incidence of congenital malformations in infants.

## Iron:

An increased dietary iron intake increases the risk of oestrogen- and carcinogen-induced kidney tumours in Syrian hamsters and rats, respectively. Administration of oestrogen promotes iron uptake by cultured cells and increases iron buildup in hamsters. Increased iron reserves in the body have been linked to an increased risk of many malignancies brought on by oestrogen in humans (Liehr and Jones, 2001). For a wide range of metabolic processes, iron serves as the catalytic centre. Several tissue enzymes, including the cytochromes, which are essential for the synthesis of energy, as well as enzymes required for immune system function, have iron as a component. It is possible that iron status affects copper metabolism because low serum copper levels have been observed in some cases of iron deficiency anaemia (Michael et al., 2009). Reduced immunity to infections, decreased productivity at work, decreased physical fitness, weakness, fatigue, impaired cognitive function, decreased learning ability, increased distractibility, impaired reactivity and coordination, itching, inability to control body temperature, and eating pica are all signs of iron deficiency. (Beard, 2001)

## Vanadium:

Vanadium has little nutritional benefit and has not been demonstrated to be necessary for humans. As a result, dietary guidelines or requirements have not been established. According to the Scientific Committee on Food (SCF), there is still a lack of data to substantiate vanadium's necessity (SCF, 1993). Adults should consume no more than 1.8 mg of vanadium per day, according to the Food and Nutrition Board (FNB, 2001). Vanadium has no maximum limit that has been determined to be safe, according to the Expert Group on Vitamins and Minerals (EGVM) (EGVM, 2003). It has been demonstrated that vanadium compounds operate similarly to insulin in isolated cell systems, animal models, and diabetes people. Therefore, it has been thought of using them in the treatment of diabetes mellitus (Shechter, 1990; Shamberger, 1996). Vanadium has also been proposed as a supplement to help with bodybuilding, however there is no proof that it works (Fawcett et al., 1997). Vanadium accumulates and is preserved in the bones of mammals, according to studies (Melchior et al., 1999). Cobalt (g) Cobalt is necessary for the body since it is a part of cyanocobalmin (vitamin B12), and it has been discovered in most bodily tissues, with the liver having the highest quantities (ATSDR, 2004b). Burning oil and cobalt compounds, which are employed as catalysts, paint driers, and colourants in glass, ceramics, and paints, releases cobalt into the air. In both agriculture and medicine, cobalt compounds are employed as trace element additions (ATSDR, 2004b). Cobalt is related with airborne particles that, within a few days, will fall to the ground. These are the main sources of exposure for the general public, and some of the compounds may settle 31 in water, food, and drinking water (Udeh, 2004).

**Mercury:**

According to Ratcliffe et al. (1996), Sweet and Zelikoff (2001), Campbell et al. (2003), Guzzi and La Porta (2008), and many more studies, mercury is a pervasive environmental toxin that has a wide spectrum of negative health impacts on people. Metallic mercury, mercuric sulphide (cinnabar ore), mercuric chloride, and methylmercury are the most prevalent naturally occurring forms of mercury found in the environment (ATSDR, 1999b; Guzzi and La Porta, 2008). Each of them has a unique toxicity profile. Methylmercury is especially dangerous because it can accumulate to levels that are many times higher in edible freshwater and saltwater fish and marine mammals than in the surrounding water (ATSDR, 1999b; Campbell et al., 2003; Guzzi and La Porta, 2008; Wiwanitkit, 2009). Metallic and inorganic mercury are released into the atmosphere during cement manufacture, coal-fired power plant emissions, burning of municipal and medical waste, mining deposits of mercury-containing ores, and uncontrolled releases in mercury-using companies. At room temperature, metallic mercury is a liquid, but part of the metal will evaporate into the air and can travel great distances. Mercury vapour in the atmosphere can be converted into different forms of mercury, which can then be carried by rain or snow into water or soil. 32 Inorganic mercury can also enter water or soil through the weathering of mercury-containing rocks, the release of contaminated water from factories or water treatment facilities, and the incineration of municipal waste that contains mercury (such as old thermometers, electrical switches, or batteries) (ATSDR, 1999b; Balshaw et al., 2007). The food chain is a place where mercury may enter and build up. Melethylmercury is the type of mercury that builds up in the food chain (Sweet and Zelikoff, 2001; Balshaw et al., 2007; Wiwanitkit, 2009). Mercury poisoning can result in long-term brain and kidney damage, personality changes (such as anger, shyness, and anxiousness), tremors, altered eyesight, hearing, muscular tremors, loss of feeling, and memory problems (ATSDR, 1999b).

## 2.10 Bioaccumulation of Heavy Metals in Living System:

Contaminants enter the body by eating, smoking, inhaling, skin absorption, and daily exposure to an infinite number of items and chemicals created and used by humans. As a result of our environment and civilization, it is impossible to avoid bodily contamination. These harmful chemicals, heavy metals, pests, and other unnatural invaders all progressively build up over time. The accumulation may eventually reach dangerous levels if the body's natural detoxification channels (such as the blood, lymph, and cerebral spinal fluid) are unable to get rid of them as quickly as they enter the body. "Bioaccumulation of metals" is the process by which organisms chelate metals from their environment and store them in their tissues. It is the outcome of a balance between the amount of the metal present in organisms, the environment, and the rates of consumption and excretion. For instance, inorganic mercury found in products like pesticides, insecticides, fungicides, etc. typically settles in water to create sediments. These substances may be absorbed by aquatic organisms, which may then be eaten by fish, which are then captured and consumed by humans. As a result, these substances may bio-accumulate in humans after prolonged exposure. The result of this could lead to a number of illnesses, some of which could be fatal (Osuj & Onojake, 2004).

## 2.11 Heavy Metals and Human Health:

However, the term "heavy metals" is now used to refer to compounds like arsenic, cadmium, chromium, copper, lead, nickel, molybdenum, vanadium, and zinc. Heavy metals are actually substances with a density greater than 5 mg mL-1 (Jarup, 2003). Additionally significant are aluminium, cobalt, strontium, and other rare metals (Khanna and Khanna, 2011). The phrase "it is the dose that makes the effect" refers to the fact that heavy metals are not always dangerous; they only become so when they accumulate to lethal levels in plants and animals. Certain compounds, known as trace elements or micronutrients, serve critical roles in the cells of plants and animals. This has been shown for Co, Cu, Fe, Mn, Mo, Ni, and Zn. They are referred to as "heavy metals" whenever the internal concentration exceeds a predetermined level (IOCC, 1996; Klaus-J, 2010). Until then, they do not cause harm.

The types and quantities of heavy metals in dumpsite soils vary depending on the soil's age, composition, and location, according to studies on these soils (Udosen et al., 1990; Haluschak et al., 1998; Odukoya et al., 2000). Significant levels of zinc, copper, chromium, and cadmium are leaking out quickly, according to field surveys and soil column tests (Sukkariyah et al., 2005). Municipal waste contains heavy metals such Cd, Co, Cu, Fe, Hg, Mn, Pb, Ni, and Zn, which are also leached into the soil from dump sites (Fatoki, 2000).

## 2.12 Routes of Heavy Metal Exposure:

The two main ways that heavy metals enter the human body are by inhalation and ingestion. The majority of human exposure to these substances occurs by ingestion (Damek-Poprawa and Sawicka-Kapusta, 2003; Ejaz ul et al., 2007; Türkdogan et al., 2003). When metals come into touch with people in industrial, residential, or manufacturing contexts, including agriculture, they can also be absorbed via the skin. For adults, occupational exposure is a typical source of exposure (Roberts, 1999; Ngan, 2006).

The most frequent method of exposure for kids is by ingestion. Children may consume dangerous levels through routine hand-to-mouth contact with polluted soil or by inadvertently ingesting non-food items (Dupler, 2001). Less frequent exposure pathways include those that occur during radiological procedures, as a result of improper monitoring or dosing during IV nourishment, or as a result of broken thermometers (Smith et al., 1997).

### Classifications of Heavy Metal Exposure:

The standard classification of toxic heavy metal exposure is as follows: acute, lasting 14 days or less; intermediate, lasting 15–354 days; and chronic, lasting more than 365 days. Heavy metals can accumulate in vital human organs because they are difficult to biodegrade. This situation causes a range of illnesses depending on the length of the exposure (Demirezen and Aksoy, 2006). Chronic low level intakes of heavy metals have harmful effects on both humans and other animals since the body lacks a dependable system for removing them (Bahemuka and Mubofu, 1999). Metals that accumulate as poisons include copper, lead, mercury, and cadmium. According to Ellen et al. (1990), these metals are thought to be exceedingly dangerous and to present environmental hazards. Acute poisoning is moreover usually caused by exposure to a significant amount of the heavy metal that occurs quickly or unexpectedly.

Chronic toxicity, which arises from ongoing or repeated exposure, causes the dangerous substance to accumulate in the body. Chronic exposure can result from a number of factors, including living close to a hazardous waste site, spending time in areas with lead paint that is deteriorating, maternal transfer while a baby is within the mother, eating contaminated food, drinking polluted water, or participating in hobbies that involve lead paint or soldering. Chronic exposure might occur at home or at work. Since the symptoms of chronic poisoning commonly match those of other common ailments, it can be challenging to distinguish between the two (WHO, 1998; Roberts, 1999; IOSHIC, 1999; Ferner, 2001; Dupler, 2001; Sharma et al., 2008b). Chronic heavy metal accumulation in the human kidney and liver disturbs numerous biochemical processes, leading to issues with the heart, brain, kidneys, and bones. Consuming foods tainted with heavy metals can also seriously deplete the body of some necessary nutrients, impairing psychosocial functioning, limiting foetal growth, resulting in disabilities linked to malnutrition, and raising the risk of upper gastrointestinal cancer (Jarup, 2003; Arora et al., 2008).

## 2.13 Natural Chelating Agents

Chelates is a verb that denotes grasping. Chelating agents are hence chemicals that have a significant affinity for metals and can loosen them from tissues to allow for removal. Chelating substances are used by the body's natural cleansing process. Cysteine, histidine, glutathione, and other metallothioneins, which are used to eliminate heavy metals and other toxins, are among the chelating agents that are produced by each cell in the body. Amino acids are the chelating substances used in natural chelation. The only source of these amino acids that our bodies can synthesise is a sufficient quantity of dietary protein. For instance, our bodies make cysteine from the amino acid methionine, which is present in foods like garlic and onions. In addition, various proteins, lipids, and carbohydrates can function as chelating agents. Our cells create fewer and fewer of these chelating chemicals as we become older. Therefore, supplementing becomes increasingly crucial as we age if we want to rid our bodies of heavy metals and other poisons. For instance, elderly persons should supplement these chelating compounds from plants, clay, and fermented meals much more frequently. In order to maintain natural chelation, a higher dietary intake of plant and animal proteins is strongly advised; otherwise, the body may become exposed to poisons absorbed.

### 2.14 Hazardous Effects of Heavy Metals On Human Health:

There are numerous ways that metals can poison the environment at large. The weathering of discharged products may also cause pollution of the soil and water systems because of their stability, which allows them to sometimes permeate environmental compartments many years after the initial deposition (Nordberg et al., 2005). The buildup of heavy metals in plants and soil from both natural and man-made sources, as well as the repercussions, represent significant environmental contamination issues. This is one of the most important environmental concerns due to potential threats to human health and food safety (Cui et al., 2004; Singh et al., 2011).

Some heavy metals, like cadmium, arsenic, and chromium, operate as carcinogens, whereas others, like copper, zinc, manganese, cobalt, and molybdenum, act as micronutrients for the growth of animals and humans when present in minute amounts (Freig et al., 1994; Trichopoulos et al., 1997). (Gibb and Chen, 1989; Pitot and Dragan, 1996; Saplakoglu and Iscan, 1997; Hartwig, 1998) have revealed that long-term consumption of cadmium promotes renal, prostate, and ovarian malignancies. Mercury and lead are also linked to the development of abnormalities in children. According to various studies (Alloway and Ayres, 1997; Nikolic and Sokolovic, 2004; Okoronkwo et al., 2005a), the toxic effects of excessive 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 phosphates groups.

### Heavy metals in vegetables:

Because they are a source of nutrients, vegetables are a crucial component of a human diet. By providing protein, vitamins, iron, calcium, and other elements that have noticeable benefits on health, vegetables contribute to crucial functional dietary components (Thompson and Kelly, 1990; Arai, 2002). Heavy metals and other harmful compounds have a natural tendency to be absorbed by plants, where they are then passed through the food chain (Singh et al., 2010). Because food is a vital part of the human nutrition, heavy metal contamination in vegetables cannot be understated. One of the most crucial components of food quality assurance is the heavy metal contamination of the food products (Marshall, 2004; Wang et al., 2005; Radwan and Salama, 2006; Khan et al., 2008). Heavy metal contamination of food has become a problem for both producers and consumers. According to Lokeshwari and Chandrappa (2006), the primary sources of heavy metals for vegetable crops are the growth media (soil, air, nutrient solutions) from which the roots or foliage absorb the heavy metals. Only after long-term eating of contaminated veggies can the harmful and negative effects of heavy metals become apparent. To avoid an excessive buildup of these heavy metals in the human food chain, regular monitoring of heavy metals in vegetables and other food products should be carried out (Khanna and Khanna, 2011). According to Alam et al. (2003), vegetables can absorb and accumulate heavy metals in levels high enough to harm humans clinically. Although it is simple to determine the potential ingestion rate of a certain metal, daily metal intake estimates do not consider the metals' potential metabolic ejection. Food consumption causes a long-term, low level buildup of heavy metals in the body, and the harmful effects don't show up for several years after exposure (Oluyemi et al., 2008; Orisakwe et al., 2012).

Because they absorb these metals through their roots, leafy vegetables grown on heavy metal-contaminated soils accumulate higher levels of metals than those grown on uncontaminated soils (Bahemuka and Mubofu, 1999; Al-Jassir et al., 2005; Sharma et al., 2006; Sharma et al., 2007; Marshall et al., 2007). Because they remain in the environment, heavy metals can bioaccumulate in food chains. In contrast to grain or fruit crops, they are more readily deposited in the edible sections of leafy vegetables (Mapanda et al., 2005).

**Vegetable contamination through Soil:**

When plants die, the heavy metals they had ingested are reallocated, which causes the soil to become once more enriched with the pollutants (Sawidis et al., 2001). It is known that different chemical forms of heavy metals in soil are related to their solubility, which has a direct impact on their mobility and biological availability. The uptake of heavy metals by plants is highly correlated with their solubility (Miller and McFree, 1983; Xian, 1989; Arora et al., 2008). 25 The concentration of heavy metals in soils is influenced by both the source of the metal and the physical and chemical characteristics of the soil (Qishlaqi and Moore, 2007). Many variables, including the climate, atmospheric depositions, soil concentrations of heavy metals, the type of soil, and the maturity of the plants at harvest time, affect the uptake and bioaccumulation of heavy metals in vegetables (Scott et al., 1996; Voutsa et al., 1996). According to findings from a study by Ebong et al. (2008) on the heavy metal contents of municipal and rural dumpsite soils and the rate of accumulation by Carica papaya and Talinum triangular, plants grown on dumpsite soils bio-accumulated higher metal concentrations than their counterparts obtained from typical agricultural soils.

# CHAPTER THREE

# MATERIALS AND METHODS

## 3.1 Study Area:

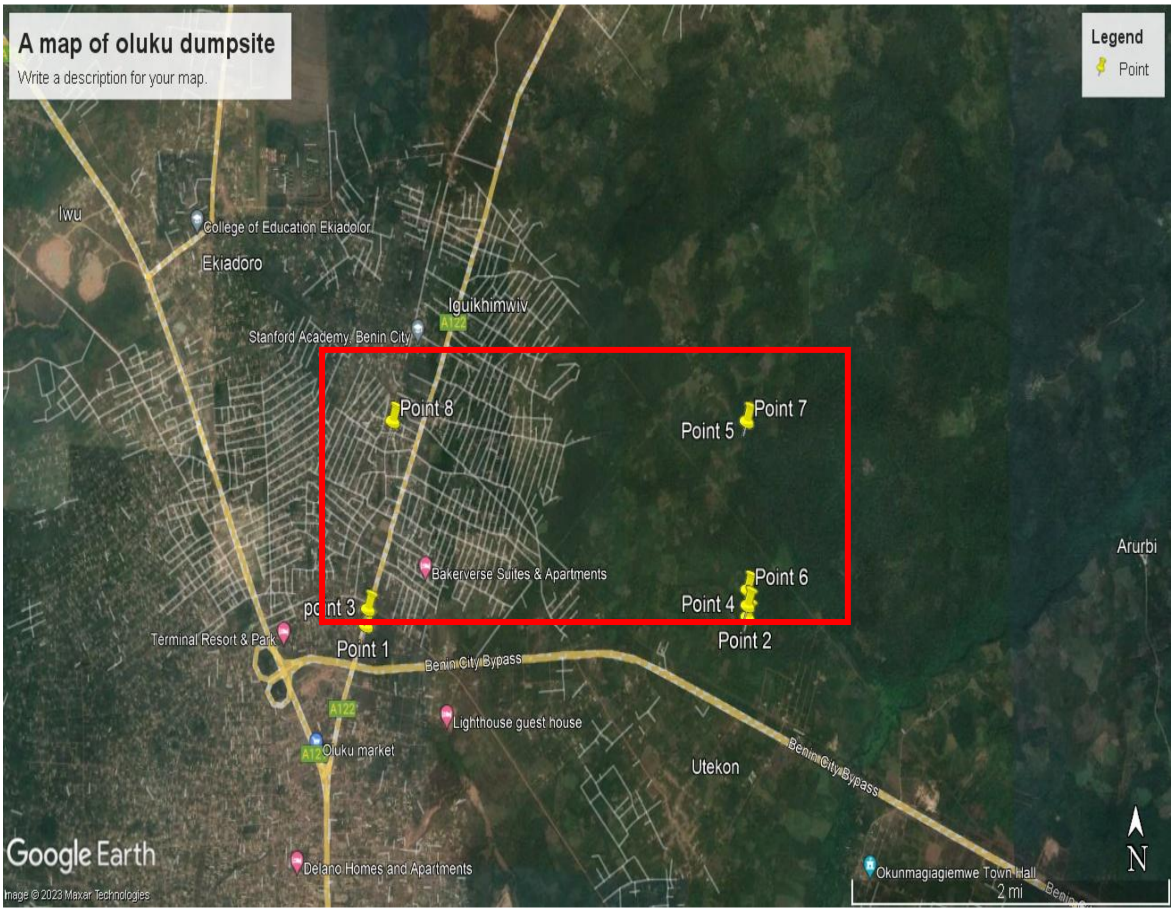

figure 3.1: map of study site (sample collection area in red square, yellow pins showing point of sample collection.

This study was carried out in Oluku, along Akure Road by Iyowa, Benin City, Edo state, Nigeria.

The location of the study area is situated in oviaNorth, Edo, Nigeria. Its geographical coordinates for the study area are 6.28’.0” N, 5.35'59"E (the red patch shows the area occupied by the dumpsite; all units are in square meters)

## 3.1 Apparatus and Equipment

Sampling is carried out with a number of tools, depending upon the purpose for which sampling is done and the nature of the sample. Equipment/apparatus used for the collection of samples in this research work as well as those used for preparation of the samples include:

1. Matchet
2. Meter rule
3. Polyethene bags
4. Trowel
5. 100 mL volumetric flask
6. 250 mL beakers
7. measuring cylinder
8. Chemical weighing balance
9. Hot plate
10. Mesh sieve (2mm)

## 3.2 Reagents

- Distilled water
- Standard buffer solution pH 4.0 & 9.2
- Aqua regia
- Concentrated HCl
- Concentrated $HNO_3$

### 3.3 Sample Collection

Soil samples were taken from a number of locations with calibrated augers at a depth of 0 to 20 cm in order to assess the concentration level of the heavy metals. The National Agency for Science and Engineering Infrastructure Research (NASENI) Laboratory in Akure, Ondo state, Nigeria, received a random collection of leafy vegetables from the dumpsite, including bitter leaf (Vernonia Amygdalina), sweet potato leaf (Ipomoea Batatas), and maize leaf (Zea Mays), for analysis. The veggies were washed with distilled water to remove any traces of dirt, and the soil samples were air-dried, powdered, and sieved. The separated, air-dried vegetable leaves were then further dried in an oven for 72 hours at 65 °C to achieve constant weight. In order to prepare the dried leaves for analysis, they were ground into a powder using a blender (Rehman et al. 2017; Muhammad et al. 2021; Haque et al. 2021).

### 3.4 Sample Digestion

**Method:**

The traditional aqua regia method of digestion—a 3:1 solution of HCl and HNO3—was used. This was carried out in a watch-glass-covered 250 mL glass beaker. On a hot plate for three hours at 1100 C, a well-mixed material weighing 0.500 g was digested in 12 mL of aqua regia. The sample was evaporated to almost dryness, diluted with 20 mL of 2% (v/v) nitric acid, put into a 100 mL volumetric flask, filtered using whatman no. 42 paper, and diluted to 100 mL with distilled water. The extract was then obtained for further heavy metal analysis (Chen, 2001).

## 3.5 Heavy metal concentration determination:

### Determination of heavy metal concentration in plant and soil samples using energy dispersive X- ray fluorescence spectroscopy (EDXRF) system:

A 200kN press was used to press ten grammes of soil and five grammes of starch into a disc that was 4.1 cm in diameter, 7 mm thick, and for five seconds. The process was repeated for the vegetable samples, and the discs were kept in desiccators until the EDXRF analyses were completed in order to preserve the samples' original dry mass. For each vegetable and soil sample, the aforementioned process was carried out four times. Using ray EDX-720, EDXRF spectrometer analyses, the mineral element concentrations in the soil and plant material were discovered. Al, Fe, Ni, Sn, and Sb were measured in terms of quantity. The findings were presented in milligrammes per kilogramme of the dry matter (mg/kg).

## 3.6 Transfer factor (TF):

By using Eq. (1), which had previously been employed by Tasrima et al. (2015), Zhou et al. (2016), Ramteke et al. (2016), and Rehman et al. (2017), it was possible to determine the ratio of heavy metals (HM) in plants to HM in soil, also known as the transfer factor, bioconcentration factor, or bioaccumulation factor.

$$TF = \frac{C_{vegetable}}{C_{soil}} \qquad (1)$$

$C_{vegetable}$ denotes HM content of vegetables, and $C_{soil}$ denotes HM content of soil.

## 3.7 Health risk assessment:

By examining the daily metal intake (DIM), health risks index (HRI), and target health quotient (THQ) characteristics, the potential health risks related to the intake of metals through vegetables were evaluated. (Khan et al. 2010; Jan et al. 2010;

Ramteke et al. 2016; Rehman et al. 2017; Fonge et al. 2021) used Eq. (2) to calculate the DIM.

$$\mathrm{DIM} = \frac{C_m \times C_f \times D_{vi}}{B_{aw}} \tag{2}$$

where $C_m$, $D_{vi}$, $B_{aw}$ and $C_f$, respectively, denote metal concentration in vegetables, daily vegetable intake, average body weight and conversion factor of vegetables from fresh to dry weight (Jan et al. 2010; Ramteke et al. 2016; Edogbo et al. 2020). $C_f$ value of 0.085 used by Rehman et al. (2017) and Edogbo et al. (2020) was adopted in this study. Respective $D_{vi}$ and $B_{aw}$ values used are 200 g/p/d (gram/person/day) and 69.9 kg for adults and 150 g/p/d and 20.2 kg for children.

Health risk index (HRI) was determined with Eq. (3) (Jan et al. 2010; Ramteke et al. 2016; Rehman et al. 2017; Fonge et al. 2021).

$$\mathrm{HRI} = \frac{\mathrm{DIM}}{\mathrm{RfD}} \tag{3}$$

where RfD represents reference oral dose. RfD values of 0.04, 0.300, 0.7 mg/kg/day for Ni, Al, Fe respectively were adopted in this study (Shah et al. 2012).

The target hazard quotient was determined from Eq. (4) (Wang et al. 2005; Storelli et al. 2008; Manea et al. 2020; Haque et al. 2021).

$$\mathrm{THQ} = \frac{E_F \times E_D \mathrm{\ x\ } F_{IR}\, C_m \times 10^{-3}}{R_{fD} \times W_{AB} \times T^A} \tag{4}$$

where $E_F$ is 350 days'/year exposure frequency; $E_D$ is 54 years' exposure duration; $F_{IR}$ is the vegetable ingestion rate (150 g/p/d and 200 g/p/d for children and adults, respectively); $R_{fD}$ values are 0.040, and 0.300 and 0.70 mg/ kg/day for Ni, and Al and Fe respectively; $W_{AB}$ is average body weights (20.2 kg and 69.9 kg for children and adults, respectively); and $T^A$ ($E_D$×365 days/year) is non-carcinogens average exposure time. Exposure will likely result to noticeable negative health effects if THQ is greater than one (Chauhan et al. 2014; Zhou et al. 2016)

# CHAPTER FOUR

# RESULTS AND DISCUSSIONS

## 4.1 Results

Heavy metal concentrations in soils Samples.

The determination of heavy metal in soil samples was done using energy dispersive X-ray fluorescence spectroscopy (EDXRF) system.

Table 4.1(a) – 4.1(c): Heavy metal concentration (mg/kg) for soil samples 1 to 9

Tale 4.1 (a)

| Element | SL1 | SL2 | SL3 |
|---|---|---|---|
| Mg | 43.2824 | 66.8189 | 49.6657 |
| Al | 2.5434 | 3.2665 | 2.2747 |
| Si | 11.9839 | 11.9887 | 17.6278 |
| P | 0.0977 | 0.1223 | 0.0968 |
| S | 0.2104 | 0.4726 | 0.3182 |
| K | 0.4753 | 0.1815 | 0.4138 |
| Ca | 0.2316 | 0.2505 | 0.0726 |
| Ti | 0.1774 | 0.3066 | 0 |
| V | 0.0048 | 0 | 0.0205 |
| Cr | 0 | 0 | 0 |
| Mn | 0 | 0 | 0 |
| Co | 0.0353 | 0.0773 | 0.0208 |
| Fe | 4.7698 | 5.6929 | 4.5983 |
| Ni | 0.1951 | 0.1842 | 0.2074 |
| Cu | 0.3443 | 0.2652 | 0.2237 |
| Zn | 0.2555 | 0.2651 | 0.2449 |
| As | 0 | 0 | 0 |
| Pb | 0 | 0.0081 | 0 |
| W | 0.33 | 0.1386 | 0 |
| Au | 0 | 0 | 0 |
| Ag | 0 | 0 | 0 |
| Rb | 0.0021 | 0.0032 | 0.0045 |
| Nb | 0 | 0.0383 | 0.0461 |
| Mo | 0.2051 | 0.2025 | 0.2257 |
| Cd | 0 | 0 | 0 |
| Sn | 7.2845 | 6.2077 | 6.4107 |
| Sb | 6.5182 | 5.7711 | 6.1141 |

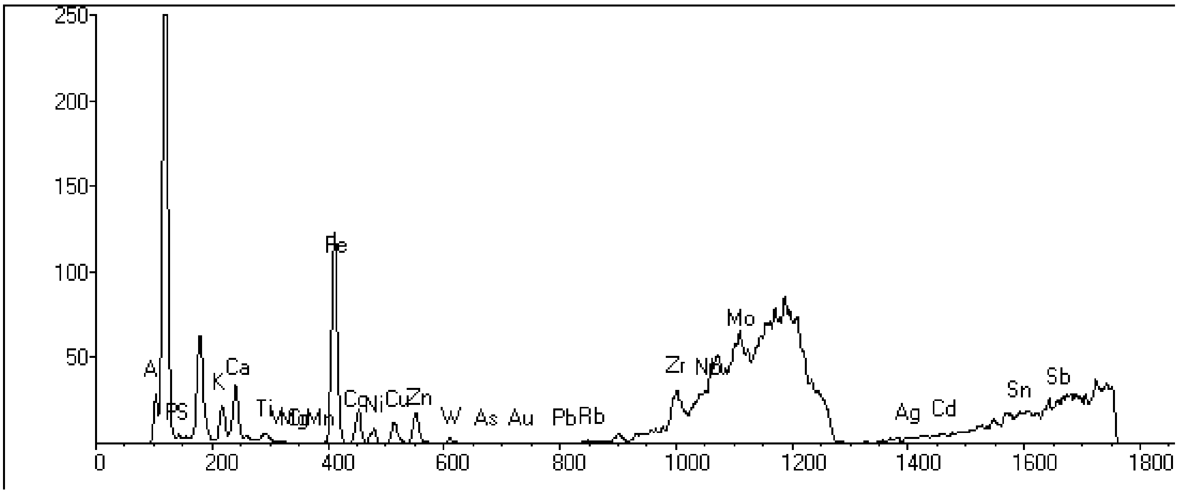

Figure 4.1.1: soil sample 1 graph

This graph shows the metals and their contents found in the sample. The analysis was done using energy dispersive X-ray fluorescence spectroscopy (EDXRF) system. The x-axis represents the metals and the y-axis represents the content of the metals found in mg/kg.

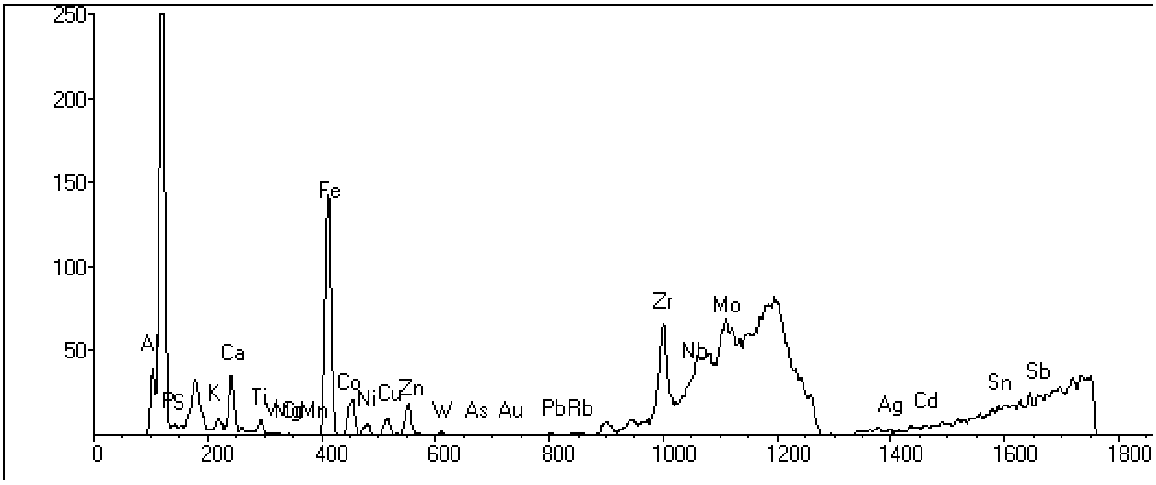

Figure 4.1.2: soil sample 2 graph

This graph shows the metals and their contents found in the sample. The analysis was done using energy dispersive X-ray fluorescence spectroscopy (EDXRF) system. The x-axis represents the metals and the y-axis represents the content of the metals found in mg/kg.

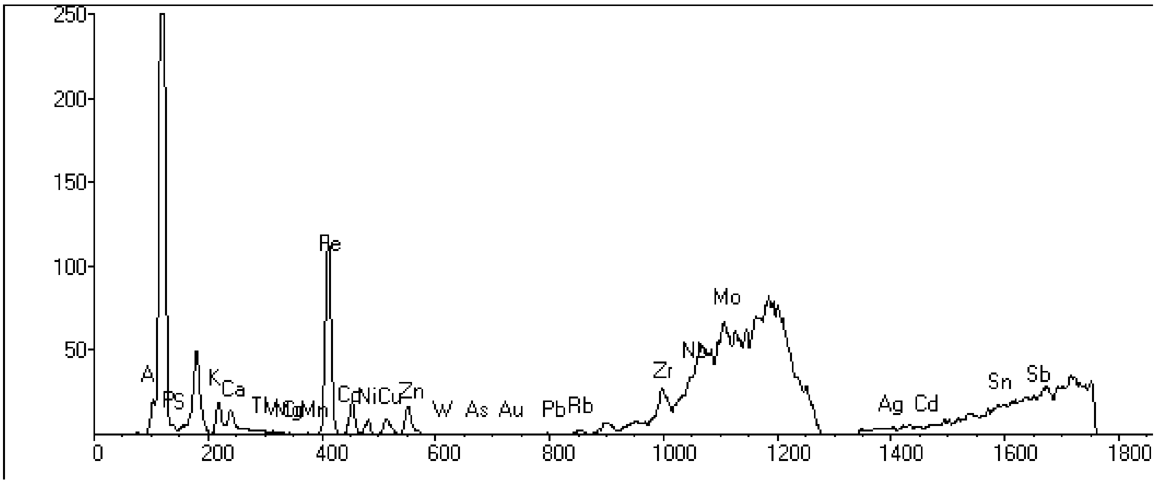

Figure 4.1.3: soil sample 3

This graph shows the metals and their contents found in the sample. The analysis was done using energy dispersive X-ray fluorescence spectroscopy (EDXRF) system. The x-axis represents the metals and the y-axis represents the content of the metals found in mg/kg.

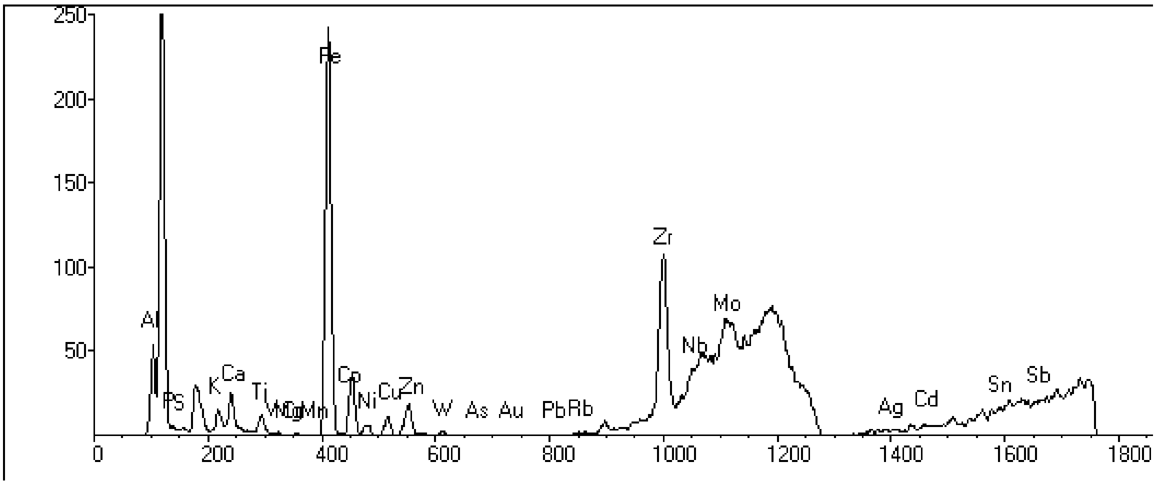

Figure 4.1.4: soil sample 4

This graph shows the metals and their contents found in the sample. The analysis was done using energy dispersive X-ray fluorescence spectroscopy (EDXRF) system. The x-axis represents the metals and the y-axis represents the content of the metals found in mg/kg.

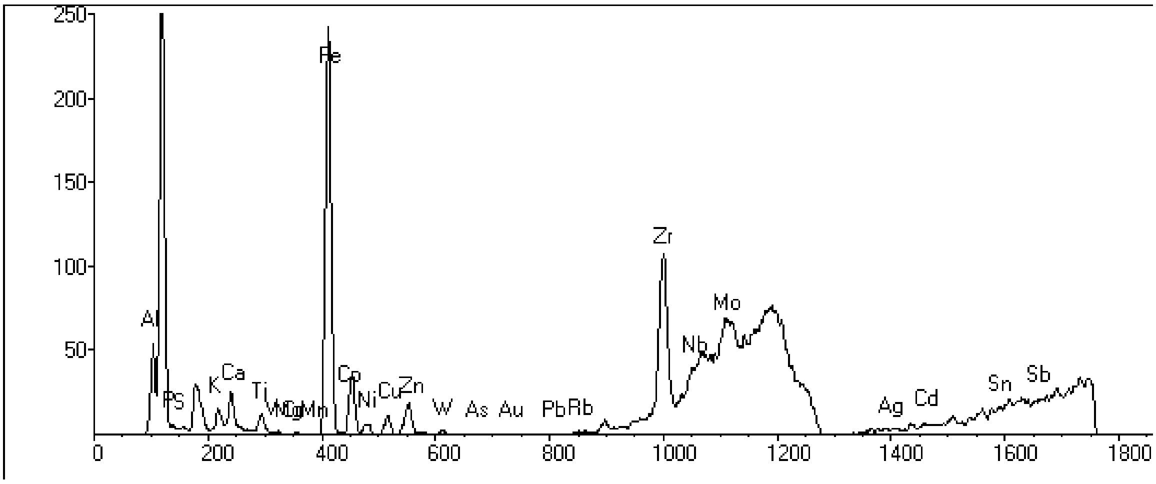

Figure 4.1.5: soil sample 5

This graph shows the metals and their contents found in the sample. The analysis was done using energy dispersive X-ray fluorescence spectroscopy (EDXRF) system. The x-axis represents the metals and the y-axis represents the content of the metals found in mg/kg.

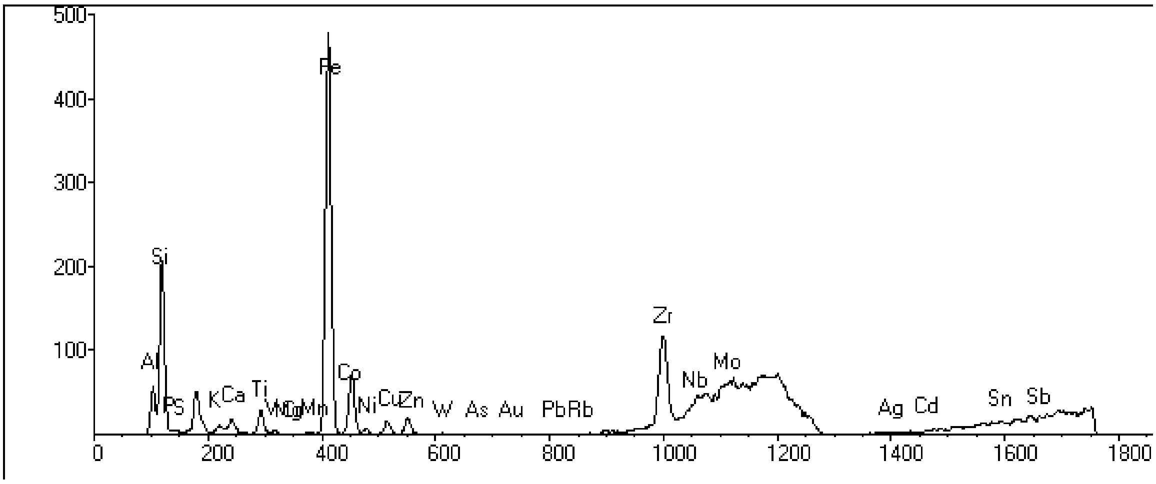

Figure 4.1.6: soil sample 6

This graph shows the metals and their contents found in the sample. The analysis was done using energy dispersive X-ray fluorescence spectroscopy (EDXRF) system. The x-axis represents the metals and the y-axis represents the content of the metals found in mg/kg.

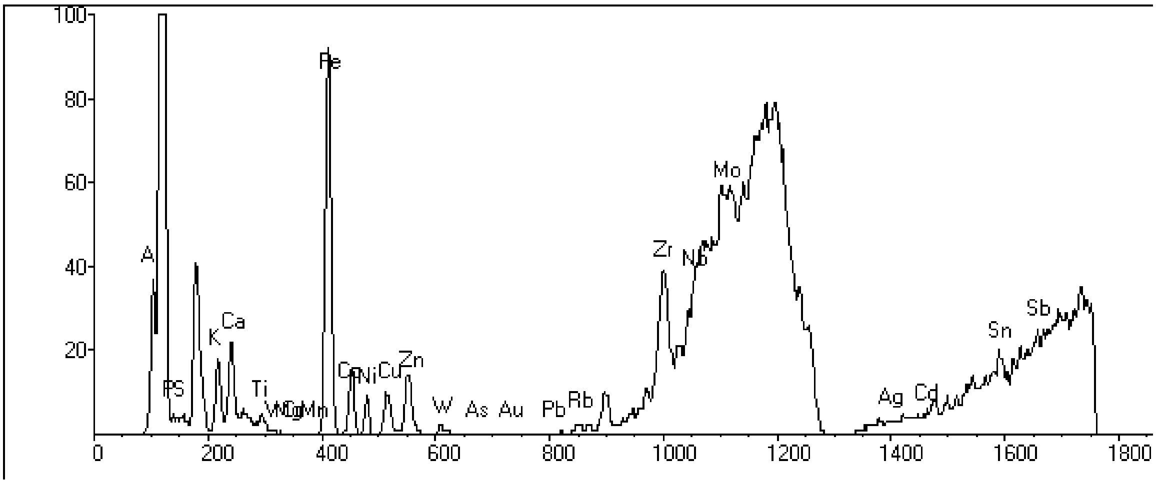

Figure 4.1.7: soil sample 7

This graph shows the metals and their contents found in the sample. The analysis was done using energy dispersive X-ray fluorescence spectroscopy (EDXRF) system. The x-axis represents the metals and the y-axis represents the content of the metals found in mg/kg.

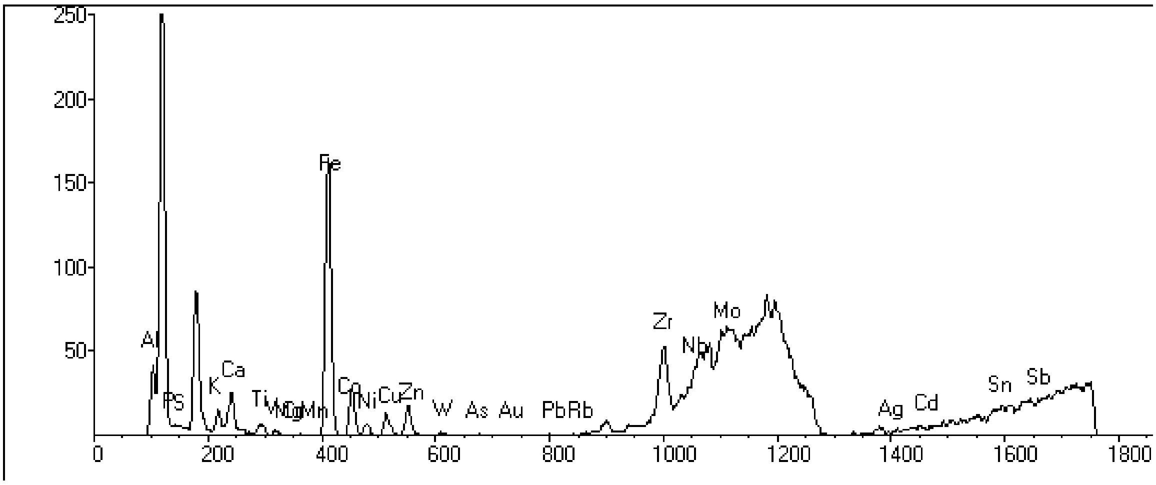

Figure 4.1.8: soil sample 8

This graph shows the metals and their contents found in the sample. The analysis was done using energy dispersive X-ray fluorescence spectroscopy (EDXRF) system. The x-axis represents the metals and the y-axis represents the content of the metals found in mg/kg.

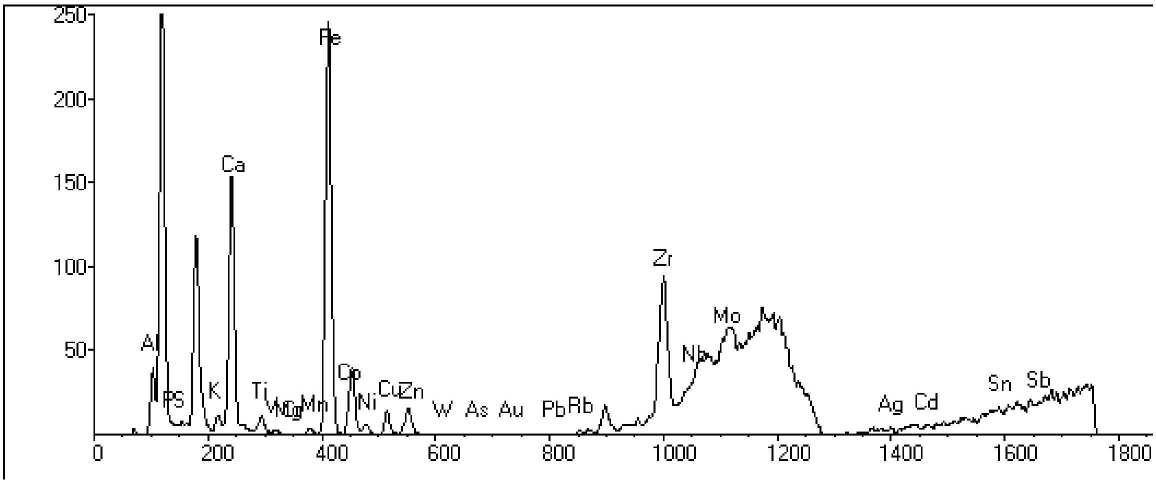

Figure 4.1.9: soil sample 9

This graph shows the metals and their contents found in the sample. The analysis was done using energy dispersive X-ray fluorescence spectroscopy (EDXRF) system. The x-axis represents the metals and the y-axis represents the content of the metals found in mg/kg.

**Heavy Metal Concentration in The Leaves of the Vegetables Grown at The Study Sites.**

The determination of heavy metal concentration in vegetables was done using energy dispersive X- ray fluorescence spectroscopy (EDXRF) system.

Table 4.2: metal concentration in plants (mg/kg).

| S/N | Sample 1<br>Bitter Leaf(Vernonia Amygdalina) | Sample 2<br>Sweet Potato Leaf ( Ipomoea Batatas ) | Sample 3<br>Maize Leaf ( Zea Mays ) |
|---|---|---|---|
| Element | Content | Content | Content |
| Mg | 12.8123 | 27.1091 | 20.0308 |
| Al | 0.8185 | 1.1318 | 1.3108 |
| Si | 0.9340 | 1.5114 | 1.8964 |
| P | 0.3073 | 0.2805 | 0.4592 |
| S | 1.4104 | 1.2641 | 1.7211 |
| K | 8.9446 | 8.9056 | 11.8508 |
| Ca | 2.2268 | 1.9632 | 0.7877 |
| Ti | 0.0000 | 0.0000 | 0.0000 |
| V | 0.0000 | 0.0000 | 0.0000 |
| Cr | 0.0000 | 0.0000 | 0.0000 |
| Mn | 0.0000 | 0.0037 | 0.0000 |
| Co | 0.0000 | 0.0303 | 0.0335 |
| Fe | 0.7607 | 2.4193 | 1.8980 |
| Ni | 0.0787 | 0.0999 | 0.0687 |
| Cu | 0.3688 | 1.0159 | 0.3268 |
| Zn | 0.2289 | 0.2684 | 0.1882 |

| S/N | Sample 1<br>Bitter Leaf(Vernonia Amygdalina) | Sample 2<br>Sweet Potato Leaf ( Ipomoea Batatas ) | Sample 3<br>Maize Leaf ( Zea Mays ) |
|---|---|---|---|
| Element | Content | Content | Content |
| As | 0.0000 | 0.0000 | 0.0000 |
| Pb | 0.0000 | 0.0000 | 0.0000 |
| W | 0.1036 | 0.1151 | 0.1236 |
| Au | 0.0000 | 0.0000 | 0.0000 |
| Ag | 0.0000 | 0.0018 | 0.0000 |
| Rb | 0.1165 | 0.1331 | 0.2173 |
| Nb | 0.0675 | 0.0937 | 0.0585 |
| Mo | 0.2167 | 0.2174 | 0.1701 |
| Cd | 0.0001 | 0.0000 | 0.0005 |
| Sn | 4.2265 | 4.0125 | 3.6644 |
| Sb | 3.5874 | 3.4902 | 3.0659 |

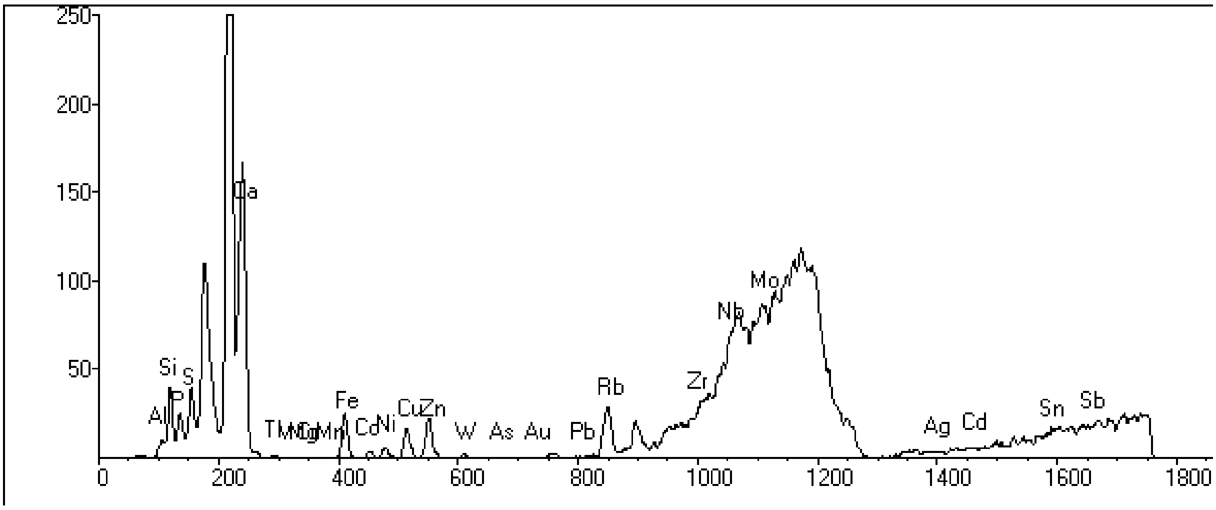

Figure 4.2.1: plant sample 1.

This graph shows the metals and their contents found in the sample. The analysis was done using energy dispersive X-ray fluorescence spectroscopy (EDXRF) system. The x-axis represents the metals and the y-axis represents the content of the metals found in mg/kg.

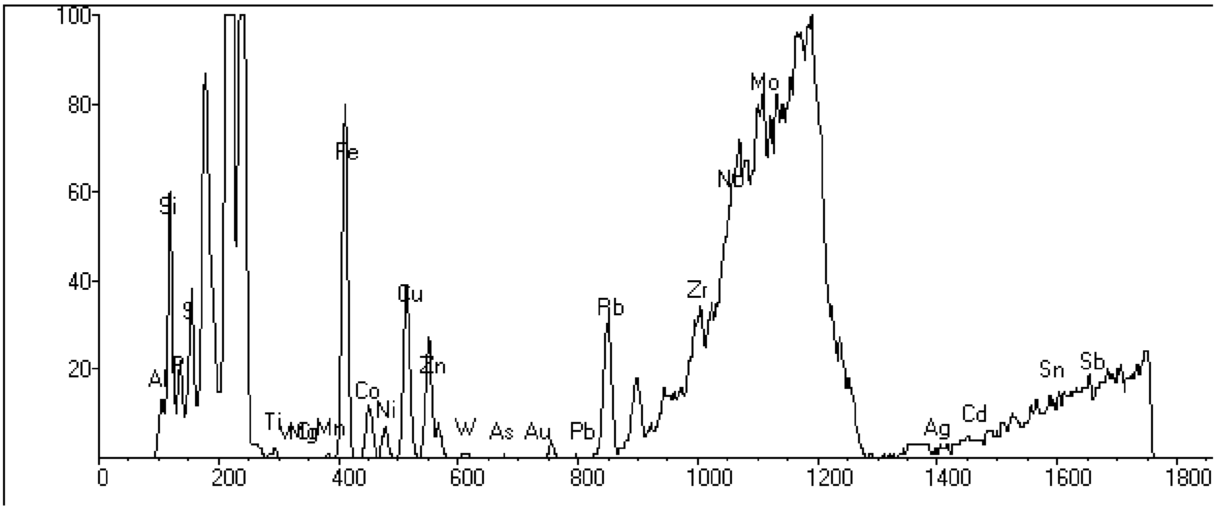

Figure 4.2.2: plant sample 2

This graph shows the metals and their contents found in the sample. The analysis was done using energy dispersive X-ray fluorescence spectroscopy (EDXRF) system. The x-axis represents the metals and the y-axis represents the content of the metals found in mg/kg.

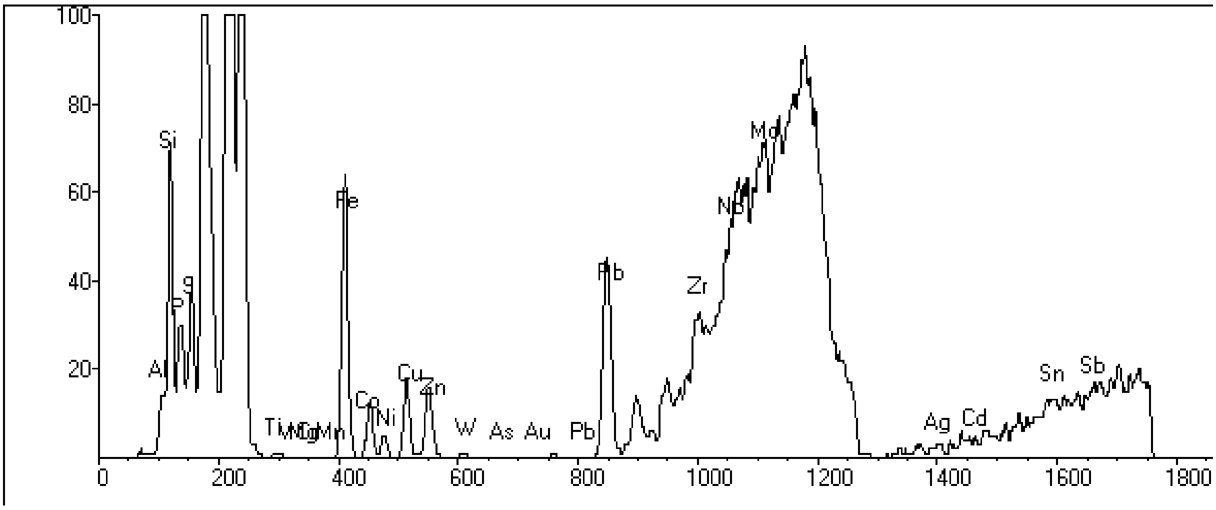

Figure 4.2.3: plant sample:

This graph shows the metals and their contents found in the sample. The analysis was done using energy dispersive X-ray fluorescence spectroscopy (EDXRF) system. The x-axis represents the metals and the y-axis represents the content of the metals found in mg/kg.

**Transfer factors (TF) of the heavy metals from soils to vegetables**:

The ratio of a plant's heavy metal concentration to that of the soil is known as the transfer factor (TF). According to Chamberlain (1983), Harrison and Chirgawi (1989), Smith et al. (1996), it denotes the amount of heavy metals in the soil that made it to the location of the vegetable crop. To determine the degree of risk and related hazard due to ingestion as a result of heavy metal deposition in edible portions of vegetables, a transfer factor (TF) was determined. Based on the procedure outlined by Harrison and Chirgawi in 1989, the transfer factors for each heavy metal were calculated. The following formula was used to calculate the transport of heavy metals from soil to vegetables: Metal content in soil divided by metal content in plants equals the transfer factor.

**Table 4.3: TF values for concentrations of metals from soil to vegetables for different sample.**

| sample number | sample | metals | | | | |
|---|---|---|---|---|---|---|
| | | **Al** | **Fe** | **Ni** | **Sn** | **Sb** |
| sample 1 | Bitter leaf | 0.28 | 0.08 | 0.70 | 0.81 | 0.75 |
| | sweet potato leaf | 0.38 | 0.01 | 21.75 | 0.76 | 0.73 |
| | Maize leaf | 0.45 | 0.00 | 17.06 | 0.70 | 0.64 |
| sample 2 | Bitter leaf | 0.28 | 0.08 | 0.70 | 0.81 | 0.75 |
| | sweet potato leaf | 0.38 | 0.01 | 21.75 | 0.76 | 0.73 |
| | Maize leaf | 0.45 | 0.00 | 17.06 | 0.70 | 0.64 |
| sample 3 | Bitter leaf | 0.28 | 0.08 | 0.70 | 0.81 | 0.81 |
| | sweet potato leaf | 0.38 | 0.01 | 21.75 | 0.76 | 0.73 |
| | Maize leaf | 0.45 | 0.00 | 17.06 | 0.70 | 0.64 |
| sample 4 | Bitter leaf | 0.28 | 0.08 | 0.70 | 0.81 | 0.75 |
| | sweet potato leaf | 0.38 | 0.01 | 21.75 | 0.76 | 0.73 |
| | Maize leaf | 0.45 | 0.00 | 17.06 | 0.70 | 0.64 |
| sample 5 | Bitter leaf | 0.28 | 0.08 | 0.70 | 0.81 | 0.75 |
| | sweet potato leaf | 0.38 | 0.01 | 21.75 | 0.76 | 0.73 |
| | Maize leaf | 0.45 | 0.00 | 17.06 | 0.70 | 0.64 |
| sample 6 | Bitter leaf | 0.28 | 0.08 | 0.70 | 0.81 | 0.75 |
| | sweet potato leaf | 0.38 | 0.01 | 21.75 | 0.76 | 0.73 |
| | Maize leaf | 0.45 | 0.00 | 17.06 | 0.70 | 0.64 |
| sample 7 | Bitter leaf | 0.28 | 0.08 | 0.70 | 0.81 | 0.75 |
| | sweet potato leaf | 0.38 | 0.01 | 21.75 | 0.76 | 0.73 |
| | Maize leaf | 0.45 | 0.00 | 17.06 | 0.70 | 0.64 |
| sample 8 | Bitter leaf | 0.28 | 0.08 | 0.70 | 0.81 | 0.75 |
| | sweet potato leaf | 0.38 | 0.01 | 21.75 | 0.76 | 0.73 |
| | Maize leaf | 0.45 | 0.00 | 17.06 | 0.70 | 0.64 |
| sample 9 | Bitter leaf | 0.28 | 0.08 | 0.70 | 0.81 | 0.75 |
| | sweet potato leaf | 0.38 | 0.01 | 21.75 | 0.76 | 0.73 |
| | Maize leaf | 0.45 | 0.00 | 17.06 | 0.70 | 0.64 |

## HEALTH RISK ASSESSMENT

The potential health risks associated with the intake of the metals through the vegetables were assessed by studying the daily metal intake (DIM), health risks index (HRI), target health quotient (THQ) parameters.

Table 4.4(a) – 4.4(c) below shows the Health Risk Assessment table.

Table 4.4.1. (a)

| sample | Metal | individual | vegetable/potential Health Risk Parameters | | |
|---|---|---|---|---|---|
| | | | Bitter leaf | | |
| | | | DIM | HRI | THQ |
| | Ni | Adults | 0.01914 | 0.478505007 | 0.068591138 |
| | | Children | 0.049675 | 1.241862624 | 0.178014377 |
| | Al | Adults | 0.199063 | 0.663543157 | 0.009145485 |
| | | Children | 0.516627 | 1.722091584 | 0.02373525 |
| | Fe | Adults | 0.185006 | 0.264293889 | 0.003919494 |
| | | Children | 0.480145 | 0.685921146 | 0.01017225 |
| sample 2 | Ni | Adults | 0.01914 | 0.478505007 | 0.068591138 |
| | | Children | 0.049675 | 1.241862624 | 0.178014377 |
| | Al | Adults | 0.199063 | 0.663543157 | 0.009145485 |
| | | Children | 0.516627 | 1.722091584 | 0.02373525 |
| | Fe | Adults | 0.185006 | 0.264293889 | 0.003919494 |
| | | Children | 0.480145 | 0.685921146 | 0.01017225 |
| sample 3 | Ni | Adults | 0.01914 | 0.478505007 | 0.068591138 |
| | | Children | 0.049675 | 1.241862624 | 0.178014377 |
| | Al | Adults | 0.199063 | 0.663543157 | 0.009145485 |
| | | Children | 0.516627 | 1.722091584 | 0.02373525 |
| | Fe | Adults | 0.185006 | 0.264293889 | 0.003919494 |
| | | Children | 0.480145 | 0.685921146 | 0.01017225 |
| sample 4 | Ni | Adults | 0.01914 | 0.478505007 | 0.068591138 |
| | | Children | 0.049675 | 1.241862624 | 0.178014377 |
| | Al | Adults | 0.199063 | 0.663543157 | 0.009145485 |
| | | Children | 0.516627 | 1.722091584 | 0.02373525 |
| | Fe | Adults | 0.185006 | 0.264293889 | 0.003919494 |
| | | Children | 0.480145 | 0.685921146 | 0.01017225 |

Table 4.4.1(b)

| sample | metal | Individual | vegetable/potential Health Risk Parameters | | |
|---|---|---|---|---|---|
| | | | Bitter leaf | | |
| | | | DIM | HRI | THQ |
| sample 5 | Ni | Adults | 0.01914 | 0.478505 | 0.068591 |
| | | Children | 0.049675 | 1.241863 | 0.178014 |
| | Al | Adults | 0.199063 | 0.663543 | 0.009145 |
| | | Children | 0.516627 | 1.722092 | 0.023735 |
| | Fe | Adults | 0.185006 | 0.264294 | 0.003919 |
| | | Children | 0.480145 | 0.685921 | 0.010172 |
| sample 6 | Ni | Adults | 0.01914 | 0.478505 | 0.068591 |
| | | Children | 0.049675 | 1.241863 | 0.178014 |
| | Al | Adults | 0.199063 | 0.663543 | 0.009145 |
| | | Children | 0.516627 | 1.722092 | 0.023735 |
| | Fe | Adults | 0.185006 | 0.264294 | 0.003919 |
| | | Children | 0.480145 | 0.685921 | 0.010172 |
| sample 7 | Ni | Adults | 0.01914 | 0.478505 | 0.068591 |
| | | Children | 0.049675 | 1.241863 | 0.178014 |
| | Al | Adults | 0.199063 | 0.663543 | 0.009145 |
| | | Children | 0.516627 | 1.722092 | 0.023735 |
| | Fe | Adults | 0.185006 | 0.264294 | 0.003919 |
| | | Children | 0.480145 | 0.685921 | 0.010172 |
| sample 8 | Ni | Adults | 0.01914 | 0.478505 | 0.068591 |
| | | Children | 0.049675 | 1.241863 | 0.178014 |
| | Al | Adults | 0.199063 | 0.663543 | 0.009145 |
| | | Children | 0.516627 | 1.722092 | 0.023735 |
| | Fe | Adults | 0.185006 | 0.264294 | 0.003919 |
| | | Children | 0.480145 | 0.685921 | 0.010172 |
| sample 9 | Ni | Adults | 0.01914 | 0.478505 | 0.068591 |
| | | Children | 0.049675 | 1.241863 | 0.178014 |
| | Al | Adults | 0.199063 | 0.663543 | 0.009145 |
| | | Children | 0.516627 | 1.722092 | 0.023735 |
| | Fe | Adults | 0.185006 | 0.264294 | 0.003919 |
| | | Children | 0.480145 | 0.685921 | 0.010172 |

Table 4.4.2(a)

| sample | metal | individual | vegetable/potential Health Risk Parameters | | |
|---|---|---|---|---|---|
| | | | sweet potato leaf | | |
| | | | DIM | HRI | THQ |
| Sample 1 | Ni | Adults | 0.024296 | 0.607403 | 0.006852 |
| | | Children | 0.063056 | 1.576392 | 0.017784 |
| | Al | Adults | 0.275259 | 0.91753 | 0.010351 |
| | | Children | 0.714379 | 2.381262 | 0.026864 |
| | Fe | Adults | 0.588385 | 0.84055 | 0.009482 |
| | | Children | 1.527033 | 2.181476 | 0.02461 |
| sample 2 | Ni | Adults | 0.024296 | 0.607403 | 0.006852 |
| | | Children | 0.063056 | 1.576392 | 0.017784 |
| | Al | Adults | 0.275259 | 0.91753 | 0.010351 |
| | | Children | 0.714379 | 2.381262 | 0.026864 |
| | Fe | Adults | 0.588385 | 0.84055 | 0.009482 |
| | | Children | 1.527033 | 2.181476 | 0.02461 |
| sample 3 | Ni | Adults | 0.024296 | 0.607403 | 0.006852 |
| | | Children | 0.063056 | 1.576392 | 0.017784 |
| | Al | Adults | 0.275259 | 0.91753 | 0.010351 |
| | | Children | 0.714379 | 2.381262 | 0.026864 |
| | Fe | Adults | 0.588385 | 0.84055 | 0.009482 |
| | | Children | 1.527033 | 2.181476 | 0.02461 |
| sample 4 | Ni | Adults | 0.024296 | 0.607403 | 0.006852 |
| | | Children | 0.063056 | 1.576392 | 0.017784 |
| | Al | Adults | 0.275259 | 0.91753 | 0.010351 |
| | | Children | 0.714379 | 2.381262 | 0.026864 |
| | Fe | Adults | 0.588385 | 0.84055 | 0.009482 |
| | | Children | 1.527033 | 2.181476 | 0.02461 |

Table 4.4.2(b)

| sample | metal | individual | vegetable/potential Health Risk Parameters | | |
|---|---|---|---|---|---|
| | | | sweet potato leaf | | |
| | | | DIM | HRI | THQ |
| sample 5 | Ni | Adults | 0.024296 | 0.607403 | 0.006852 |
| | | Children | 0.063056 | 1.576392 | 0.017784 |
| | Al | Adults | 0.275259 | 0.91753 | 0.010351 |
| | | Children | 0.714379 | 2.381262 | 0.026864 |
| | Fe | Adults | 0.588385 | 0.84055 | 0.009482 |
| | | Children | 1.527033 | 2.181476 | 0.02461 |
| sample 6 | Ni | Adults | 0.024296 | 0.607403 | 0.006852 |
| | | Children | 0.063056 | 1.576392 | 0.017784 |
| | Al | Adults | 0.275259 | 0.91753 | 0.010351 |
| | | Children | 0.714379 | 2.381262 | 0.026864 |
| | Fe | Adults | 0.588385 | 0.84055 | 0.009482 |
| | | Children | 1.527033 | 2.181476 | 0.02461 |
| sample 7 | Ni | Adults | 0.024296 | 0.607403 | 0.006852 |
| | | Children | 0.063056 | 1.576392 | 0.017784 |
| | Al | Adults | 0.275259 | 0.91753 | 0.010351 |
| | | Children | 0.714379 | 2.381262 | 0.026864 |
| | Fe | Adults | 0.588385 | 0.84055 | 0.009482 |
| | | Children | 1.527033 | 2.181476 | 0.02461 |
| sample 8 | Ni | Adults | 0.024296 | 0.607403 | 0.006852 |
| | | Children | 0.063056 | 1.576392 | 0.017784 |
| | Al | Adults | 0.275259 | 0.91753 | 0.010351 |
| | | Children | 0.714379 | 2.381262 | 0.026864 |
| | Fe | Adults | 0.588385 | 0.84055 | 0.009482 |
| | | Children | 1.527033 | 2.181476 | 0.02461 |
| sample 9 | Ni | Adults | 0.024296 | 0.607403 | 0.006852 |
| | | Children | 0.063056 | 1.576392 | 0.017784 |
| | Al | Adults | 0.275259 | 0.91753 | 0.010351 |
| | | Children | 0.714379 | 2.381262 | 0.026864 |
| | Fe | Adults | 0.588385 | 0.84055 | 0.009482 |
| | | Children | 1.527033 | 2.181476 | 0.02461 |

Table 4.4.3(a)

| sample | Metal | Individual | vegetable/potential Health Risk Parameters | | |
|---|---|---|---|---|---|
| | | | Maize | | |
| | | | DIM | HRI | THQ |
| | Ni | Adults | 0.016708155 | 0.417703863 | 0.004712211 |
| | | Children | 0.043362624 | 1.084065594 | 0.012229588 |
| | Al | Adults | 0.318792561 | 1.062641869 | 0.011987902 |
| | | Children | 0.827361386 | 2.757871287 | 0.031112166 |
| | Fe | Adults | 0.461602289 | 0.659431841 | 0.007439199 |
| | | Children | 1.19799505 | 1.711421499 | 0.019306931 |
| sample 2 | Ni | Adults | 0.016708155 | 0.417703863 | 0.004712211 |
| | | Children | 0.043362624 | 1.084065594 | 0.012229588 |
| | Al | Adults | 0.318792561 | 1.062641869 | 0.011987902 |
| | | Children | 0.827361386 | 2.757871287 | 0.031112166 |
| | Fe | Adults | 0.461602289 | 0.659431841 | 0.007439199 |
| | | Children | 1.19799505 | 1.711421499 | 0.019306931 |
| sample 3 | Ni | Adults | 0.016708155 | 0.417703863 | 0.004712211 |
| | | Children | 0.043362624 | 1.084065594 | 0.012229588 |
| | Al | Adults | 0.318792561 | 1.062641869 | 0.011987902 |
| | | Children | 0.827361386 | 2.757871287 | 0.031112166 |
| | Fe | Adults | 0.461602289 | 0.659431841 | 0.007439199 |
| | | Children | 1.19799505 | 1.711421499 | 0.019306931 |
| sample 4 | Ni | Adults | 0.016708155 | 0.417703863 | 0.004712211 |
| | | Children | 0.043362624 | 1.084065594 | 0.012229588 |
| | Al | Adults | 0.318792561 | 1.062641869 | 0.011987902 |
| | | Children | 0.827361386 | 2.757871287 | 0.031112166 |
| | Fe | Adults | 0.461602289 | 0.659431841 | 0.007439199 |
| | | Children | 1.19799505 | 1.711421499 | 0.019306931 |
| sample 5 | Ni | Adults | 0.016708155 | 0.417703863 | 0.004712211 |
| | | Children | 0.043362624 | 1.084065594 | 0.012229588 |
| | Al | Adults | 0.318792561 | 1.062641869 | 0.011987902 |
| | | Children | 0.827361386 | 2.757871287 | 0.031112166 |
| | Fe | Adults | 0.461602289 | 0.659431841 | 0.007439199 |
| | | Children | 1.19799505 | 1.711421499 | 0.019306931 |

**Table 4.4.3(b):**

| sample | metal | individual | vegetable/potential Health Risk Parameters | | |
|---|---|---|---|---|---|
| | | Maize | | | |
| | | | DIM | HRI | THQ |
| sample 6 | Ni | Adults | 0.016708155 | 0.417703863 | 0.004712 |
| | | Children | 0.043362624 | 1.084065594 | 0.01223 |
| | Al | Adults | 0.318792561 | 1.062641869 | 0.011988 |
| | | Children | 0.827361386 | 2.757871287 | 0.031112 |
| | Fe | Adults | 0.461602289 | 0.659431841 | 0.007439 |
| | | Children | 1.19799505 | 1.711421499 | 0.019307 |
| sample 7 | Ni | Adults | 0.016708155 | 0.417703863 | 0.004712 |
| | | Children | 0.043362624 | 1.084065594 | 0.01223 |
| | Al | Adults | 0.318792561 | 1.062641869 | 0.011988 |
| | | Children | 0.827361386 | 2.757871287 | 0.031112 |
| | Fe | Adults | 0.461602289 | 0.659431841 | 0.007439 |
| | | Children | 1.19799505 | 1.711421499 | 0.019307 |
| sample 8 | Ni | Adults | 0.016708155 | 0.417703863 | 0.004712 |
| | | Children | 0.043362624 | 1.084065594 | 0.01223 |
| | Al | Adults | 0.318792561 | 1.062641869 | 0.011988 |
| | | Children | 0.827361386 | 2.757871287 | 0.031112 |
| | Fe | Adults | 0.461602289 | 0.659431841 | 0.007439 |
| | | Children | 1.19799505 | 1.711421499 | 0.019307 |
| sample 9 | Ni | Adults | 0.016708155 | 0.417703863 | 0.004712 |
| | | Children | 0.043362624 | 1.084065594 | 0.01223 |
| | Al | Adults | 0.318792561 | 1.062641869 | 0.011988 |
| | | Children | 0.827361386 | 2.757871287 | 0.031112 |
| | Fe | Adults | 0.461602289 | 0.659431841 | 0.007439 |
| | | Children | 1.19799505 | 1.711421499 | 0.019307 |

**Table 4.5: ORAL REFERENCE DOSE**

| Metal | RfD |
|---|---|
| Ni | 0.04 |
| Al | 0.3 |
| Fe | 0.7 |

**Table 4.6: Range of trace metal concentration in the soil accepted by WHO (mg/kg).**

| METALS | RANGE |
|---|---|
| Aluminum (Al) | 6 – 3500 |
| Chromium (Cr) | 0.002 – 0.2 |
| Nickel (Ni) | 0.1 – 5 |
| Arsenic (As) | 0.009 – 1.5 |
| Cadmium (Cd) | 0.02 – 0.5 |
| Lead (Pb) | 0.3 – 10 |

4.2 Source: (Akaeze C.S. 2001

## 4.3 Discussion:

The assessment of health associated with the ingestion of the vegetables was necessary to be determined. The parameters (DIM, HRI, THQ) for assessment of health risk associated with the ingestion of the vegetables in the area of study were determined for adults and children (table 4.4a – 4.4c).

The level of a metal's toxicity is usually a function of daily intake of the metal (DIM) (Edogbo et al. 2020). The daily intake values of Ni, Al, and Fe through ingestion of the vegetables were found to be within the respective oral reference doses (RfDs) of 0.04, 0.30 and 0.70 mg/kg/day for adults, the intake of Al for the children were higher for all samples. The HRI values (the ratio of respective DIM to respective RfD) were observed to follow the trend of the corresponding DIM. In every soil sample and for every vegetable, some of the HRI values were found to be greater than one (HRI> 1) for children. These implied that the health risk of exposure to the metals through food chain is high.

For the bitter leaf sample, it was observed that the HRI values for children for both Al and Ni were above 1(table 4.4.1(a) – 4.4.1(b)). This can be attributed to the low body weight of children(20.2kg) as compared to that of the adults (69.9kg).

These higher HRI values for children shows that children are at greater health risk arising from the intake of these vegetables. The higher values of HRI arose from the dependence of HRI on average body weight of a person and daily intake of vegetables (Ramteke et al. 2016; Zhou et al. 2016; Rehman et al. 2017; Edogbo et al. 2020).

The HRI values for the sweet potato plant as shown in table 4.4.2(a) – 4.4.2(b), indicated that the children were at greater risk ingesting this plants than the adults as their HRI values were above the desired value. The Fe metal was twice the maximum required value for our HRI. Although the body needs Fe in little quantities, it is not advisable for these vegetables to be consumed especially by the children.

For the maize vegetable, it was observed that the HRI values for both children and adults were greater than one (HRI>1). Which poses a health risk for both individuals if ingested? The values were still observed to be greater than one for Ni and Fe for only children, which could have resulted from the difference in the body weight of adults(69.9kg) to that of the children(20.2kg).

The THQ is a typical method for estimating potential health risks that are non-carcinogenic (State of Oregon Department of Environmental Quality 2000; Storelli 2008). The values of THQs were observed to follow the trend of the values of the DIMs calculated and used for determining the THQs of the current study.

The THQ value intake by adults and children as seen in table 4.4.3(a) – 4.4.3(b) shows that the ingesting Ni, Al and Fe through intake of every vegetable from every sample were less than one (THQ>1).

This indicates that there were no potential health risks concerning non-carcinogenic.

Table 4.1(a)–4.1(c) shows the tiny concentrations of nickel (Ni) that were discovered. This suggests that there aren't many waste materials around that contain nickel. The lack of manufacturing and smelting activity near Oluku, Akure Road by Iyowa, may account for the low concentration.

Al was also found throughout the dumpsite, as shown in Tables 4.1–4.3. However, the concentrations were small. Low Al transporting waste could be the cause of this as well. In comparison to the WHO norm of Al = 6 - 3500 mg/kg, the obtained levels were low.

The majority of the samples did not contain any cd. According to Uba et al. (2008), dumpsites have the highest bioavailability of Cd. According to Ali et al. (2005), there are many different causes that can be blamed for the concentrations of Cd and Al, some of which are car tyre dust, burning of oil and tyres, plastic packaging, paints, dyes and particularly, garbage dumps and commercial operations. The quantities of these heavy metals found in these garbage dumps are below the permissible limit established by the WHO (USEPA, 1986).

In one sample, there was no evidence of arsenic (As) or lead (Pb). Even in those samples where Pb was found, it was discovered to be quite low when compared to the WHO limit for the content of heavy metals in soil (Pb = 0.3 - 10 mg/kg).

Chromium (Cr) was not found in all of the dumpsites; this can also be explained by the fact that some of the dumpsites contained garbage with low Cr concentrations. There may have been less human activities that could have produced chromium as a result. Chromium +3 is less harmful to health because to the body's 1% absorption rate, but Cr +6 is acutely hazardous and causes dermatitis, allergies, and irritations when it comes into contact with the skin, making it regarded to be carcinogenic to humans (Asemave et al., 2012).

The investigation of soil and plants near a garbage dump in Oluku, Akure Road, by Iyowa produced results for heavy metals that showed their concentrations to be quite low. The low concentration may be due to waste in the area having lower concentrations of particular metals (Pb, Ni, Al, Cd, Cr, and As, Sn, and Sb).

# CHAPTER FIVE

## SUMMARY, CONCLUSION AND RECOMMENDATIONS

### 5.1 Conclusion:

The study investigates concentrations of heavy metal in waste dumpsite in Oluku, Akure Road by Iyowa, Edo State, Nigeria. The results indicate that the dumpsite didn't shown to be having high concentrations of heavy metals, since some heavy metals could not be detected in dumpsite. This may be as a result of less contamination with those metals due to human activities. Some metals could not be detected; the implication is that the concentration of these metals are below detection limit or not present at all.

Although there is a little Health risk concern for the children in the area who consume these vegetables which could lead to them having nausea, vomiting, abdominal pain and diarrhea, the dumpsite has concentrations of heavy metals within the allowable limit; as a result, may not appear to pose very serious environmental or health problems at the moment.

However, there is cause for some concern as continuous accumulation in the levels of heavy metals may occur with time and may result in health challenges.

From the studies, the dumpsite in Oluku, Akure Road by Iyowa, contained less heavy metals. It was also observed that the dumpsite had higher concentration of these metals like magnesium (Mg) than others; this could be attributed to the presence of waste carrying higher amounts of magnesium. The heavy metals concentration in these dumpsites were all within the WHO acceptable limit in the dumpsite.

Heavy metal concentration in refuse dumpsite of Oluku, Akure Road by Iyowa may not appear to pose very serious environmental and health problems at the moment; however, the continuous accumulation of these metals may later pose a threat to both human's health and the environments.

### 5.2 Recommendations:

The most effective way to reduce/eliminate the impact of these heavy metals on the environment is to develop and implement an effective waste management plan. Plans to identify the materials and wastes at a particular site and try to manage it. Designated places should be used as dumpsites and not indiscriminate marking of dumpsites as it is the case. Dumpsites should be treated before use especially for cultivation. Also the people living around these dumpsites should stop farming on or around them.

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