INFLUENCE OF MINING ACTIVITIES ON PHYSICOCHEMICAL PROPERTIES OF SOIL AT IFEWARA GOLD MINE SITE DURING DRY SEASON, OSUN STATE, NIGERIA.

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CERTIFICATION

This is to certify that this project was written by **JULIUS ELIBAZBETH ABIOLA** with the Matric Number **(HND/23/MNE/FT/027)** supervised, read and approved as having satisfied part of the requirements for the award of Higher National Diploma in Mining Engineering Technology by the Department of Mineral and Petroleum Resources Engineering Technology, Kwara State Polytechnic, Ilorin.

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DEDICATION

This project is dedicated to Almighty God who had been my helper through my HND program .

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I give thanks to Almighty God, the only one who has knowledge of attitude, to him be the glory, for His mercy and goodness throughout my project work.

I also forward my acknowledgment to my wonderful handsome and hardworking supervisor Engr Agbalajobi, S. A for his knowledge used to input lightness in my darkness. May Almighty God continue to be with you (Ameen).

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ABSTRACT

Soil is one of the most important constituents for fulfilling the basic needs of human beings. It plays a vital role in agriculture as the foundation for farming and food production. This study investigates the effect of mining on the physicochemical properties of soil at the Ifewara Gold Mining site, Osun State, Nigeria, by analyzing the physicochemical parameters and heavy metal composition of soils collected within and outside the mine perimeter. Ten soil samples were collected and analyzed for physicochemical parameters, including soil pH, electrical conductivity (EC), total dissolved solids (TDS), temperature, sodium, potassium, magnesium, calcium, sulphate, chloride, and total organic carbon (TOC). Additionally, concentrations of heavy metals such as Fe, Co, Zn, Ni, Pb, Cr, and Cd were analyzed using standard analytical methods. The pH values ranged from 5.1 to 6.9, electrical conductivity (EC) ranged from 1131 to 1502 μS/cm, and total dissolved solids (TDS) ranged from 186 to 319 ppm. Concentrations of sodium (Na^{+}) ranged from 10.56 to 43.83 mg/kg, potassium (K^{+}) from 12.59 to 38.27 mg/kg, magnesium (Mg^{2+}) from 13.64 to 32.41 mg/kg, calcium (Ca^{2+}) from 21.48 to 52.36 mg/kg, sulphate (SO_4^{2-}) from 18.26 to 57.36 mg/kg, chloride (Cl^{-}) from 3.81 to 10.46 mg/kg, and total organic carbon (TOC) ranged from 1.57% to 2.28%. Heavy metal analysis (in mg/kg) showed the following concentration ranges: Fe (8.768 – 10.58 mg/kg), Co (0.005 – 0.515 mg/kg), Zn (3.411 – 3.679 mg/kg), Ni (0.054 – 1.407 mg/kg), Pb (0.001 – 0.001 mg/kg), Cr (0.053 – 0.124 mg/kg) and Cd (0.001 – 0.088). The results showed significant changes in soil physicochemical properties and elevated heavy metal concentrations in samples collected within the mine perimeter, which may be attributed to mining activities and waste generation from the mine. The contamination level indices for the heavy metals in the samples could not be accurately determined due to sampling during the dry season and the possible leaching of contaminants.

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CHAPTER ONE

INTRODUCTION

1.1 GOLD MINING OPERATIONS

Gold mining operations started in the Ilesa-West Local Government Area of Osun state Nigeria in early 1950s. Though official mining operation stopped in mid 1990s, illegal mining is still active in the area till today. Mining activities adversely affect the physicochemical and qualities of sub-surface of the earth crust through unfavourable pH, alteration of soil nutrients and accumulation of heavy metals in the soil. This study Influence of Mining Activities on Physicochemical Properties of Soil at Ifewara Gold Mine Site During Dry Season, Osun State, Nigeria will be analyzed through the determination of the physicochemical parameters and heavy metals composition of the soil within and outside the mine perimeter. Soil samples will be collected and analyzed for the physicochemical parameters such as the soil pH, Organic carbon, Electrical conductivity, Chloride, Sulphide and Nitride. Also, some heavy metals concentration such as As, Cd, Cu, Pb and Zn will be analyzed using standard analytical method.

Mining occurs when there is an extraction of minerals or other geological materials from the earth's crust; which forms the mineralized package of economic interest to the miner (Oluwafemi, 2018, Oyinloye, 1992). However, mining activities also impact negatively on the waters, landscape, vegetation and the atmosphere at the mine sites (Oyinloye, 1992; Ako *et al*., 2013). Gold with the chemical symbol (Au) coined from the Latin word aurum falls into the categories of transition metals. It can occur as nuggets or grains, in rocks veins or alluvial deposits. According to Hawas *et al*. (2013), environmental consequences of gold mining can be devastating, particularly in fragile tropical ecosystems because toxic substances like cyanide and mercury are usually involved in its extraction. Several studies exist on the impact of mining on the environment both at micro and macro levels (Schueler, *et al*., 2011; Oyinloye, 1996; Ako *et al*., 2014; Hawas *et al*., 2013). For instance, Sima, *et al*. (2008) observed that both natural and socioeconomic activities are impacted qualitatively and quantitatively as a result of mining activities. Few studies, (Hawas *et al*., 2013; Oyinloye, 1996; Ako *et al*., 2014) especially in the field of Geoinformatics, have examined mining and its impact on the geomorphology and social wellbeing in a comparative manner. Koruyan *et al*. (2012) in their study of Remote Sensing in management of mining land and proximate habitat, used satellite images taken in the summer of 2001 to 2009 to determine land use and landcover at Mulga province in western Turkey. Advanced Spaced Thermal Emission Radar (ASTER) and Landsat images used include 15m and 30m resolution in order to use a consistent set of data. The study revealed that the extent of marble quarries expansion covered 36,390 hectares and revealed clearly the rate of quarry expansion grew from 0.54 % in 2001 to 2.89% in 2009 over the entire study area. The study also confirmed that the vegetation around quarries was influenced by mining operations, natural vegetation reduced drastically while quarries covered larger land areas. The study however, recommended that mining sites should be closely monitored at both micro and macro scales using geospatial techniques. Gold in Nigeria is found in alluvial deposits and primary deposit in rock veins from several parts of supracrustal (schist) belts in the northwest and southwest of Nigeria (Mesubi, *et al*. 1999). In fact, Nigeria is one of the countries in Africa producing gold in large quantities preceded by Ghana and Tanzania (Schueler *et al*., 2011). It is interesting to know that the most resourceful gold occurrences in Nigeria are found in the Maru, Anka, Malele, Tsohon Birin Gwari-Kwaga, Gurma, Bin Yauri, Luku, Okolom-Dogondaji, Itagunmodi, Igun and Iperindo areas, all associated with the schist belts of northwest and southwest Nigeria.

1.2 AIM AND OBJECTIVE OF THE RESEARCH WORK

1.2.1 Aim of the Research

The aim of this project is to investigate on the Influence of Mining Activities on Physicochemical Properties of Soil at Ifewara Gold Mine site during Dry Season, Osun State, Nigeria.

1.2.2 Objectives of the Study

The main objectives of the study are to:

i. determines the physical and chemical parameters such as, soil pH and temperature, Electric Conductivity (EC), Total Dissolved Salt (TDS), chlorine ion, sulphide ion and nitrite ion, Mg^{2+}, Na^{2+}, K^{+}, Ca^{2+}, Also, some heavy metals contaminants such as Cobalt (Co), Cadmium (Cd), Zinc (Zn), Cr (Chromium) and Lead (Pb).

ii. ascertain the effect of mining activities of Ifewara gold mine site, Osun State on the soil quality.

1.3 SCOPE OF THE RESEARCH WORK

The study of soil sample will be collected from the mining site and adjourning undisturbed area. They physicochemical properties of the sample collected will be analyzed using standard procedures and the results will be compared with World Health Organization (WHO) and understand threshold limit.

1.4 STATEMENT OF PROBLEM

The Influence of mining activities on soil properties can damage the soils on which crops are grown and also the environmental contamination of soil can pose a significant threat to human health and aquatic life.

1.5 JUSTIFICATION

The results of this study will be recommended to the Government's Ministry of Environment at all levels to adopt a good management approach to the incessant and inadequate mining activities going on in the study location.

CHAPTER TWO

LITERATURE REVIEW

2.1 BACKGROUND OF STUDY

Traditionally, the effects of gold mining have long attracted the interest of geomorphologists both in terms of their landforms, vegetation alteration and biodiversity response to change. An important goal in mapping and assessment process is to extract hidden relationships and effects between some variables. In recent year, there has also been a wider growing recognition of human impacts on the earth's global systems (Adediji and Oluwafemi, 2007). Surface mining, for example, removes vegetation and soils, interrupts ecosystem service flows, and results in inevitable and often permanent farmland loss. Gold mining activities also frequently result in toxic waste that causes water pollution and health problems. Studies have also shown that mining at both small and large scale has great impact on vegetation and soil, land use, livelihood foundations and geomorphology of African countries.

The Itagunmodi-Igun drainage basin occupies an area of 74,031,443 km2 within mining sites in close areas like Faforiji, Epe, Ibodi, Iwara Odo, Iperindo, Atorin and Iyemogun (Oluwafemi, 2018). Ilesa Schist Belt has a north-south length of approximately 200 km and reaches its maximum width of approximately 60km in the south. Hence, it consists of two structural units with contrasting lithology, separated by the NNE-trending Ife fault zone (Oke *et al*., 2013). The western unit (Figure 2.1) (which is the focus of this study) consists of amphibolite, amphibole schist, and pelitic schist with much intimately associated trondjemitic granite, gneiss, and pegmatite (Oke *et al*., 2013; Oyinloye, 2011).

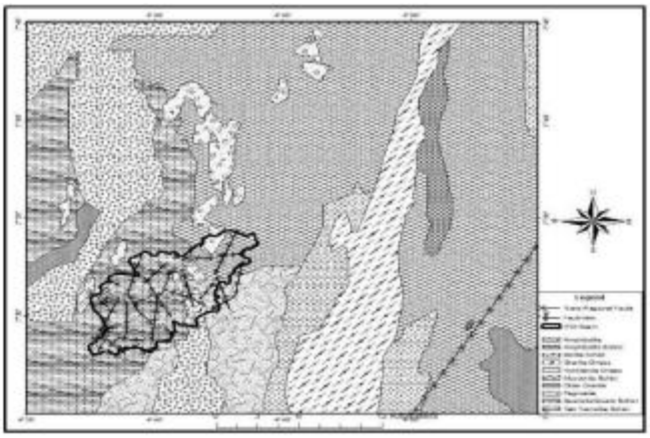

Figure 2.1: Geology of Ilesa Schist Belt showing the Study Area
Source: Modified after Oyinloye, 1992

The metamorphism is mainly evident in the amphibolite facies, but locally in greenschist facies (Oke *et al*., 2013; Oyinloye, 2011). At the eastern axis of the fault (the Iperindo catchment) quartzite is dominant, occurring together with quartz schist, quartzo-felspathic-gneiss, and minor iron-rich schist (Oke *et al*., 2013; Oyinloye, 2011). The deciduous rainforest of the study area can be sub-divided into three types. These include the disturbed rainforest, the light forest, and the patches of thick forest. The disturbed rainforest is the anthropogenically impacted rainforest with many randomly distributed open spaces as a result of human activities such as agriculture, mining, lumbering, and fuelwood harvesting. The light forest is an emerging forest at the stage of secondary succession that is common on the slightly weathered rocks. The patches of thick forest are the few natural rainforests of the Southwestern Nigeria that are relatively protected from encroachment. These include the forest reserves and traditionally preserved forests that are consecrated to some traditional religions and festivals in Yoruba Land (Orimoogunje, Oyinloye, and Momodou, 2009; Oluwafemi, 2018). The wet season in the area is normally characterized by two maximal rainfalls with peaks occurring in July and September or October. The rainfall record of Itagunmodi between 1975-2000 indicates that annual rainfall varies from 923mm-2116mm with a mean of 1389.29mm, and the temperature is generally high (Olayiwola and Aguda, 2009). The range of temperature during the dry season especially between December and

April is between 21^0C and 30^0C. Also, as observed by Olayiwola and Aguda (2009) the mean daily minimum and maximum temperature in the area is 20^0C and 33^0C respectively.

2.2 SMALL-SCALE MINING (ASM) ACTIVITIES

The process of formalizing ASM land access aims to be straightforward; however, operators encounter difficulties in obtaining permits due to their limited expertise in geology, inadequate funding, substantial expenses, and bureaucratic obstacles Fisher, 2009: Hilson, Yakovleva., 2007. Moreover, it has been noted that some artisanal and small-scale mining (ASM) operators in Nigeria and other parts of Africa do not have any intention to legalize their activities, Andrews. 2015. The persistent problem of marginalization of artisanal and small-scale mining (ASM) in terms of its ability to access mineral-rich land is emphasized due to its connection with large-scale mining operations Yankson, Gough, 2019. The lack of sufficient data on the role and impact of small-scale gold mining operations in Ghana's socioeconomic development has led to differing viewpoints and discussions on the actual extent of small-scale mining's contribution to socioeconomic progress. The employment opportunities resulting from artisanal and small-scale mining (ASM) activities are clearly advantageous for marginalized rural inhabitants who rely primarily on agriculture for their livelihood despite the adverse environmental consequences associated with these activities Adu-Baffour, *et al*.,2021; Conteh, and Maconachie, 2021. The present circumstances are highly alarming as the considerable consequences of recent variations in weather patterns have greatly affected rural farmers, especially those engaged in small-scale production. The increase in illegal mining activities can be attributed to mining regulations implemented by the government that prioritize the protection of commercial mining companies at the expense of small-scale mining operations. The study seeks to examine the impact of mining activities on agriculture and soil fertility in both the study area. The findings of this study will aid in developing strategies to alleviate the adverse impacts of mining activities on livelihoods, agriculture, and soil fertility. This will enhance rural transformation by tackling the substantial influence of mining operations on rural livelihoods and the environment.

CHAPTER THREE

MATERIALS AND METHODS

3.1 SAMPLE DESCRIPTION

The material that was mainly used for the research was soil which was collected at the subsurface of the earth crust. The samples were collected at the mine at Ifewara, Atakumosa Local Government Area, Osun State, Nigeria. It lies within latitude 07° 03' 13" N to 07° 03' 22" N and longitude 04° 11' 09" E to 04° 12' 22" E (Figure 3.1) lies about 35 km west of Ilesa town. The area is a developing resident's layout towards the east side of the Ifewara Township. The residents of the area are of different tribes living in their own houses. The remaining parts of the open fields, apart from the gold mining pits, are used mainly by the residents for farming and cash crop (cocoa). The topography of the area in undulating, drained by river and its tributaries, it is underlain by the rocks typical of the Basement Complex of southwest Nigeria and characterized by the tropical rain forest climate. The artisanal miners haphazardly select Artisanal Gold Mine (AGM) pit sites, where gold-bearing saprolitic layers are panned (Figure 3.3) to extract gold and associated heavy minerals. Locally fabricated sluice boxes are also employed in the beneficiation of the saprolite slurries where carpets, which act as traps, are placed in these boxes while the slurries are run over them (Figure 3.2) and Figure 3.4 and Figure 3.5 Site Location with group picture with the project students and miners.

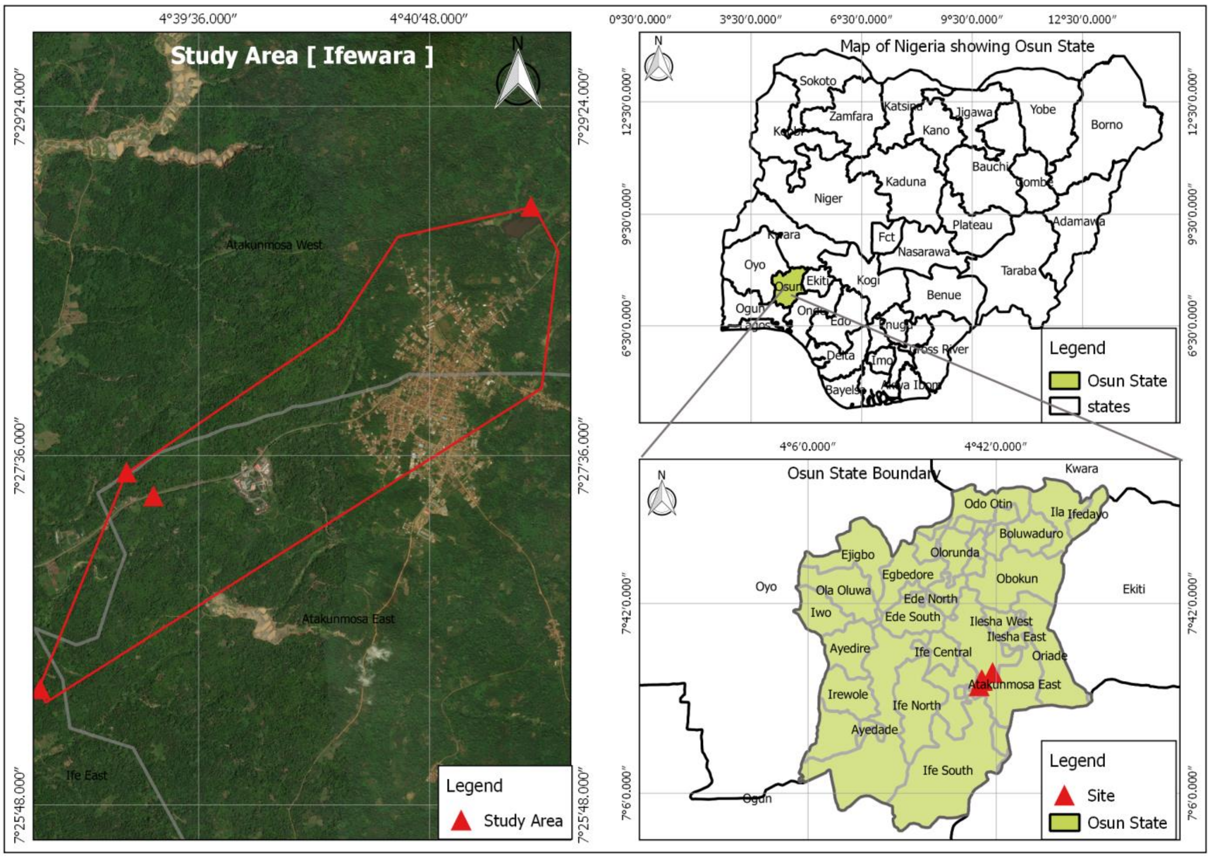

Figure 3.1: Map of the Study Area Location Ifewara, Atakumosa Local Government Area, Osun State, Nigeria.

Plate 3.1: Typical Artisanal Small-Scale Gold Mining Process in the Study Area using a Sluice Box

Plate 3.2: The artisanal miners haphazardly select Artisanal Gold Mine (AGM) pit sites, where gold-bearing saprolitic layers are panned.

Plate 3.3: Site Location with group picture with the project students and miners

Plate 3.4: Site Location with group picture with the project students and miners

Plate 3.5: Site Location with group picture with the project students

3.2 SAMPLE COLLECTION

Soil samples were randomly collected at ten (10) different points within mine perimeter whiles the sixth, seventh and eighth location was 500m away from the mine. Ten samples were taken randomly at each sample location at a depth of 30cm with the aid of hand auger drill and were rigorously mixed together in a polythene bag. At the end of the samples collection, ten set of samples were available for laboratory analysis.

3.3 SAMPLE PREPARATION

The analyses of the soil sample to determine the composition of heavy metals were carried out. The samples collected from the surface and subsurface soil of each sampling point were later mixed to form composite sample for each sampling location. The collected samples were dried, grinded to fine powder using ball milling machine and sieved with 150µm mesh size. The sieved samples were stored in the polythene bag and labelled accordingly prior to analysis, and the residue samples were discarded.

Organic carbon was determined by dichromate oxidation method of Walkley and Black procedure (Neson and Sommers 1982), wet oxidation, and corrected to soil organic matter by multiplying with a correction factor of 1.724, particle size analysis of the soil was determined using the Bouyoucos hydrometer method. The soil samples were analyzed for the following physicochemical parameters: pH, Electrical conductivity (EC), available phosphorus, exchangeable calcium, potassium, sodium, total organic matter. Heavy metal concentrations of the sample were also determined using Atomic Absorption Spectrophotometer (ASS) for the following heavy metals: Fe (iron), Cobalt (Co), Zinc (Zn), Chromium (Cr), Nickel (Ni), Lead (Pb), and Cadmium (Cd). Available phosphorus was extracted using Bray II extractant as described by Bray and Kurtz (1945). Exchangeable Calcium, Magnesium, Sodium and Potassium were extracted with ammonium actateethylenediaminetetraacetic acid (NH_4OAC-EDTA). Calcium and Magnesium were determined using Ethylene Diamine Tetra-acetic Acid disodium salt (EDTA) titration method while Potassium and Sodium were determined by flame photometer (Rhoades, 2002). Cation exchange capacity was determined titrimetrically using 0.01N NaOH. Exchangeable acidity was determined titrimetrically using 0.05N NaOH. Bulk density was determined on the core samples by core method as described by Anderson and Ingram (2013).

3.4 PHYSICOCHEMICAL ANALYSIS

All the soil samples were subjected to tests at the Central Research Laboratory, University of Ilorin, Kwara State. The physicochemical properties of the soil samples were determined according to standard methods. Soil pH was determined using digital pH meter according to the method described by Bates (2004). Soil electrical conductivity was determined using conductivity meter according to the method outlined by Godson *et al*., (2002). Calcium and magnesium in soil samples were determined by versenate titration method as outlined by Piper, (1966). Potassium was determined by flame photometrically after extracting the soil with neutral normal ammonium acetate (Jackson, 2003). Available phosphorus was extracted using Bray II extraction as described by Bray and Kurtz (2015). Sodium in soil samples was determined turbidometrically. The intensity of turbidity was measured using spectrophotometer at 420nm of wavelength as outlined by Piper, (1966). Total organic matter was determined according to the method outlined by Osuji and Adesiyan, (2005).

3.4.1 Measurement of Physicochemical Parameter

During sampling, some immediate probing referred to as physical investigation was carried out on the samples in-situ by a portable water kit before the samples were sent to the laboratory for analyses. The measured physico-chemical parameters include the PH, Temperature, Electrical conductivity and Total Dissolved Solid (TDS).

3.4.2 Electrical Conductivity (EC)

Electrical conductivity is a good measure of salinity hazard to crops as it reflects the TDS in water and soil. Electrical conductivity of natural waters is determined by the presence of substances, which dissociate into cations and anions. Measurement of EC can be used to monitor and determine the degree of water pollution. The value of EC may serve as an appropriate index of the total content of the dissolved substances for the bodies of waters, which have been subjected to considerable influence run-off waters, to establish the origin and distribution of various waters in the body of water and delineation pollution zones.

The measurement of electrical conductivity in microsiemen per centimeter (us/cm) was determined using portable field conductivity meter for each of the water samples. Conductivity is a measure of the ability of water to conduct an electric current. It increases as the amount of the dissolved minerals (ions) increases.

3.4.3 pH Test

The pH of water is a measure of hydrogen ion concentration in water. It ranges from 0 to 14, with neutral water at 7. While lower of it is acidic and PH greater than 7 is known as basic. Drinking water with a pH ranging from 6.5 to 8.5 is generally considered satisfactory. It is noticed that water with low pH tends to be toxic and with high degree of pH tastes bitter. The pH of the studied water samples was measured by dipping the electrode of the pH meter into the bowl of the water samples.

3.4.4 Temperature

The temperature of the water is one of the most important characteristics which determines, to a considerable extent and tendencies of changes in the quality of water. It is taken with the aid of multifunction water kit, and measured in degree Celsius. The water temperature was taken before the other water measurements, because the temperature tends to change very rapidly after a sample is collected.

3.4.5 Total Dissolved Solid (TDS)

The concentration of impurities is often termed Total Dissolved Solid (TDS). It is often measured in ppm or mg/l and can be determined using conductivity method or TDS meter. Water has the ability to dissolve a wide range of inorganic and some organic minerals or salts such as potassium, calcium, sodium, bicarbonates, chlorides, magnesium, sulphates etc. these minerals produced unwanted taste and diluted colour in appearance of water which may be injurious to animals and plants.

3.4.6 Major Ions

The major ions analyzed in the water samples are of two groups, which are;

1. Cations
2. Anions

The major cations analyzed include sodium (Na^+), potassium (K^+) and calcium (Ca^{2+})· The major anions analyzed include chloride (C^{l-}) and sulphate (SO_4^{2-}).

3.4.7 Determination of Sodium and Potassium Using AAS

100mls of the water sample was measured into a clean 250mls digestion flask. 15mls of conc. nitric acid (HNO_3) and 5mls of conc hydrochloric acid (HCL) were added into the sample in digestion flask. The solution inside digestion flask was heated on a hot plate until all the brownish fumes (nitrogenous compound) expelled out, which confirmed that the water sample is digested and it was allowed to cool at room temperature, 2mls of distilled water was added. Then, the mixture was filtered into 50mls standard flask and it was transferred into plastic reagent bottle for atomic absorption spectrometry (A.A.S) at Central Research Laboratory University of Ilorin for determination of Na^+ and K^+.

3.4.8 Determination of Calcium Ion Using Muroxide as Indicator

25mls of the water sample was measured into a clean conical flask, then 2mls of dilute NaoH was added into the sample and 2 – 3 drops of muroxide indicator were added into the solution, and then titrated against 0.01m of EDTA (titrant) until a pinkish color appeared as equation 3.1.

$$Ca^{2+}(mg/l) = \frac{\text{Titre Value x Molarity x Molar Mass}}{\text{Volume of Sample}} \times 1000 \qquad \text{equation 3.1}$$

3.4.9 Determination of Magnesium Ion (Mg^{2+}) Using Erichrome as Indicator

Total hardness is due to the presence of both calcium and magnesium ions so that the sum of calcium and magnesium is determined readily using erichrome as indicator. Direct titration method was used in which 25mls of the water sample was buffered to pH 10 (i.e. 5mls of ammoniacal buffer). It was then titrated against 0.01m EDTA, the end point was noted when the solution changes from purple to pure blue. Note, the mg^{2+} was determined by subtracting the already known Ca^{2+} from the total hardness as in equation 3.2 and 3.3.

$$\text{Total hardness (mg/l)} = \frac{\text{Titre Value x Molarity x Molar Mass}}{\text{Volume of Sample}} \times 1000 \qquad \text{equation 3.2}$$

$$Mg^{2+}(mg/l) = \text{Total Hardness – Calcium Ion} \qquad \text{equation 3.3}$$

3.4.10 Determination of Sulphate ($So4^{2-}$) Using Precipitation Method

10mls of the sample was poured into a beaker, 5mls of barium chloride was added into the solution. The initial weight of the beaker together with the solution was weighed. The solution was heated on a burse burner until white precipitate formed. The beaker was removed from the burner and allowed to cool. Then, its final weight was taken in equation 3.4.

$$SO4^{2-}(mg/l) = \frac{\text{Change in Weight}}{\text{Volume of Sample}} \times 1000 \qquad \text{equation 3.4}$$

3.4.11 Determination of Chloride Ion (Cl^-) Using Mohr Method

25mls of water sample was measured into a conical flask and placed on a white tile surface. 1ml of potassium chromate solution ($K_2Cr_2O_4$) as an indicator was added and a light-yellow solution appeared; it was then titrated against silver nitrate solution ($AgNO_3$) with constant stirring until lightest reddish coloration persists at the end point as in equation 3.5.

$$Cl^-(mg/l) = \frac{\text{Titre Value x Molarity x Molar Mass}}{\text{Volume of Sample}} \times 1000 \qquad \text{equation 3.5}$$

3.5 DETERMINATION OF HEAVY METALS

The concentrations of heavy metals in all the samples were determined using the BUCK Scientific ACCUSYS (Model 203) Atomic Absorption Spectrophotometer. One grams of each sample was introduced into a digesting tube then 10 ml of concentrated HNO_3 was added. The samples were placed in the digester for 8 hours at 96^oC with alternating turning. When the digestion has completed, the samples were filtered into 100 ml volumetric flask using what man filter paper. Samples were made up to 100 ml mark in the volumetric flask using distilled deionised water. The concentration of Iron (Fe), cobalt (Co), zinc (Zn), nickel (Ni), lead (Pb), chromium (cr), and cadmium (cd) in the solution were determined using Varian Spectra AA 600 Atomic Absorption Spectrophotometer (AAS) with air acetylene flame connected to it.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 RESULTS

4.1.1 Physicochemical Analysis of the Samples

In this study, ten samples were collected within the mine perimeter at 100meter interval while a control sample was collected at 500m away from the mine parameter. The samples were labelled sample LS1, LS2, LS3, LS4, LS5, LS6, LS7, LS8, LS9 and LS10 with the control sample being labelled sample LOS10. In order to understand the soil capability to retain heavy metals, geochemical soil characteristics such as pH, carbon content, electric conductivity were performed on the sample. Table 4.1 shows the results of the Physiochemical analysis of the samples.

Table 4.1: Results of physiochemical Analysis of the soil samples from the study site during dry season

Sample Codes	Ph	EC (µS/cm)	TDS (ppm)	Temp^o (^{o}C)	Na^{2+}	K^+	Mg^{2+}	Ca^{2+}	SO_4^{2-}	Cl^-	TOC %
LS 1	6.1	1157	186	31.8	21.42	12.59	15.29	21.48	18.26	7.40	2.11
LS2	6.3	1388	287	32.1	24.08	17.84	13.64	44.81	52.09	6.83	1.76
LS3	5.4	1502	319	35.2	43.83	33.93	19.14	52.36	57.36	9.51	2.19
LS4	6.9	1437	299	32.3	34.79	38.27	13.61	48.99	48.99	8.23	1.98
LS5	5.6	1131	178	31.3	17.41	14.60	16.48	25.63	25.63	9.16	1.99
LS6	5.6	1191	199	35.6	20.06	15.14	19.72	33.39	33.39	8.94	1.70
LS7	6.9	1265	235	34.6	19.94	21.95	28.67	39.74	39.74	10.46	2.28
LS8	5.5	1414	259	35.9	13.28	24.42	32.41	36.63	36.63	5.31	1.86
LS9	5.3	1335	218	33.8	10.56	28.04	25.37	31.31	31.31	5.611	2.11
LS10	5.1	1243	286	35.6	12.71	26.56	29.51	29.25	29.25	3.81	1.57

Range	5.1 – 6.9	1131 – 1502	186 – 319	31.3 – 35.6	10.56 – 43.83	12.59 – 38.27	13.64 – 32.41	21.48 – 52.36	18.26 – 57.36	3.81 – 10.46	1.57 – 2.28

4.1.2 Variation of pH and Electrical Conductivity

Table 4.1 show the soil pH at the eight (8) locations (LS1, LS2, LS3, LS4, LS5, LS6, LS7, LS8. LS9, LS10/control) to be 6.1, 6.3, 5.4, 6.9, 5.6, 5.6, 6.9, 5.5, 5.3, and 5.1 respectively during the dry season. The recorded values of samples value collected within the proximity of the site are lower than the pH recommended value range of 6.6 to 7.5 for optimum plant growth (Queensland Department of Environment and Heritage Protection (QDEHP), 2019), but the control sample is within the recommended limit. The results of the Electricity conductivity range from 1131 to 1502 µs/cm. The EC was observed to be higher in the sample within the mine (LS2, LS3, LS4, LS7, LS8, LS 9 and LS 10) while it was observed to be low in LS1, LS5 and LS6 which are flowing river samples. Since the EC is a measure of level of salts content in the soil and it is understood that if the EC value in soil sample increases, then more dissolve ion was being deposited from a source which could be from the mine (Yasir and Alain, 2016).

4.1.3 Variations of Potassium, Sodium, Calcium and Magnesium (mg/kg)

The results of potassium for the dry season were recorded with range from 12.59 to 38.27, potassium is not an integral part of any major plant component but it plays a key role in a vast array of physiological process vital to plant growth from protein synthesis to maintenance of plant water balance (Sumithra *et al*., 2013). Potassium is found in its mineral form and affect plants division, carbohydrate formation, translocation of sugar, various enzyme actions and resistance to certain plant disease (Jain *et al*., 2014). For Sodium the recorded value was between 10.56 – 43.83 for dry season and magnesium ranged between 13.64 – 32.41 during the dry season, the Calcium content in the soil samples was observed to be between 21.48 to 52.36 with control sample possessing the lowest calcium content value 21.48.

4.1.4 Variations of Total Organic Matter, Chlorine, and Sulphide (mg/kg)

The total organic matter (TOC) ranged from 1.57% to 2.28% as shown in Table 4.2 from the result, it could be seen that all the samples within the mine perimeter have high carbon content LS10/control sample. Soil organic carbon is a key attribute in assessing soil health, generally correlating positively with crop yield (Bennett *et al*., 2010). The soil organic carbon affects important functional processes in soil like the storage of nutrients, mainly nitrogen, and water holding capacity (Silva and Sa-Mendonca, 2007).

The content of chlorine in the sample ranged from 3.81 to 10.46 with the control sample having the lowest CI content. This implies that the mining activities could have contributed to increment. Increase in chlorine content in the soil indicated high rate of CI in take by immediate plants which could reduce the crop yield (Onipede *et al*., 2020).

The results of the sulphide content ranged from 57.36 to 18.26 while the LS1 sample has value of 13.80. High waste generation in the mine could be attributed to the high level of sulphide content within the mine perimeter. Though, sulphide content in soil may be advantageous for optimal plant growth so far, the threshold limit as specified by (NCHRP, 2009) is not exceeded.

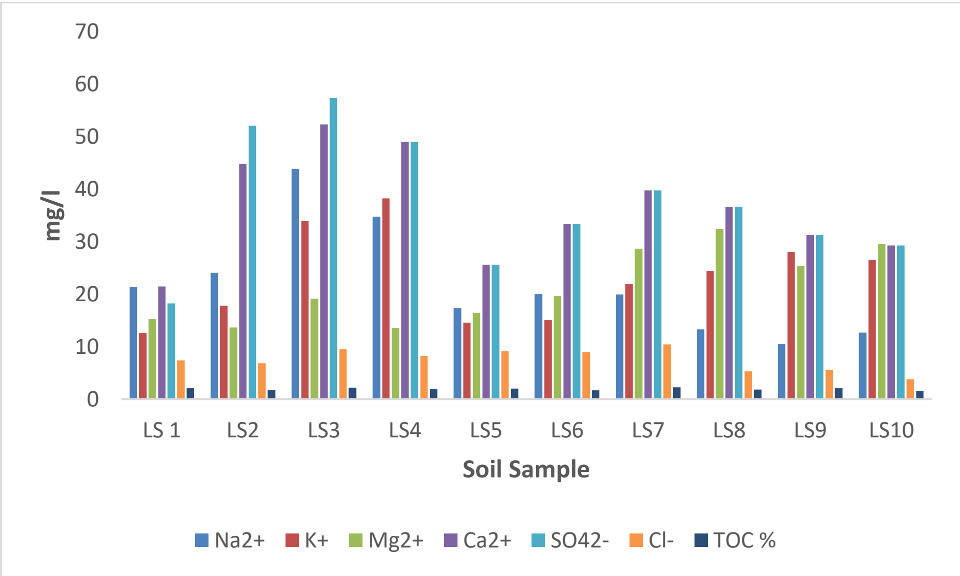

Figure 4.1: Concentrations of Metallic Elements in Soil Samples around the mine

4.1.5 Heavy Metal Concentration of Samples

The results of the heavy metal concentration of the sample are shown in Table 4.2. The average concentration of Fe present in the sample ranged from 10.508 (LS 4) to 8.789 (LS 9). The content of Fe was observed to be high in all the samples within mine perimeter with the control sample. This could also be observed in other heavy metals such as Co, Zn, Ni, Pb, Cr, and Cd with average results ranging from 0.515 (LS 3) to 0.005 (LS7); 3.679 (LS 4) – 3.411 (LS 6); 1.407 (LS 2) – 0.054 (LS 3); 0.001 – 0.001 (Constant); 0.124 (LS 2) – 0.053 (LS 5); and 0.088 (LS 4) – 0.001 (LS 2,6,7,9) respectively.

Table 4.2: Result of Heavy Metal Concentration in Samples (mg/kg) during the dry season

Sample Code	Fe		AVE	Co		AVE	Zn		AVE	Ni		AVE	Pb		AVE	Cr		AVE	Cd		AVE
LS 1	9.608	9.608	9.608	0.495	0.495	0.495	3.663	3.663	3.663	1.237	1.237	1.237	0.001	0.001	0.001	0.090	0.090	0.090	0.001	0.001	0.001
LS 2	9.752	9.752	9.752	0.514	0.514	0.514	3.550	3.550	3.550	1.407	1.407	1.407	0.001	0.001	0.001	0.095	0.152	0.124	0.013	0.013	0.013
LS 3	10.243	10.243	10.243	0.515	0.515	0.515	3.634	3.634	3.634	0.054	0.054	0.054	0.001	0.001	0.001	0.086	0.086	0.086	0.001	0.001	0.001
LS 4	10.508	10.508	10.508	0.0811	0.111	0.096	3.679	3.679	3.679	0.195	0.195	0.195	0.001	0.001	0.001	0.070	0.070	0.070	0.088	0.088	0.088
LS 5	9.173	9.173	9.173	0.016	0.016	0.016	3.545	3.545	3.545	0.135	0.135	0.135	0.001	0.001	0.001	0.077	0.029	0.053	0.022	0.022	0.022
LS 6	9.763	9.763	9.763	0.052	0.052	0.052	3.411	3.411	3.411	0.223	0.223	0.223	0.001	0.001	0.001	0.008	0.008	0.008	0.001	0.001	0.001
LS 7	10.383	10.383	10.383	0.005	0.005	0.005	3.467	3.467	3.467	0.325	0.325	0.325	0.001	0.001	0.001	0.038	0.038	0.038	0.001	0.001	0.001
LS 8	10.365	10.365	10.365	0.041	0.041	0.041	3.587	3.587	3.587	0.034	0.034	0.034	0.001	0.001	0.001	0.115	0.115	0.115	0.044	0.044	0.044
LS 9	8.789	8.789	8.789	0.001	0.001	0.001	3.501	3.501	3.501	0.109	0.109	0.109	0.001	0.001	0.001	0.088	0.081	0.085	0.001	0.001	0.001
LS 10	9.619	9.619	9.619	0.136	0.136	0.136	3.484	3.484	3.484	0.168	0.168	0.168	0.001	0.001	0.001	0.054	0.054	0.054	0.083	0.083	0.083

It could be observed that heavy metals concentration was high in the entire sample within the mine perimeter than that of the control samples in Figure 4.1, Figure 4.2 and Figure 4.3 respectively. It could be connoted that the mining activities have influences in the accumulation of heavy metals in the soil.

Table 4.3: Results of the Average heavy metals concentration in the sample (mg/kg) during the dry season

Sample Code	Fe (mg/kg)	Co (mg/kg)	Zn (mg/kg)	Ni (mg/kg)	Pb (mg/kg)	Cr (mg/kg)	Cd (mg/kg)
LS 1	9.608	0.495	3.663	1.237	0.001	0.090	0.001
LS 2	9.752	0.514	3.550	1.407	0.001	0.124	0.013
LS 3	10.243	0.515	3.634	0.054	0.001	0.086	0.001
LS 4	10.508	0.096	3.679	0.195	0.001	0.070	0.088
LS 5	9.173	0.016	3.545	0.135	0.001	0.053	0.022
LS 6	9.763	0.052	3.411	0.223	0.001	0.008	0.001
LS 7	10.383	0.005	3.467	0.325	0.001	0.038	0.001
LS 8	10.365	0.041	3.587	0.034	0.001	0.115	0.044
LS 9	8.789	0.001	3.501	0.109	0.001	0.085	0.001
LS 10	9.619	0.136	3.484	0.168	0.001	0.054	0.083
Range	8.768 – 10.58	0.005 – 0.515	3.411 – 3.679	0.054 – 1.407	0.001 – 0.001	0.053 – 0.124	0.001 – 0.088

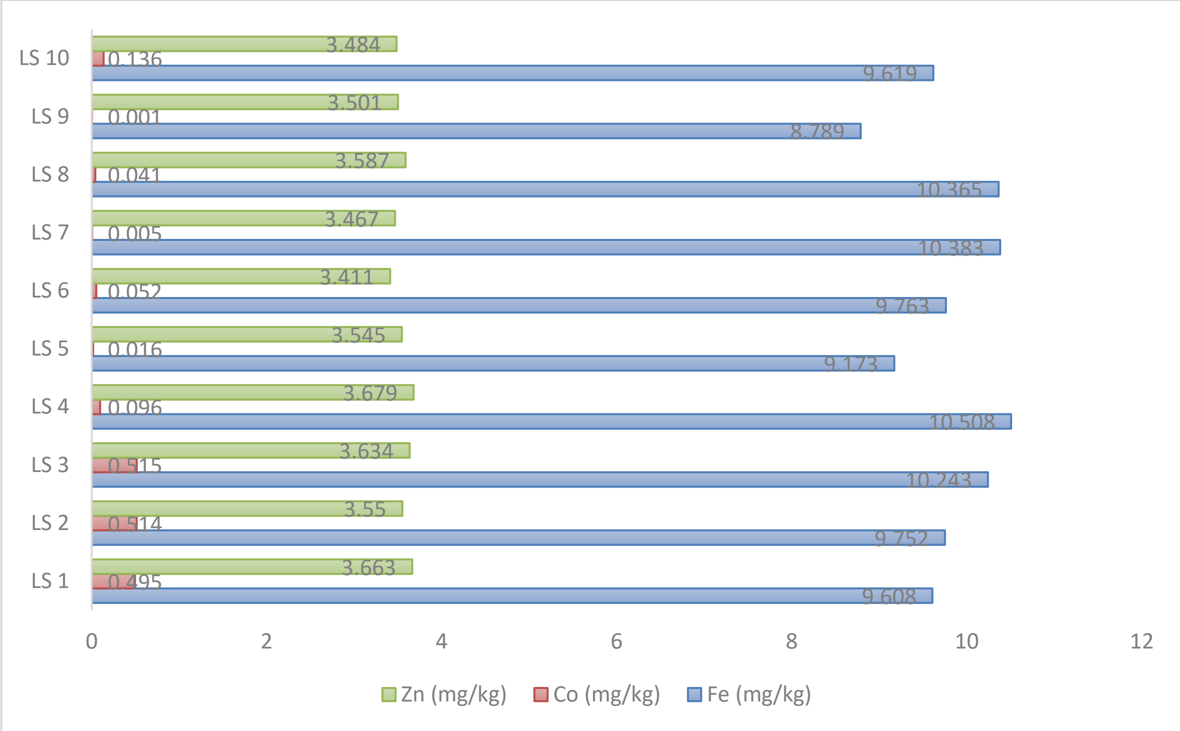

Figure 4.2: Heavy Metals Concentration of the Sample (mg/kg)

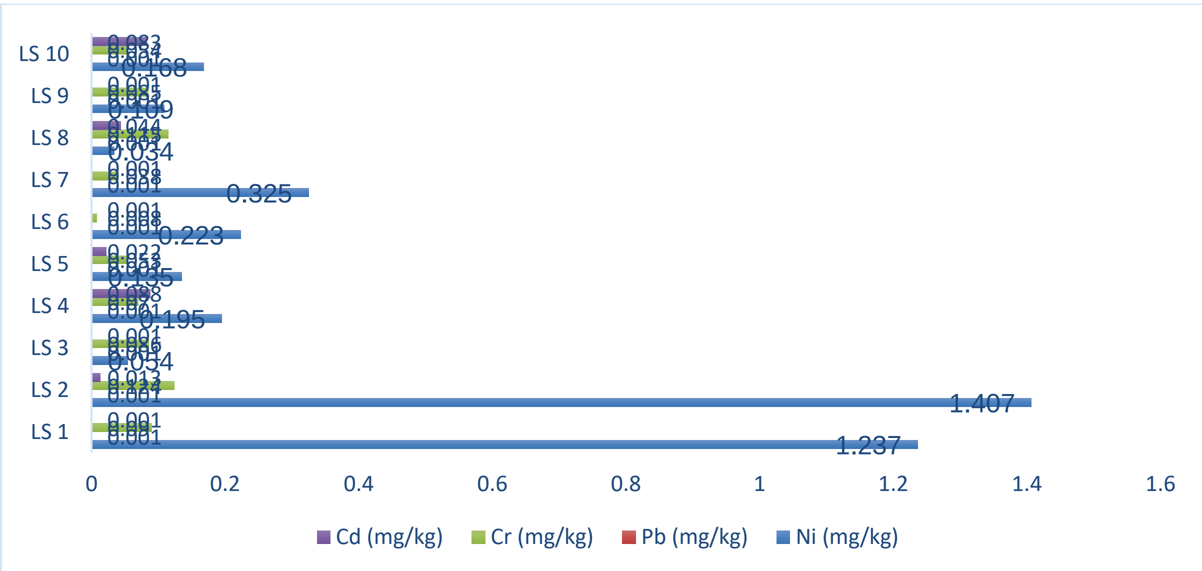

Figure 4.3: Heavy Metals Concentration of the Sample (mg/kg)

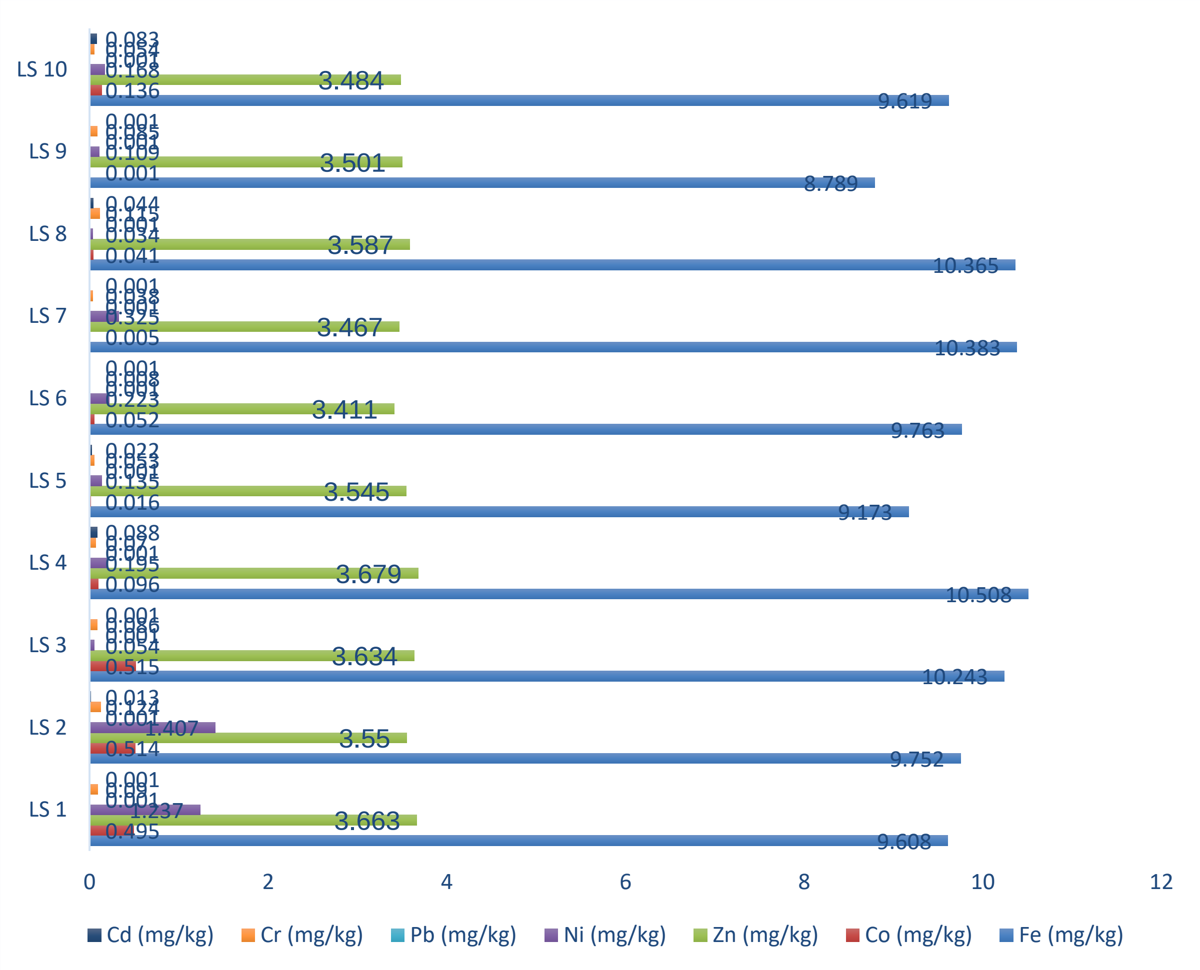

Figure 4.4: Heavy Metals Concentration of the Sample (mg/kg) for all the Soil Samples

4.2 IMPACT OF MINING ON METALLIC ELEMENTS IN THE SOIL

Plants require metallic elements, such as calcium (Ca), potassium (K), magnesium (Mg), Iron (Fe), and Zinc (Zn) as nutrients to grow and develop (Tripathi *et al*., 2014). Disturbance or contamination of the soil could negatively impact the availability of these metals and affect the suitability of the soil for sustainable agriculture. Therefore, it is imperative to assess the impact of mining activities on the metallic elements in soil samples at the different locations around the mine are in Figure 4.1. Ca, K, and Mg are macronutrients that plants need in large quantities for growth. The concentrations of these macro-nutrients in the soil samples are interpreted using Table 4.4.

Table 4.1 presents different concentrations of macronutrients in soil (Hazelton and Murphy, 2016). Ca concentrations in all the soil samples in all the location are below the moderate concentration of Ca required for agricultural soils (Table 4.4). Ca deficiency in soil could affect the ability of legume plants to associate with nitrogen-fixing bacteria. Soil K is essential for plant growth and development and the plant's mobility of nutrients (Adams and Shin, 2014). The Mg concentrations are below the typical concentration required for plant growth. Similarly, Onifade *et al.*, 2020 reported a low average Mg concentration of 13.64 mg/kg around the mining site in Komu, South-western Nigeria. Generally, it can be observed that many researchers have reported the impact of mining activities on soil macronutrients (Afeni and Ibitolu, 2018; Oladipo *et al.*, 2014; Onifade *et al.*, 2020; Mensah *et al.*, 2015; Wang *et al.*, 2021). In addition, the low concentrations of these macronutrients in the soil samples could be linked to the acidity of the soil samples; macronutrients are less available in acidic soil samples; macronutrients are less available in acidic soil (Gondal *et al.*, 2021).

Sodium concentration in the soil has little effect on plant growth, but a too-high concentration can affect plant growth and crop productivity (Maarguis, 2014; Essandoh *et al.*, 2021). The sodium concentrations in all the Soil samples, which range from 10.56 to 43.86 mg/kg, are within the low range recommended for agricultural purposes (Table 4.4). A similar range of sodium concentration was also found in the soil of a mine site in Dunkwa East municipality of Ghana (Essadoh *et al.*, 2021). In a mining site at Komu south-western Nigeria, Onifade *et al.*, (2020) reported a lower average sodium concentration of 10.56 mg/kg.

Table 4.4: Concentration levels of macronutrients in Soil (adapted from Hazelton and Murphy, 2016)

Elements (mg/kg)	Low	Moderate	High
Ca	400 – 1000	1000 – 2000	2000 – 4000
K	78 – 117	117 – 273	273 – 780
Mg	36 – 120	120 – 360	360 – 960
Na	23 – 69	69 – 169	169 – 460

Iron and zinc are micronutrients because they are needed in small quantities for plant growth. Nevertheless, high concentrations of these micronutrients or their deficiencies can affect plant metabolism and growth (Chatzistathis, 2014). Iron and zinc concentrations in all the soil samples in and around the mining site are below the recommended concentrations of 100 and 20 mg/kg respectively (Epstein, 1965). Low concentrations of Fe and Zn may also relate to low soil pH in and around the mining site, as a low pH enhances the solubility of heavy metals (Arogunjo, 2007). The region's low concentration of Fe and Zn in the studied area seems peculiar. Onifade *et a*l., (2020) obtained a low average concentration of Fe (8.768 mg/kg) and Zn (3.411 mg/kg) from the mining site at Komu, south-western Nigeria. The study revealed relative concentration of heavy metal in the soil during the dry season at Ifewara mine site in the following order: Fe>Zn>Pb>Ni>Cr>Cd. The Iron and Zinc content of the soils was extremely low but they are needs to analysis the soil during dry season to ascertain degree of contamination assessing the trace element pollution risk evaluation and calculation of contamination factor index and potential ecological risk index.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSIONS

This study revealed that the mining activities going on in Ifewara, Osun State, Nigeria have a negative impact on the soil by introducing heavy metal above the threshold limit and altering the soil's physicochemical parameters; thereby causing severe pollution of the soil. There is urgent need to compose guiding principles that will guide and regulate mining activities especially artisanal mining activities in this area in order to prevent numerous poisoning effects of these heavy metals.

5.2 RECOMMENDATIONS

The following recommendations are made in light of this study's conclusions:

1. The contamination of the soils by heavy metals in the area is increasing and such a situation requires effective measures to prevent further pollution to the ecosystem.
2. Also, the intermittent monitoring of the quality of soil around the mines should be encouraged at both government and organizational levels to always ascertain the concentration of the assessed soil parameters.
3. Further, research should focus on the assessment, monitoring and control of the heavy metal's contamination of the air-borne dust, steam water and sediments.

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